ASSESSING THE ROLE OF YOUTHS IN PROMOTING VEGETABLE PRODUCTION AMONG SMALLHOLDER FARMERS IN BUSIA COUNTY, KENYA

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DECLARATION AND RECOMMENDATION

Declaration

This thesis is my original work and has not been submitted or presented in part or whole for examination by any other institution.

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Recommendation

The thesis has been submitted for examination with our approval as the university supervisors.

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DEDICATION

Special dedication to my ever-supportive parents (Mr. and Mrs. James Lugaye) for their unrelenting support and empathy toward me throughout the entire course. I also dedicate this thesis to my husband Edwin and daughter Becky whose unyielding support and encouragement have inspired me to pursue and complete my research.

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ABSTRACT

Currently, pressure to change agricultural extension strategies to increase vegetable production through farmer technology acceptance is on the rise. Various approaches to extension service have been explored as a result. However, a secondary school-based approach to extension service is yet to be tried in Kenya. Using a mixed research design, the study aimed at assessing whether a secondary school-based training approach to agricultural extension could be used to promote off-season diversified vertical vegetable gardening among smallholder farmers in Busia County, Kenya. The study targeted agriculture students and school administrators in four schools, smallholder farmers and field extension officers. A total sample of 271 respondents was purposively selected to participate in the study. Data was collected using one interview schedule, survey, two focus group discussion schedules and observation guide at baseline and endline survey. The instruments were validated by research experts from the Department of Agricultural Education and Extension, Egerton University. A pilot test for the instruments was carried out among 30 respondents in SA Kolanya boy's high school in Teso North Sub County to estimate the reliability. Cronbach alpha coefficient was calculated and accepted at 0.885. Baseline and endline surveys were analyzed using Wilcoxon sign-rank test, descriptive and thematic analysis, using Statistical Package for Social Sciences (SPSS). Results were significant at $P < 0.05$. A baseline survey was conducted before the onset of the study to identify the gap and possible interventions. Three diversified vertical vegetable gardening technologies; mound bed, second wall and primary tower, were used in the study as knowledge gap interventions to promote kales, black nightshade, spinach/ Swiss chard, capsicum and carrots. Endline survey was conducted to assess the outcome of the intervention. The results showed that there was increased ease of accessing extension services on vegetable production. The approach boosted smallholder farmer's confidence in diversified vertical vegetable gardening as a vegetable production technology, as a result, the level of technology acceptance improved (1% to 22%), at $P = .000$. This significantly increased household availability of black nightshade (83%-89%), at $P = 000$ and kales (50% - 68%), at $P = .003$. However, there was no guiding policy to sustainably support agricultural extension through schools. Therefore, with suitable policy guidelines, extension service through secondary schools proved to be a potential strategy for promoting agricultural technologies as youths can be both recipients and providers of extension service.

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LIST OF ABBREVIATIONS AND ACRONYMS

AAVF	The African Association for Vertical Farming
AET	Agricultural Education and Training
ATA	Agricultural Transformation Agenda
ASDSP	Agriculture Sector Development Support Programme
ASDS	Agricultural Sector Development Strategy
CGIAR	Consultative Group on International Agriculture Research
DVVGs	Diversified Vertical Vegetable Gardening
EAS	Extension and Advisory Services Delivery
FAO	Food and Agriculture Organization
FFS	Farmer Field Schools
ICT	Information and Communication Technologies
ICRISAT	International Crop Research for Semi-Arid Tropics
KALRO	Kenya Agriculture Livestock and Research Organization
MoALF	Ministry of Agriculture Livestock and Fisheries
NABARD	National Bank for Agriculture and Rural Development
NALEP	National Agricultural Livestock Extension Programme
NASEP	National Agriculture Sector Extension Policy
NEGP	National eGovernance Project
PPP	Public Private Partnership
PRA	Participatory Rural Appraisal
RRI	Rapid Results Initiative
T&V	Training and Visit
UPUFS	Urban and Per-urban Farming Systems
WHO	World Health Organization
YFC	Young Farmers Club
4K	Kuungana, Kufanya, Kusaidia Kenya
4H	Head, Heart, Hands and Health

CHAPTER ONE
INTRODUCTION

1.1. Background Information

The world produces about 1,128 million tons of vegetables annually (Tummons et al., 2017). However, available vegetables are not enough to supply the adequate volumes recommended for consumption as the global Prevalence of Undernourishment sharply increased in 2020 due to COVID-19. Different organizations are engaged in promoting vegetable production as a way of increasing their availability among households around the world. Among them, the World Vegetable Center (AVRDC) aims at improving the research and development of vegetable crops, enhancing nutrition and increasing food security. In Kenya, the Vegetarian Club aims at promoting human health, protecting animal rights and preserving the environment (Dinssa et al., 2016). These organizations promote both indigenous and exotic vegetable varieties such as black nightshade, spider plant, spinach/Swiss chard, kales, capsicum and broccoli, among others. However, their production is still low, increasing poverty levels, more so in developing countries (Ebert, 2020).

The high levels of poverty in Africa are largely linked to low agricultural production, including that of vegetables (Gassner et al., 2019). Besides, irreversible changes in urbanization, climate, population, water and land availability, prompt a need to embrace sustainable high-yielding technologies (Urban and peri-urban systems, kitchen gardens and organic farms) in vegetable production. In the recent past, Urban and Peri-urban Farming Systems (UPUFS) have proved to provide food and nutrition security to vulnerable urban communities thus responding to urban unemployment and poverty. Vertical vegetable farming as a UPUFS has gained prominence as it yields more while utilizing limited spaces, labour and resources, though the rural communities have less embraced it. Technologies in vertical gardening such as mound bed, primary tower, second wall, rooftop gardening, vertical wall gardening, and bucket gardening can help developing countries not only reduce poverty levels but also promote broad-based growth in rural areas. These types of gardening can easily be managed by smallholder farmers, regardless of the socio-economic factors since they rely on low-cost, low-risk technology and are easily adapted to hostile environments (Kumar et al., 2020). They can also be a good niche for agricultural extension to adequately engage the youths as they are key in the adoption and sustainability of modern technologies.

Since its inception, the Agricultural Extension and Advisory Services (EAS) in Kenya, have been undergoing continuous changes in delivery approaches and methods of disseminating information. The national government has been providing the bulk of advisory services, however, since the devolution of agricultural services from the central government to county governments, there are multiple advisory service providers (Resnick, 2022). Even with the benefits of devolution, there are still challenges in agricultural extension services delivery at county levels, gaps still exist in reaching out to the youth and getting them involved in agriculture. Youth engagement can help Agricultural Sector Development Strategy (ASDS) cope with the new and dynamic demands of modern agriculture. Adequate harmonization of ASDS and youths' engagement can improve the sustainability and impact of sustainable agricultural programmes and technologies (Andresen et al., 2013).

Youth involvement in agriculture can enhance farmer-to-farmer extension, hence offering opportunities for promoting sustainable production of diversified vegetables. The Agricultural Transformation Agenda (ATA) for 2013 is an example of an approach that was set out to reach out to the youth. This programme was launched to attract the private sector to add value to agricultural production in Nigeria. The approach was participatory and increased youth interest in agriculture, and that of the smallholder farmers as well. This further increased agricultural production in Nigeria (Lyocks et al., 2013). ATA is a success story that further strengthens the need for agricultural extension to positively engage the youth in production using yield-increasing technologies such as peri-urban systems (Lyocks et al., 2013).

Apart from ATA in Nigeria, other approaches such as Positive Youth Development (PYD), have been used to improve extension services for development among the youths. The 4-H clubs in the USA, such as the ‘tomato club’, drastically improved the production of tomatoes in the US (Worker et al., 2019). The participatory and action approach to training that was used in the clubs helped the girls to have a substantive income from the sales of tomatoes, both locally and nationally. At the turn of the 20th century, the ‘tomato clubs’ undoubtedly played a critical role in improving agricultural productivity (Uricchio et al., 2013).

Tomato clubs in the USA were the most effective way of convincing smallholder farmers of the need and value of Good Agricultural Practices (GAP), while educating the future generation of farmers. As a result, crop production increased, food and nutrition security, and as well as profits made from the sales (Uricchio et al., 2013). The same approach could help

agricultural extension improve its impact on agricultural development through diversified vegetable production in Kenya. However, challenges in the production of diversified vegetables coupled with several economic factors affect the production of both indigenous and exotic vegetables in Kenya (Imathiu, 2021). To bridge the gap, the use of sustainable vegetable production technologies should focus more on diversified production to accommodate both the challenges of production and nutrition security and low level of technology acceptance.

To overcome these challenges, training youths on diversified vegetable production can enhance the sustainability of these technologies thus offering the resultant benefits over a longer period (Resnick, 2022). However, there are few instances where such an approach to training has been used among youths for agricultural development, especially secondary school students in Kenya (Ng'atigwa et al., 2020). There is a missing link between extension service delivery, school-going youths and ultimately, the smallholder farmers who are primary targets of EAS. In East Africa, countries like Tanzania have tried to enhance agricultural extension through schools and connect it to smallholder farmers. However, the findings on how to enhance agricultural extension through schools showed that youth engagement required further investigation on how it can be implemented to seamlessly fit into the school schedule (Ng'atigwa et al., 2020).

Moreover, the approach used in agricultural extensions, such as the top-down approach and participatory approaches, are mainly targeting the old smallholder farmers. In Kenya, there is limited evidence showing how and which approach agricultural extension can involve the youths to disseminate agricultural information to smallholder farmers. Nevertheless, there are different initiatives that the government used to engage the youths in agricultural activities in schools such as the 4K and Young Farmers Clubs-Kenya {YFCK} (Gikonyo et al., 2022). The clubs mainly focused on improving students' psychomotor skills, but they lacked a link between students in schools and smallholder farmers. Based on such evidence, there is a need for a workable and accommodative approach to an agricultural extension that can engage the youths in schools as a resource for agricultural development in Kenya (Gikonyo et al., 2022).

The use of these approaches among the youths in secondary schools has a higher probability of enhancing the technology uptake and increasing the impact of agricultural extension among smallholder farmers (Ramalingam et al., 2019). Besides, the 4K and YFCK are in line with the general objective of agriculture in primary and secondary schools (Adam et al., 2017). Therefore, introducing vertical gardening technologies to students in secondary schools

can offer an opportunity for the students to not only learn more approaches to vegetable production but also be a link between agricultural extension and smallholder farmers for learning. Introducing the students to vertical vegetable gardening can also largely boost curriculum implementation and, ultimately, agricultural development. There is, therefore, a gap between extension service delivery, secondary school youth engagement and the farmers for agricultural development.

This is also an opportunity that can be used by agricultural extension to reduce the human resource challenges facing the sector. While there is some overlap between agricultural education and agricultural extension, the two fields have distinct roles and objectives. Agricultural education focuses on formal education and training for students, while agricultural extension provides practical training and support to farmers and other stakeholders in the agricultural sector. The study aimed at merging the two in secondary school setup to devise an approach that would link secondary school students, extension and farmers. Thus, improving vegetable production as well as achieving additional benefits associated with Diversified Vertical Vegetable Gardening (DVVGS) in Teso South Sub County, Busia County, Kenya.

The study was part of EaTSANE which applies an integrated approach to innovation and capacity-strengthening to facilitate systemic change in the food system. It aims to implement sustainable diversified vegetable farming practices and improved diets of households in Kenya and Uganda, using a participatory action learning approach to enhance the technology level of acceptance. Also, according to the County Intergraded Development Plan (CIDP) 2018-2022, the preview of the CIDP 2013-2017 showed that there was low adoption of technologies (Republic of Kenya, 2018). Therefore, the study sought to bridge the gap of relevant information and access to the required technologies on DVVGs among households through the youth in secondary schools in Teso South Sub County, Busia County, Kenya.

1.2. Statement of the Problem

Diversified vertical vegetable gardening, as an enhancement of the kitchen garden. It promises environmental benefits, adequate and nutritious vegetables with improved use of resources (moisture, manure and space) that are less available through traditional weather-dependent vegetable gardening technologies. It is also an attractive opportunity for the youth as it can enhance income and livelihoods, food security, and good health and wellness. Agricultural extension in Busia County is gradually changing to improve its impact on food security and rural

development, however, the level of technology acceptance of vegetable production technologies is still low. It is also devoid of its adequate youth engagement mechanism, which further affects the sustainable level of acceptance of technologies and youth engagement in agriculture. There are limited efforts done by public extension in promoting diversified vertical vegetable gardening among the youth in terms of transfer and exchange of practical information to them, especially for youths in secondary schools. This limits the opportunity for the introduction and promotion of vertical garden technologies and hence also benefits households in Teso South. Hence it is crucial to fill the gap of limited youth participation in vegetable production and establish their extent of participation and production of vegetables as a way of improving vegetable production and livelihoods in Teso South Sub County, Busia County, Kenya.

1.3. Purpose of the Study

The purpose of the study was to assess how secondary school youth in Teso South Sub-County, Kenya could learn about diversified vertical vegetable gardens and upscale the same to the community.

1.4. Objectives of the Study

The following objectives guided the study:

i. To document the status and use of the vertical garden in secondary schools in promoting DVVGs among smallholder farmers in Teso South Sub-County, Busia County, Kenya.
ii. To assess the readiness of agricultural extension and secondary schools in promoting DVVGs among smallholder farmers in Teso South Sub County, Kenya.
iii. To assess the extent to which a secondary school-based training approach to agricultural extension can be used in promoting DVVG technology among smallholder farmers in Teso South Sub County, Busia County, Kenya.

1.5. Research Questions

The following research questions were used to answer the research objectives:

i. What were the current status and use of vertical gardens in promoting DVVGs in Teso South Sub County, Busia County Kenya?
ii. What was the extent of readiness of the agricultural extension service and secondary schools to work together to promote DVVGs in Teso South Sub County, Busia County?

iii. How could the secondary school-based training approach to agricultural extension be deployed to promote DVVGs among smallholder farmers in Teso South Sub County, Busia County, Kenya?

1.6. Scope of the Study

The study was limited to Teso South Sub County, Busia County Kenya, targeting day secondary schools' agriculture students, school administrators, smallholder farmers and extension officers. The study covered three technologies in vertical vegetable gardening. They included: the mound bed, primary tower, and second wall. The vegetable crops that were promoted through the vertical gardens were: spinach/Swiss chard, carrots, black nightshade, capsicum and kale. The study focused on increasing their production to foster nutrition-sensitive diets for households. The agricultural extension aspect of the study measured several aspects of training and skill acquisition on DVVGs technologies, the extent of awareness and replicability of the technologies among farmers and a suitable link of research, extension, students and farmers on DVVGs technologies, vegetable diversity, uptake of the practices involved in DVVGs, and the number of households practicing the three technologies.

1.7. Significance of the Study

The findings of the study provided insights into how the production of vegetables could be improved in the area using vertical vegetable gardening that requires limited space. The use of participatory learning in the study increased skills, knowledge, and interest among the youths in secondary schools thus increasing vegetable production. The use of secondary schools was a suitable opportunity to enhance agricultural extension service delivery on vegetable production and consumption among youths at the same time improve the uptake and adoption of the technologies thus boosting vegetable production. This was a suitable alternative for public agricultural extension. The study has also provided information to extension officers and field officers on the importance of participatory learning in the adoption of vertical vegetable production among youths in secondary schools. Through youth engagement, the study aimed at creating awareness of sustainable economic opportunities in vegetable production. Youth engagement is enhanced by increasing the sustainability of the technologies and improving the production of diversified vegetables.

1.8. Limitations of the Study

The following were the limitations of the study:

i. The study was limited to Teso South Sub County, Busia County Kenya, therefore there was a need to be cautious in the generalization of the findings of the work.

1.9. Assumption of the Study

The study was based on the following assumptions:

i. Both the school management and parents were to be receptive to the idea of DVVGs and apportioning part of their land to the students to practice the technology.

ii. The agricultural extension officers in the area were to be receptive to the idea and be ready to offer the required assistance during and after the study.

1.10. Definition of Terms

Agricultural development – It implies, the increase in production and productivity of various crops which can to a great extent offer employment opportunities for improved living standards of the smallholder farmers (Chaudhuri et al., 2021). According to the study agricultural development meant increased production of diversified vegetables using sustainable agricultural practices that provided both vegetables for households in and out of season and additional income.

Diversified Vertical Vegetable Gardening (DVVGs) - Diversified gardening is having a variety of vegetables in both traditional and nontraditional growing spaces (Tamiru et al., 2016). In the study, DVVGs were the growth of more than one vegetable in a single vertical garden for two benefits; for plants' mutual benefit (biological pest control) and easy availability and accessibility of a variety of vegetables for consumption among households using different vertical vegetable gardening technologies while using limited space.

Farmer – A farmer is a person engaged in agriculture as a landowner or a manager on leased land (Radić et al., 2021). In the study, a farmer was a person who owns and manages a farm, or the small spaces surrounding their homes or commercial residence and was a parent/guardian to a student in the selected schools.

Extension approach- is an approach for extension service delivery having a body of new knowledge, farming communities, extension agency to link, set of education methods and infrastructure, and support services. The approach used in extension is evolving as a result of new emerging realities and emerging opportunities (Chand & Kumar, 2019). The agricultural extension approach in the study was the method/strategy used to deliver agricultural extension services through secondary schools where students could work and acquire skills on emerging vertical gardening technologies and agricultural realities, and disseminate the information to farmers.

The participatory approach to extension service- Participatory approach in extension is a learning approach aimed at strengthening the capacities of individuals more so in rural communities to enable them to improve their livelihoods. It allows them to cope with development aspects independently (Magut et al., 2014). In the study, the participatory extension approach was a process that enhanced the self-organization of the students, to enable them to

identify the need to learn vertical vegetable gardening, learn by doing and find a solution to the problems that surround them.

Promoting – these are activities that support or encourage a cause venture or aim (oxford dictionary). According to the study, promotion involved activities that would empower through knowledge and skills acquisition, economic and environmental viability of DVVGs among the youth and the community around the schools. It also looked at how the farmers would either fully accept the approaches or partly adapt the approaches based on their current situation.

Smallholder farmers – these are farmers engaged in farming using very little pieces of land, less than 10 acres and are using less expensive technologies (Savari & Zhoolideh, 2021). According to the study, smallholder farmers were groups of farmers farming on less than 10 acres of land, were using less expensive resources and also were parents/guardians of students in the selected schools.

Sustainability- these are activities that aim to identify ways of protecting the natural environment, and human and ecological health while developing and implementing innovations without compromising our way of life (De Olde et al., 2017). In the study, sustainability were activities that aimed at enhancing the continuous production of vegetable varieties in and off seasons and were economically viable. The off-season vegetable production in the study referred to the cultivation of vegetables during a period outside the normal growing season. Which was achieved through the use of DVVGs.

Vegetables: These are crops grown for their edible leaves, roots, stems, bulbs and fruits (English dictionary). According to the study, vegetables were crops grown for their edible leaves and roots that could be grown for a minimum of three months and were suitable for vertical gardens.

Vegetable production diversity – the practice of cultivating a variety of vegetables in an area, not just one. In case a household can incur a loss of a crop in a year, the household can comfortably survive (Sibhatu et al., 2015). In the study, diversification meant growing vegetable varieties in vertical gardens. The vegetable varieties are intended to help meet the nutrition demands of households. The vegetables were spinach/ Swiss chard, carrots, black nightshade, capsicum, and kale. The other aspect of diversifying in the study was also the process that utilized less land and provided additional benefits to the smallholder farmers such as income, other than traditional farming.

Vertical vegetable gardening- Vertical vegetable gardening is an easy way of growing more vegetables on support, which is pest and disease-free on a small piece of land. Vertical gardening technologies are mainly used for horticultural crops for families (Kleszcz et al., 2020). In the study, vertical vegetable gardening was the growth of more vegetables on support using second wall, mound bed, and planting tower for diversified vegetable production.

Youth – According to the United Nations, youth is a person of age between 15 and 24 years, while according to the Kenyan constitution, youth is a person of age 18 and 35 years (Djurfeldt et al., 2019). In the study, youth were people of age between 12 and 22 years who were not landowners and could not lease out land for farming. They were persons with a 100% level of dependency, that is, they were persons who fully relied on their respective families for both emotional and economic support.

CHAPTER TWO
LITERATURE REVIEW

2.1. Introduction

The chapter provided an overview and critique of previous scholarly research on the topic of knowledge sharing. The section also presented the theoretical and conceptual framework.

2.2. Vertical Vegetable Gardening

With the rapid population growth and limited resources in both rural and urban areas, alternative options are being sought to increase food availability, especially for vegetables. Vegetable production has been largely appreciated by the majority of the people living in many urban areas. Almost 50% of people in the world are residents of urban areas (Egidi et al., 2020). The urbanization trend is expected to increase even more in the coming years, especially in Africa and many parts of Asia. The trend has seen the demand for fresh vegetable increase by more than half. Research by Seferidi et al. (2022) showed that the uncontrolled growth of cities in many regions of the world will lead to poverty and malnutrition incidences for many people, approximately more than 600 million people by 2025 if basic foods like vegetables are not adequately produced. To increase production, there is a need to adopt high-yielding technologies such as peri-urban systems.

Vertical vegetable gardening as a peri-urban system can assist in boosting the production of vegetables in the world. The approach has some benefits such as; it requires less water by up to 70% and also saving considerable space and soil. Being a less weather-dependent technology, vertical vegetable gardening can be a great percentage reduce the amount of farmland thus saving the limited natural resources, such as water, food and energy. The innovative aspect of this technology is its ability to produce more heads of vegetables, sustainably, and they are eco-friendly (Pribadi & Pauleit, 2015; Zhang, 2016).

Globally, several countries have used vertical gardens to help meet vegetable demands in their regions. Based on the available resources, different countries have sustainably used simple structures to grow vegetables. In Indonesia, the benefits of the banana plant don't just stop at the fruit (Luther et al., 2018). After production, the banana trucks are used as planters for growing the short-root plants. This helps the country to reduce banana plant wastage. Indonesians have utilized the advantages of banana stems/trunks. The stems/trunks have good water retention

abilities therefore one may not be required to water the plants manually. Two, weed infestation is unlikely. Three, plants draw their nutrients from the soil filled in the pits. The use of banana trunks can be suitable in areas with acute water shortages (Kelley & Prabowo, 2019). Apart from saving on water usage, it has numerous benefits such as reducing the amount of money spent on installing irrigation systems (Rozaki, 2020). The stems do last for a longer period and when they decompose, they add a lot of manure back to the soil (Mao et al., 2020; Odum & Akinsola, 2021). A success story of vertical gardening.

In Africa, the African Association for Vertical Farming (AAVF) has a mandate of driving innovations in the African urban agriculture sector among smallholder farmers. AAVF is a nonprofit organization that was founded in 2010. The organization is giving the smallholder farmers knowledge to leap into the industrial revolution and have access to technology so that they can solve food insecurity issues in the communities (Petrovics & Giezen, 2022). The organization has trained smallholder farmers in South Africa, Morocco and Egypt where they have recorded positive progress.

In Rwanda due to land scarcity and the rapid population, the use of vertical vegetable gardening has been embraced by both urban and rural dwellers (Al-Kodmany, 2018). In Kampala Uganda, the majority of the residents have shifted from normal vertical gardening to rooftop gardens to reduce the effects of rapid urbanization and food insecurity coupled with the effects of COVID-19. Scaling-up local vegetable production has now become an important activity to increase resilience on food availability/demand among households. Urbanization in Indonesia, the USA and other cities in the world calls for comprehensive solutions such as vertical gardening and green roofs to meet the ever-growing vegetable foods demand (Al-Kodmany, 2018). To improve the use of vertical gardens in urban areas, there is a need for city dwellers to embrace more sustainable approaches to urban gardening (Petrovics & Giezen, 2022)

Therefore, sustainable production of vegetables that involves the use of vertical vegetable gardens presents numerous opportunities in addressing global growing concerns in the 21st century, such as poverty, hunger, health issues and alarming youth unemployment, besides, humans are becoming urban dwellers (Kalantari et al., 2018). The approach can as well offer the opportunity for households to access vegetables outside the normal season, as it is both economical and environmentally sustainable. It can also boost the work done by Kenya agriculture livestock and research organization (KALRO), the Consultative Group on

International Agriculture Research (CGIAR) in urban and peri-urban gardening thus addressing the challenges and maximizing the opportunities (Chihambakwe et al., 2018).

It's in this regard necessary to develop different approaches to agricultural extension that would sustainably boost vegetable production through vertical gardening technologies. The key target to the success of such approaches should mainly be the youth. However, from varied approaches used in agricultural extension, approaches that maximally engage the youths are minimal and there are very few studies carried out on how the youths can be engaged in agricultural production.

2.3. Evolution and Readiness of Extension Advisory Approaches

Evidence in many countries shows that agricultural extension is a useful resource for agricultural development (Buehren et al., 2019). There are different approaches used by different countries for agricultural extension. Most countries in the world follow a combination of approaches (Berhanu & Poulton, 2014). A basic approach to agricultural extension has five components; a body of new knowledge, people who need the knowledge, extension agency, extension methods and infrastructure (Chand & Kumar, 2019). Each approach is evolving in response to new realities and other emerging opportunities. So far, there is no one-size-fits-all approach (Berhanu & Poulton, 2014). Overall, agricultural extension services play a critical role in supporting sustainable agriculture and rural development. By providing farmers with the knowledge and resources they need to improve their productivity and profitability, agricultural extension services can help to promote food security, reduce poverty, and support rural economies (Berhanu & Poulton, 2014).

Agricultural extension has evolved from top-down services to the use of information and communication technology carried out by both the public and private sectors. Currently, most of the services offered are demand-driven and target-specific but not universal (Mwololo et al., 2019). To improve food and nutrition security, the government of Kenya has been involved in delivering extension services through several initiatives, such as National Agricultural Livestock Extension Programme (NALEP), Training and Visits (T&V), Participatory Rural Appraisal (PRA), Rapid Results Initiative (RRI), Farmer Field Schools (FFS) and Agriculture Sector Development Support Programme (ASDSP), among others (Mwololo et al., 2019).

These programmes were mandated to promote issues in the third green revolution such as the use of high-yielding varieties and technologies, the use of inorganic fertilizers and pesticides,

irrigation and mechanization (Akuja & Kandagor, 2019). However, structural adjustments in the late 1980s saw the inception of the privatization of some agricultural plans such as artificial insemination services (Hlatshwayo & Worth, 2019). This led to a decreased number of extension workers in Kenya. The shift prompted a need to include other players in agricultural extension service delivery. In 2012, the National Agriculture Sector Extension Policy (NASEP) established a committee to harmonize the activities of various players. NASEP is a review of NAEP that was implemented to introduce other players in the provision of agricultural extension services after the structural adjustments (Ong'ayo et al., 2016). But there was no operationalization of the policy's implementation framework.

The lack of a suitable implementation framework led to new negative trends in agricultural extension service delivery. That included increased competition, making agricultural extension seen as a marketing strategy with less impact, especially among smallholder farmers (Buehren et al., 2019). According to the study carried out by Tegemeo Institute of Egerton University, one private company was spending about KSh 5m annually on extension services that include promotions, free trial samples, advertisements, meetings and conferences with insignificant impact. Currently, one can get extension services from the public sector (national and county governments, Parastatals, and agricultural research and training institutions), from the private sector and from civil society sector operators (companies, NGOs, faith-based organizations, cooperatives and community-based organizations). Other areas where the services are sought include agricultural shows/trade fairs, websites, posters and brochures, field visits/demonstrations and exchange tours (Waswa, 2018). However, there is still a lot to be done, to improve agricultural service delivery for smallholder farmers to meet its core objective.

To make the agricultural extension services effective and responsive in Kenya, there is a need to borrow the agricultural extension approaches used in India. The use of ICT and Public-Private Partnership (PPP) has seen the success of agricultural extension service delivery in India and Sub-Saharan Africa (Olayemi et al., 2021). The use of ICT in India has been through National eGovernance Project (NeGP). The NeGP platform ensures that all government services are accessible to smallholder farmers at a central point in their localities (Chachra et al., 2020). The country offers common service centers, broadband connectivity and a one-stop destination for all citizen services such as Kisan Call Centre (KCC) (Chachra et al., 2020). On the other hand, PPPs for agricultural extension development were initiated with the government's aim of

capital mobilization and efficiency improvement while the private sector hoped to maximize profits (Olayemi et al., 2021).

Nakuru County in Kenya, is the first county in Kenya, to use call centers for public agricultural extension. Nakuru call center has assisted many smallholder farmers with real-time information. This has boosted agricultural production in the county, as smallholder farmers have the opportunity to services delivered based on their demands in real-time (Kaur & Singh, 2019). With the current technology and information era, the use of ICT is the way to go. However, the use of ICT requires several electronic equipment and resources (Verkaart et al., 2018). Poverty levels and illiteracy can hinder the effectiveness of ICT as a mode of agricultural extension delivery in Kenya (Hlatshwayo & Worth, 2019). To boost the use of ICT, there is a need to devise an approach that is ICT-independent and can deliver real-time agricultural extension services to a larger community within a short period (Tata & McNamara, 2018). Having an approach that can engage the youth in secondary schools in agricultural extension can help the agricultural information reach the targeted audience within a short period. The approach can have multiple beneficiaries as schools are public institutions.

Therefore, the challenges that prompt a need to change the agricultural extension are derived from, on one hand, the challenges smallholder farmers face in the production of sufficient food and on the other hand, the changes that emerge from extension organization (Steinke et al., 2021). These changes range from the type of funding to the emergence of e-extension and the development of extension theories. During the green revolution era, food security through agricultural intensification was deemed ill-suited in social and environmental terms. The lessons picked from the failure of the green revolution indicated that agricultural development devices new routes to agricultural intensification other than the use of external inputs. Based on such evidence, there is a clear need to devise agricultural extension to meet the ever-demanding challenges in the food and nutrition security sector, including social and environmental aspects (Baloch & Thapa, 2019; Raidimi & Kabiti, 2017).

Moving forward the readiness of agricultural extension institutions would demand the need to embrace collective issues as innovations in present-day agriculture require collective dimensions. These innovations need also to be re-designed to shape and enhance the facilitation of the innovation process. The innovation process further calls for matching the technical and social aspects of the innovation being promoted (Senyolo et al., 2018). To enhance this,

agricultural extension providers need to be brokers, that is, they are required to meet the goals of the agricultural extension funding agencies and at the same time maintain credibility with the smallholder farmers who have different priorities from the funding agencies (Llewellyn & Brown, 2020). However, the ever-declining resources hinder the effective implementation of the new agricultural extension approaches leading to several new approaches.

As a result, the pluralism and participation of the private sector have increased. The concentration of these new players in extension has primarily commercialized the agricultural sector (Dhehibi, 2018). Yet only a few smallholder farmers can access and pay for major extension services (Aydogdu, 2018). This has disadvantaged the smallholder farmers and other marginalized farming communities who, in most cases focus on small-scale agriculture suitable for crops such as vegetables. Therefore, with limited resources, there is a need to develop new agricultural extension strategies that would enable smallholder farmers and youths to access agricultural extension information, especially for vegetable crops that can be produced and consumed by individual households while the surplus is sold to earn little income. This will assist in solving both current and future food production challenges.

2.4. Youths in Agriculture Extension Advisory Systems

Young people account for a larger percentage of the world's population. They can play a crucial role in agricultural development. According to the study carried out by Developing Local Extension Capacity (DLEC) in Rwanda youths in extension are both providers and also the recipient of agricultural extension (Babu et al., 2021). According to DLEC supporting and strengthening the inclusion in agricultural extension will improve their economic opportunities and livelihoods and increase the effectiveness of extension and advisory service systems. However, the approach to engaging the youths in extension in Kenya is still low (Njeru, 2017). This prompts a need for agricultural programme developers, extension agents and policymakers to consider the role of the youth in agricultural development (McCune et al., 2017). Equally important, is a need that exists for all stakeholders in the agricultural sector to identify the benefits as well as the opportunities that can be made available through adequate youth involvement in agricultural development activities.

Such agricultural development activities through agricultural extension can play a crucial role in engaging youth through interactions with the local community. 4-H, tomato and corn clubs in the USA, for example, adequately engaged the youths in agricultural extension,

particularly in the implementation of the programs. The clubs offered numerous extension opportunities and activities that enhanced rural life through youths. According to McCune et al. (2017), the youths can be long-life participants in development efforts only if they can be included in the programmes that are aimed at empowering the community.

Youths can play a key role in community development. However, for them to function as responsible members of society, engaging them in change efforts at the community level is the key (McCune et al., 2017). Community building through youths should emphasize enhancing capacity and empowerment. This will identify opportunities that can be changed within or outside of the community. For agricultural extension and other development professionals to maximize youths as a resource, there is a need to understand youth's motivation and efficacy (Bednaříková et al., 2016). Discussions on the sustainability of agriculture activities show that engaging the youths is the way to go, however, options for engaging the youths are minimal in agricultural extension. Devising ways to adequately engage the youths is key.

2.5. Secondary School-Based Agricultural Extension Approach

As mentioned earlier in this section, the commercialization of agricultural extension has majorly benefited large-scale farmers, at the expense of smallholder farmers. As a result, various and distinct approaches have been explored. The government of Kenya through NASEP has employed various strategies such as devolution, partial privatization of agricultural extension and other cost-recovery measures for agricultural development (Boulanger et al., 2018). However, due to several dynamics that affect the agricultural sector, (climate change and diminishing resources) the various strategies used to promote agricultural extension for agricultural development, to a larger extent, do not adequately assist the smallholder farmers.

According to NASEP, devolution of the agricultural sector under the Department of agricultural extension aimed at enhancing agriculture service delivery and promoting self-governance at the county level trickling down to individual smallholder farmers. Devolving the sector came with several opportunities as well as challenges in equal measure. Agricultural activities such as extension services were expected to be provided by county governments (Muhumed & Minja, 2019). The aim was/is to increase food production which should translate to food security and enhance income generation. According to Muatha et al. (2017), the success of

agricultural extension at the county level would require maximum utilization of the bottom-up strategy in making a critical decision about agricultural development.

The critical decisions were to touch on key components of extension, from personnel to the approaches to use and resources required. The aim was to aid in increasing access to obtaining raw and unbiased information for action. Though 90% of these staff are based at the county headquarters, with very few staff at the ward level, thus minimizing farmer–extension interaction. The presence and routine visits of experts at village levels or in individual farms can to a great extent enhance food security in individual households (Muatha et al., 2017). However, due to limited resources, there is still a problem of understaffing, which translates to inadequate extension service delivery to smallholder farmers.

This calls for the use of new and improved strategies by extension in its service delivery. There are several approaches used by agricultural extension in disseminating the information. Such as field days, exhibitions, agricultural shows e-extension and farm visits (Tata & McNamara, 2018). Access to infrastructure and other limited resources has led to most of these forms of service delivery being done for a short period. This reduces the uptake and sustainability of the learned technologies. Introducing new approaches that would at least reach out to smallholder farmers weekly would have greater chances of improving the level of technology acceptance (Ogutu et al., 2020). Continuous acquisition and practice of new knowledge have a higher probability of enhancing the sustainability of new technologies. The use of secondary and primary school students can be one of the suitable approaches for regular and timely agricultural extension information transfer.

However, the use of secondary school-based approach to agricultural extension has not been tried in Kenya (Gichamba et al., 2017). The ex-curriculum agricultural activities done in 4K clubs and YFCK can help boost the agricultural extension. Since its inception, the 4K Clubs engaged pupils in primary schools in sustainable agricultural practices through outdoor hands-on activities in school farm demonstration plots. As a result, the 4K club members transferred the learned technologies to the farming communities. Such an approach is a perfect foundation for agricultural extension to enhance their activities among smallholder farmers, as they are the main drivers of the country's economy. However, the 4K and YFCK in primary and secondary schools are slowly becoming inactive and a mechanism to connect the students and the farming community is missing.

Reintroducing the clubs in schools would to a large extent increase knowledge acquisition among youths as they can retain knowledge and skills learned in their childhood, and be able to apply them later to offer solutions to their existing challenges (Gichamba et al., 2017). Besides, to mitigate the challenges of climate change, food and nutrition insecurity and diminishing natural resources in the entire continent, children must be introduced to adaptation practices at a young age. Therefore, there is a need for agricultural extension to seize the opportunity and work with the youths in schools.

There is evidence that approaches almost similar to YFCK and 4K clubs for agricultural development have been used in Kenya. According to the Agricultural Education and Training (AET) improving agricultural development across Africa require a strong link between link AET and formal education (Gill et al., 2016). However, since their recommendations, linking pre-service and in-service AET to the school systems is an area that has been less explored. Communication between secondary school agricultural teachers and extension officers can provide a base for the exchange of ideas and should be encouraged. This would go a long way in enhancing the link between schools and local/farming communities (Reinhardt, 2018). The approach was attempted quite widely in the 1970s and 1980s with limited success. With the current situation, reviving such an approach is the way to go. Outreach programmes between formal agriculture training institutions and informal agriculture training would greatly assist in improving the situation. The programmes can be strengthened by the creation of networks where schools, NGOs, private institutions and community-based organizations are involved as intermediaries. This would enable the wide dissemination of innovations.

A good example of such an approach is the Rural Outreach Programme (ROP) Africa. The organization aims at working with students in secondary and primary schools in carrying out agricultural activities (Karanu & Oniang'o, 2017). Since its inception in Kakamega, the students have not only supplemented food to the school feeding programmes, but are also provided an additional source of income and nutrition to the school (Karanu & Oniang'o, 2017). This approach has seen a positive increase in food production among households in Kakamega County, Kenya as students can replicate the learned ideas at home.

2.6. Theoretical Framework

Several theories can explain the central role that experience (learning by doing) plays in the learning process, such as experiential learning theory (ELT), positive youth development

theory, and community youth development theory. The study was guided by the positive youth development theory, as it does not only focus on improving an individual but using the same individual as a positive change agent in their environment. The theory looks at the capabilities, development potentials and increasing thriving behaviors of the youth rather than their deficiencies (Benson et al., 2007). According to the positive youth development theory, to achieve a healthy, productive and engaged youth, good programmes, practices and policies must work with the youth to improve their; i) Assets – at their age, youths have varied capabilities, skills and necessary resources to help achieve desired outcomes, ii) Agency- moved with their aspirations, youths can employ their assets to make decisions about their lives and set their life goals with clear projected outcomes, iii) Contribution- Youth are an essential source of change for themselves and their communities. And iv) Enabling environment- the enabling environment develops and supports youth's assets, agency and opportunities, and enhances their ability to identify and avoid risks, stay safe, and secure, and be protected while promoting their social and emotional competence to thrive.

In the context of this study, positive youth development was crucial for agricultural extension and generally rural development and it formed the basis for the study. The schools provide a suitable niche for agricultural extension. Therefore, the theory was suitable for the study as it guided the right procedure of involving the youth to have a positive impact on communities. The procedures enabled the development of their capacities and meaningful contributions to the community. Therefore, the theory informed on the need for training, the suitable approach to training and how the approach could enhance the sustainability of the learned concepts from generation to generation for agricultural development.

2.7. Conceptual Framework

While relating to the theoretical framework, availing necessary resources for DVVG learning among students had a higher probability of increasing diversified vegetable production and sustainability of the technologies among the smallholder farmers. The conceptual framework of the study was grouped into three variables dependent, independent, and intervening variables. Therefore, these factors were thought to influence vegetable production as shown in Figure 1.

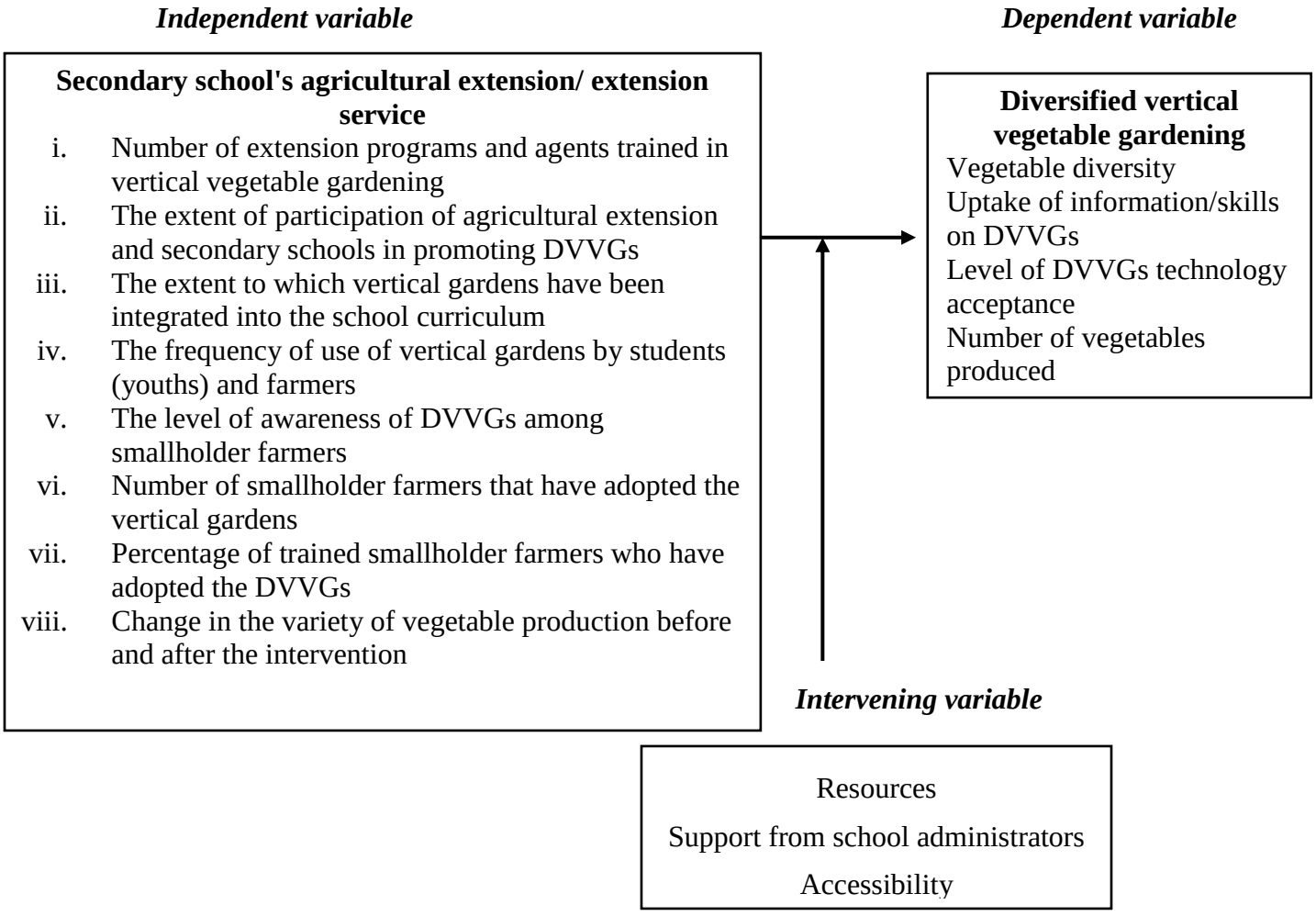

Figure 1

Conceptual Framework Showing the Interaction between Variables

The intervening variables for the study were controlled. Resources used in the study were provided by the researcher. Permission to access school for learning was sought before the study hence the demos were accessible to the target audience using the locally available resources alongside the ones that were provided by the researcher. The study also hypothesized that the use of locally available resources can enhance creativity among students and improvise any available resource in their environment established by the gardens in their homes. Training materials and training content were availed to students. Brochures were given to students as a take-home message for reference. The researcher packaged the information hence there was no need of engaging extension officers during the training.

CHAPTER THREE
RESEARCH METHODOLOGY

3.1. Introduction

This chapter describes the overall approach that was taken to conduct the study including research design, study location and participants, data collection and analysis and ethical considerations.

3.2. Research Design

The study adopted a mixed research design using qualitative and quantitative methods. The qualitative approach comprised action research, observation, Focus Group Discussion (FGD) and semi-structured interviews. Action research as a qualitative approach was used to introduce the intervention after the baseline survey. The baseline survey was conducted to understand the training needs and suitable interventions. The interventions were carried out to create awareness about three vertical vegetable gardening techniques using a training manual developed following the baseline survey. The endline survey assessed the change caused by the intervention and the feasibility of agricultural extension through schools while comparing it to an ideal or tested agricultural extension approach.

A survey was undertaken to understand the overall situation of vertical vegetable gardening and access to agricultural extension information by smallholder farmers from schools and public extension at the baseline and endline surveys. The survey drew responses from smallholder farmers and youths in secondary schools. The qualitative approach involved the use of action research, FGD, and observation. Action research was used to introduce the interventions after the baseline survey. Observation guides were used to assess the utilization of available spaces for farming activities within the school compound at the baseline survey, the performance of each technology and opportunities for multiple information delivery channels at the intervention stage and to find out how much of what had been learned was applied at the endline survey. FGD was used for training needs assessment at the baseline survey.

3.3. Study Location

The study was conducted in Teso South Sub County, Busia County. Busia County is located in the western region of Kenya. It is made up of seven sub-counties; Funyula, Teso North, Teso South, Budalangi, Matayos, Nambale, and Butula. The county has a total population

of 886,856 (Kenya National Bureau of Statistics, 2019) with about 31% malnourished and under 5 years of children and 26.5% stunted (Republic of Kenya 2018). Agriculture is the major economic activity in the County; however, food insecurity status stands at 88.7% compared to 76% in the pre-COVID times. In the year 2021, 88.7% of the households did not have enough food or could not eat preferred food varieties or sufficient amounts due to a lack of resources. With all the challenges of food and nutrition insecurity and poverty in the area, the need for improved agriculture productivity was evident (Republic of Kenya, 2018). According to the county integrated development plan 2018-2022, the preview of the CIDP 2013-2017 showed that there was low adoption of technologies (Republic of Kenya, 2018). This suggested a need to implement new agricultural extension strategies that would improve the technology level of acceptance. Apart from the highlighted concerns, climate change, population increase, and urbanization are realities that are here to stay.

3.4. Population of the Study

The study targeted day secondary school students, smallholder farmers, school administrators and field extension officers in Teso South Sub County, Busia County. Since the study aimed at assessing the extent to which the students can be used in the dissemination of information on DVVGs among smallholder farmers, the target population of smallholder farmers was derived from the target population of agriculture students. That is one student that was selected for the study automatically selected the smallholder farmer for the study. Therefore, the target population of smallholder farmers was the same as the target population of the students. The schools had a total population of 530 students; the accessible population was 196 students in forms 1, 2 and 3, smallholder farmers, four school administrators and five field extension officers. A sample of 131 students and 131 smallholder farmers, four school administrators, and five field extension officers at the sub-county level were selected.

3.5. Sampling Procedure and Sample Size

The study used purposive sampling to select four-day secondary schools within Teso South Sub County. Purposive sampling was suitable for the study due to the proximity to an already established three-stata forage cropping system demonstration plots near the schools. The three-strata forage cropping system is a conservation agriculture practice that integrates forages for animal feeds with food crops as a strategy for enhancing food and feed availability The

schools were therefore selected in areas where there were three-tier stata demonstration plots. Both the community and the students got a chance to learn from the demonstration plots in the community and the schools. The study purposively selected day secondary schools since the students in day schools were able to translate and practice the learned skills on vertical gardening at home within a short period. A complete list of registered students in the day secondary schools was obtained from Teso South, Sub County Ministry of Education. Systematic random sampling was used to select 131 respondents from forms one, two, and three in the four schools. A total of 33 students per school were selected to participate in the study. The equal proportions were reached by taking the average of 131 students by four schools. From the list of students in each school, the names on the list were reorganized to remove biases. A skip factor was established for each school, depending on the accessible population size in the four schools to determine the sample size. The starting point was determined randomly. The sample size of farmers was purposively selected from the accessible population of the students. Five field extension officers in the sub-county and four school administrators were purposively selected to participate in the study. From the sample size of farmers, 12 farmers were randomly selected for FGD. Therefore, the FGD sample was embedded in the 131 smallholder farmers that were initially selected. The agriculture teachers were also purposively selected and engaged in the study to enhance the sustainability and the continuity of the project in the long run. Using Yamane's formula, the sample size of the students was calculated (Israel, 2013). Therefore, the total sample size for the study was 271 respondents, as summarized in Table 1.

$$n = \frac{N}{\left(1 + \ (Ne^2)\right)}$$

Where n= Sample size, N = Population size, e = the error at 5%

$$\frac{196}{\left(1 + 196(0.05^2)\right)}$$

= 131 students

Table 1

Sample Size Summary

Subject category	Accessible population	Actual Sample
Agriculture Students	196	131
Smallholder farmers	196	131
School administrators	4	4
Field extension officer	5	5
Total		**271**

3.6. Instrumentation

Both qualitative and quantitative data were collected using questionnaires, observation guides, FGD guides and semi-structured interview guides. The data collection process was in three phases; the first phase collected data for the baseline survey, the second phase collected data during the intervention and the third phase collected data from the change that was caused by the intervention. Data collected at the baseline survey were used in the analysis of the baseline survey that informed the training manual and suitable intervention. The intervention was rolled out after the analysis of data from the baseline survey. Both qualitative and quantitative data had equal dominance and were collected concurrently at each phase. The study was conducted on a single group using the same set of data collection tools at different periods.

Questionnaires, semi-structured interview guides, and observation guides provided qualitative data. The questionnaires were self-administered. However, guidance was given to respondents who had challenges in reading and writing. The observation guide was used to assess, the utilization of empty spaces in schools, the level of technology acceptance and to find out how much of what had been learned was applied. The semi-structured interviews were researcher administered, the interviewees were allowed to express their views, in ways they understand, thus providing consistent and comparable qualitative data. FGD was conducted to understand the social issues of vegetable production and consumption.

The respondents, namely the smallholder farmers and agriculture students, completed the same surveys at the baseline and immediate endline surveys. The semi-structured interviews for field extension officers and FGD for smallholder farmers were only done at the baseline survey.

An observation guide was used for baseline survey, during the intervention and at the endline survey.

Multiple data collection tools were used in the study to help ensure that the data that was collected was comprehensive, valid and reliable, enabling the researcher to draw meaningful conclusions and make an informed decision based on the study findings.

3.6.2 Validity of Data Collection Instruments

The validity of the research tools was measured by having a consultation with the supervisors and was appraised by the experts at Egerton University from the Faculty of Education and Community Studies. Individual questions were analyzed critically to make the questions effective for data collection and ensure they were authentic. The validity involved construct, face, and content validity. The data that was obtained from pre-testing the questionnaires were analyzed, and the results obtained provided a basis for further modification to improve the validity.

3.6.3 Reliability of Data Collection Instruments

To determine the reliability of the research tools, the researcher carried out a pilot study of the research instrument on 30 respondents in SA Kolanya Boys High School in Teso North Sub County. The school was at the far end of Teso North Sub County hence minimizing interaction with the study area. A reliability coefficient of 0.885 was obtained. Since that was above the 0.7 reliability threshold for accepting the instruments, the instrument was used to collect data.

The pilot area had similar demographics and geographical characteristics to the target area and, therefore, was suitable for testing the reliability of the instruments. According to Johanson and Brooks (2010), a pilot study sample should be at least 10% of the sample project for the larger parent study. Therefore, the pilot sample size was 30 respondents (students) who were randomly selected. All items in the questionnaire with the rating scale were coded and Cronbach Alpha reliability was determined using SPSS software (SPSS Inc V 22, 2013). Cronbach Alpha was the suitable tool to test the reliability as the data collection instruments had homogeneity of items measuring only one construct using sufficient sample size. The results

from the pilot study were discussed together with the supervisors and the tool was amended where necessary. The reliability test was done on students' questionnaires only.

3.7. Data Collection Procedure

An introductory letter was sought from the Graduate School, Egerton University to enable the researcher to get a permit from National Commission for Science Technology and Innovation (NACOSTI) before proceeding to the field for the actual data collection. The researcher carried out a pre-visit to the area and sought permission from Busia County, Teso South Sub-County education directors and school administration from each respective school. The researcher also sought permission from sub-county extension officers to interview and involve them in the study. The sub-county extension officers were involved in the establishment of the vertical garden in each school. The arrangements to involve them in the study were made before ensuring their availability.

The researcher took the following steps in administering research instruments; the questionnaires were distributed after the respondents were made aware of the purpose and intention of the study and their free will to participate, Personal semi-structured interviews were carried out based on the availability and convenience of the respondents. FGD among smallholder farmers was carried out after the smallholder farmers had completed responding to the baseline survey questionnaires. The responses were collected from various individuals within the shortest time possible to reduce misinformation from non-targeted individuals and only those respondents who completed the full questionnaire were included in the analyses.

3.8. Data Analysis

The study employed a statistical package for social science (SPSS Inc V 22, 2013) to analyze the data that were collected. The questionnaires were cross-checked to ensure that all the questions were answered well. The data analysis was only done after a minimum of 85% of the questionnaires were returned (Richards & Hemphill, 2018). Wilcoxon sign-rank test for comparison of baseline and endline survey means frequencies and corresponding percentages and tables were used in data analysis and presentation. Wilcoxon sign-rank test was suitable as the samples were related but did not meet the assumptions of the parametric test. The qualitative data was also analyzed using thematic analysis. Each research question was analyzed separately, and the general conclusion was made after each research question was analyzed. The data that

were analyzed were used to make interpretations and conclusions on each of the research questions in the study. Preliminary analyses were conducted to determine the suitable intervention that would help bridge the gap between limited vegetable production, consumption and the challenges facing agricultural extension. Thereafter, the intervention was rolled out. The outcome of the intervention was analyzed using an observation guide from farm visits among the sampled population. Table 2 is a summary of the statistical tests that were used.

Table 2

Summary of the Data Analysis

Research questions	**Independent variable**	**Dependent variable**	**Statistical tool**
What are the current status and use of vertical gardens in promoting DVVGs in Teso South Sub County, Busia County Kenya?	Status and use of vertical garden	Promoting DVVGs	Descriptive, Wilcoxon sign-rank test Thematic analysis
What is the extent of readiness of the agricultural extension service and secondary schools to work together to promote DVVGs in Teso South Sub County, Busia County?	Readiness of the agricultural extension service and secondary schools	Promote DVVGs	Descriptive and Thematic Analysis
How could the secondary school-based training approach to agricultural extension be deployed to promote DVVGs among smallholder farmers in Teso South Sub County, Busia County, Kenya?	Secondary school-based training	Promote DVVGs	Descriptive and Thematic Analysis

3.9. Ethical Considerations

Information from the respondents was treated as confidential, and the data given were used in a format in which the individual respondents were not identifiable. The respondents were made aware of their guaranteed confidentiality. Their consent was obtained before the study commenced. The researcher's behavior was very responsible and respectful of the respondents, and the responses from respondents were received with a lot of respect and clarifications sort with immersed humility. Each questionnaire was labeled by the use of numeric numbers to protect the identity. Where photographs were taken, their subsequent use was done after seeking permission from the respondents.

CHAPTER FOUR
RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter describes the response rate, results and discussion based on the three objectives used in the study. It includes the various stages that were used in the study, from the baseline survey, intervention and the endline survey.

4.2. Response Rate

For questionnaires as research instruments, the study targeted a sample of 131 agriculture students, 131 smallholder farmers and 4 school administrators. For a complete analysis, data from baseline and endline surveys for individual respondents were to be in pairs for them to be analyzed. From the students and parents' questionnaire, 125 questionnaires were tallied for both baseline and endline surveys. This accounted for 95.4% of the total questionnaires given to the respondents. Six questionnaires were not returned in pairs and they were discarded during analysis. Four questionnaires that were given to school administrators were properly filled and returned. A return rate of above 50% and above was satisfactory for data analysis.

4.3. Baseline Survey

The baseline survey included two main activities; assessment of the training needs and identification of suitable interventions. The study began with the sensitization of targeted respondents in the study. They included smallholder farmers and schools because the study targeted youths in secondary schools. The sensitization meeting between the researcher and targeted respondents was aimed at introducing the new project, explaining the upcoming activities, and clarifying any questions asked by the respondents.

For training needs assessment, two sets of FGD were conducted among smallholder farmers using semi-structured discussion guidelines. The average FGD included six participants, and the FGD was conducted on an average session of two hours. The discussion focused on vegetable production and consumption and access to vegetable production information. A survey was also completed by smallholder farmers, school administrators and youths in secondary schools. The survey was conducted to understand the status of vegetable production, the concept of vertical vegetable gardening and the status of agricultural extension through schools and public extension.

At the baseline survey, the observation guide was used to assess the utilization of empty spaces for agricultural farming within the school compound. Semi-structured interviews were also done among agricultural extension officers to understand the role of extension in vegetable production, level of vegetable production, extension services on vertical vegetable gardening technologies and their views on agricultural extension through schools. The baseline survey was conducted by the researcher during the first month of the project.

4.4. Findings from Baseline Survey on Training Needs

The baseline survey findings showed that; (i) the concept of vertical gardening as a vegetable production technology was new to the respondents, as 1% of the respondents were aware of vertical vegetable gardening, (ii) agricultural extension and its role in food and nutrition security were new to 83% of the youths in schools (iii) the schools had agriculture schools' farms, but the farms were only available for practice and learning for students in their fourth year of study, (iv) outdoor hands-on agricultural learning activities and efficient use of empty spaces within the school compound for agricultural activities were also lacking, (v) there was no active YFCK in the four sampled schools to provide an avenue for outdoor agricultural learning. On agricultural extension through schools; (vi) there was no evidence on how the schools allowed smallholder farmers to access agricultural information from school farms, (vii) assessment of awareness of learning opportunities in school farms showed that 95% of the smallholder farmers were not aware of the learning opportunities that existed in school farms, hence 90% of the smallholder farmers rarely visited the schools.

4.5. Intervention

The study interventions included the formation of YFCK as there were no active clubs in the four sampled schools and participatory training on three vertical gardening technologies; mound bed, primary tower, and second wall.

4.5.1 Formation of Young Farmers' Club

The YFCK in each school was formed by all youths who showed interest in vertical vegetable gardening. Group dynamics in the formation of YFCK, such as gender, level of learning agriculture in school, and selection of agriculture as a subject of interest in school were considered insignificant in influencing learning and skills acquisition in vertical vegetable gardening and, therefore, all the youths who showed interest were allowed to participate in

vertical vegetable gardening activities in each school. The agriculture subject teachers in the respective schools coordinated the activities of the clubs. The active participation of agriculture subject teachers was key to the sustainability of YFCK and its activities. The YFCK was used as an entry point for agriculture extension and an avenue for group learning among youths in the three classes in secondary schools that were sampled in the study.

4.5.2. Participatory Vertical Vegetable Gardening Training

The participatory training focused on three vertical vegetable gardening technologies; primary tower, second wall, and mound bed. The training was conducted in two phases. The first phase involved theoretical learning that highlighted key areas of vertical vegetable gardening concepts, the benefits of vertical gardening and the steps involved in establishing each technology. The details of the theoretical training are attached in the appendix as a brochure. A printed copy of the brochure was also given to each student for reference as they try the technologies at home and also to share with smallholder farmers or guardians. After theoretical learning, participatory training was then conducted during the establishment, planting, management, and harvesting of produce within the life of the project as seen in Figure 1. The activities that were conducted during participatory learning were conducted between the second and the fourth month of the project. Youths in the YFCK were directly involved in all the activities during this stage. During this stage youths in YFCK established a kale production sustainability scheme that involved the use of a thousand-headed kale variety. The suckers that were produced were later used in growing second season of vegetables in the gunny bags, while excess suckers were shared among the youths, to use them for home trials as they establish their vertical vegetable gardens.

Figure 2

Students Participating in Establishing Vertical Gardens in School

The study used locally available, sustainable resources during the interventions in schools to encourage improvisation in vertical vegetable gardening at homes. These resources included construction and planting materials that were used in the vertical vegetable gardens. However, labour as a resource was largely provided by the youths as part of their skills acquisition and learning process as seen in Figure 2.

In each school, five vertical gardens were established. For gunny bag technology (second wall and primary tower) four structures were established. For mound bed one structure was established in each school. The study adopted the east-west sun rays' direction while establishing the four gunny bags vegetable gardening structures. The aim was to assess the performance of each gunny bag technology depending on the direction they were facing. This was to guide the students to identify a good site for establishing vertical gardens at home. The gunny bags were separated using a wall made of timber offcuts. There were two structures (second wall and primary tower) on each side of the timber off-cut wall which gave each structure an equal advantage of harnessing either morning or afternoon sun rays for maximum production as seen in Figure 1.

To reduce the cost of production, onions, coriander, and marigold were used as biological pest control plants. Carrots and black nightshade were grown on the mound bed, while kales, swiss chard, coriander, onions, capsicum, and marigold were grown on the second wall and primary tower vertical gardens. The observation guide was the data collection tool that was used at this stage.

4.6. Endline survey

The endline survey was conducted to assess the change caused by the interventions. The change was to inform on the practicality of the approach while comparing it to an ideal/tested agricultural extension approach. The following key indicators were used to assess the feasibility of agricultural extension through schools: the ability to allow for multiple delivery channels (this indicator was also assessed during the interventions); the change in the level of technology acceptance; the replicability of each vertical gardening technology at home; and the scope of learning for agricultural extension activity in secondary school that would recommend the approach suitable for a guiding policy for implementation

Questionnaires and observation guides that were used at the baseline survey were also used at the endline survey to assess the change. Observation guides were used to assess the level of skills acquisition and use for each technology that was used in the study; individual technology acceptance and overall level of vertical gardening technology acceptance; and the number of vegetables grown in vertical vegetable gardens at home. The vegetables that were used in the study were the reference points during data collection at this stage. Questionnaires at the endline survey focused on changes that were caused by the interventions based on the findings of the baseline survey. The endline survey was conducted during the fifth month of the project.

Objective one: To document the status and use of the vertical garden in secondary schools in promoting DVVGs among smallholder farmers in Teso South Sub-County, Busia County, Kenya

4.7. Baseline and Endline Survey Status of Vegetable Production and Consumption

Using questionnaires, the baseline survey results showed that 77.6% of the respondents depended on farming as the main source of income, and 86% used the open field method in growing vegetables Table 3. The method was weather dependent, therefore there was a

likelihood of seasonal vegetable production. The use of fewer weather dependents methods, for example, greenhouses and vertical gardening, in vegetable production were less appreciated by the respondents at 0% and 1% respectively at the baseline survey. Moreover, the majority of the respondents also got the vegetables consumed at home from their farms. This accounted for 77.6 % of the total respondent's Table 3.

Table 3

Baseline Characteristics of Smallholder Farmers on Vegetable Production and Consumption

Characteristics	**n (%)**
The main source of income	
Farming	97 (77.6)
Business	20 (16)
Employment	8 (6.4)
Method of vegetable production	
Use of Open field method	108 (86)
Kitchen gardening	66 (53)
Vertical vegetable gardening	1 (1)
Use of greenhouses	0 (0)
Sources of vegetables consumed at home	
From the farm	97 (77.6)
Bought	16 (12.8)
Supplied in kind	12 (9.6)

From the major findings, at the baseline survey, smallholder farmers relied on weather-dependent vegetable production technologies. Hence there was the seasonality of vegetable production on the supply side. This probably affected the consumption rates. The findings conformed to research done by Dong et al. (2020), that the over-reliance on weather-dependent production technologies increases the uncertainties of vegetable production and their availability during the dry season, negatively affecting the consumption of vegetables.

Other than drought, the study found that there are minimal agricultural extension services/activities on vegetable production and consumption, significantly reducing the availability of information on sustainable vegetable production technologies among smallholder

farmers (Table 4). The focus of public agricultural extension in the study area was inclined toward present county government pilot projects. This significantly impacted the availability and consumption of vegetables, as there is a positive correlation between increased extension-farmer contact and farm productivity at the household level (Paltasingh & Goyari, 2018). It further explained the strong influence of politics/current government on agriculture development through agricultural extension (Taylor & Bhasme, 2018). And this could be one reason why the majority of the respondents consumed readily available vegetables as seen in Table 4.

Table 4

Comparison of Baseline and Endline Survey on Commonly Consumed Vegetables

Vegetable Name	**Vegetable Consumption**		
	Baseline survey	**Endline survey**	***P***
	n (%)	**n (%)**	
Exotic			
Swiss chard (*Beta vulgaris)*[a]	8(6)	14(11)	.014
Capsicum (Capsicum annuum)[a]	2 (1.6)	10(8)	.005
Carrot (*Daucus sativus*)[a]	3 (2.4)	7(5.6)	.157
Tomatoes (*Solinum lycopersicum*)	43 (34)	24(19)	.000
Indigenous			
Pumpkin (*Cucurbita pepo*)	58 (46)	10(8)	.000
Spider plant (*Cleome gynandra*)	73 (58)	13(10)	.000
Sunn hemp (*Crotalaria juncea*)	81 (64)	55(44)	.000
Kales *(Brassica oleracea*)[a]	63 (50)	85(68)	.003
Cow peas (*Vigna unguiculata*)	107 (85.8)	79(63)	.000
Pumpkin leaves (*Cucurbita moschata*)	68 (54)	53(42)	.071
Jute mallow (*Corchorus olitorius*)	60 (47)	42(34)	.009
Pig weed (*Amaranthus retroflexus*)	99 (78)	94(75)	.059
Amaranth (*Amaranthus cruentus*)	70 (55)	59(47)	.001
Black Nightshade (*Solanum americanum*)[a]	104(83)	112(89)	.000

[a]Vegetables that were promoted by the study

However, after the intervention, the endline survey findings showed that the overall own farm sources of vegetables and frequency of vegetable variety consumption (among the vegetables that were being promoted) significantly changed from the baseline and endline survey, Table 4. Among the vegetables that were used for learning, kale (*Brassica oleracea*) from 50% to 68% and black nightshade (*Solanum americanum*) from 83% to 89% were the only vegetables that respondents tried growing using vertical vegetable gardening technology at home after the intervention. The vegetables were indigenous vegetables and native to the study area.

This significantly increased their availability and consumption among the five vegetables that were being promoted in the study, Table 4. According to Kansanga et al. (2021), the use of scaling up a participatory approach in vegetable production has the potential of increasing the level of acceptance hence strengthening extension service delivery and probably the availability of what was promoted. However, the increase in consumption of carrots was not significant at the endline survey. Consumption of exotic vegetables, herbs and spices was generally low, Table 4. From the FGD, the majority of the respondents, due to lack of information, preferred indigenous vegetables over exotic vegetables. According to the literature, a lack of awareness of the cultivation, production, and utilization of exotic vegetables can limit consumption preferences among individuals (Amfo & Baba Ali, 2021).

4.8. Baseline and Endline Survey Status of Diversified Vertical Vegetable Gardening

The concept of DVVGs was new to agriculture students and smallholder farmers at the baseline survey. In schools, strict adherence to the agriculture curriculum delivery guidelines and lack of information on DVVGs affected the use of DVVGs in promoting vegetable production and consumption. Besides, the four sampled schools had no practical agriculture learning sessions for agriculture students in forms 1, 2 and 3. Using the observation guide, the assessment of awareness of the practical benefits of DVVGs of maximizing the output while using limited resources was also missing. Moreover, the use of DVVGs demonstration plots in enhancing hands-on educational opportunities was not clear in all four sampled schools. This agrees with the findings of Gikonyo et al. (2022), which showed that the institutional framework and secondary schools learning curriculum guidelines limit students from enhancing environmental literacy.

During the intervention and at the endline survey, the demonstration and participatory approach to DVVGs among secondary school agriculture students increased exposure to vegetable production technologies. Which likely led to familiarity, knowledge and skills and ultimately confidence. Through the YFCK, the approach allowed for hands-on practice by both smallholder farmers and agriculture students, which increased their understanding and confidence in the technology Table 5. This boosted the home availability of vegetable varieties that could not have otherwise been available during the dry season. At the endline survey, using the observation guide to assess the extent of what was learned was applied, among the vegetables being promoted, kales (*Brassica oleracea*) and black nightshade (*Solanum americanum*) were the only vegetables that respondents tried growing using DVVGs at home after the intervention. The findings were promising since several previous research showed an increase in varieties of vegetables and their home availability positively increased vegetable consumption (Parizel et al., 2017).

While comparing the level of technology acceptance at the baseline and endline survey, there was a significant difference from 1% to 22% at *P=.000* of smallholder farmers who appreciated the use of DVVGs at the baseline and endline survey. The majority of the respondents (90%) appreciated vertical gardening using the second wall technology, 10% using primary tower and 0% using mound bed.

The participatory training on vertical vegetable gardening intervention enabled the participants to evaluate the difference between the three technologies based on their performance and characteristics. The results showed that among the three technologies that were used in the demo plots, the second wall technology was the most appreciated (90%) by smallholder farmers. Its simplicity and good performance during the five months, make it easier for the youths in schools to repackage the information and disseminate it to smallholder farmers. At 10%, the primary tower was adapted as a vertical vegetable gardening technology. The smallholder farmers used a column of ballast at the center of the gunny bag instead of using a PVC pipe. This significantly reduced the cost of establishing the gunny bags. Thus, explaining the importance of participatory learning and technological simplicity, as they allow for improvisation (Lindblom et al., 2017)

However, none of the respondents who participated in the study appreciated the use of mound bed as a vertical vegetable gardening technology. Despite its simplicity in construction, it

still did not attract farmer interest because of its lower performance compared to the other two technologies. The low performance in school demonstrations probably led to the low dissemination of mound bed information by youths to smallholder farmers. The overall results showed that the technologies were replicable and the targeted respondents could modify the technologies to fit their situation. Klerkx et al. (2017), explained the benefits of participatory approaches when translated to institutional conditions at different levels as they would likely enhance technology uptake.

4.9. Perception of the Respondents on Diversified Vertical Vegetable Gardening

The perception of smallholder farmers and students on DVVGs significantly changed after the intervention as measured by the endline survey. There was no significant difference in the student's need to learn more about vertical gardening and the cost of establishing the vertical vegetable gardens at the endline survey as seen in Table 5.

While examining the views of the agriculture students on sustainable diversified vegetable production through the stages of the DVVGs project, the participatory learning gave a stimulus of their role in vegetable production. This was illustrated by how the agriculture students cared for the gardens in schools and their creativity while establishing their vertical gardens in homes Table 5. This view illustrated the youth's centric thinking which contributed to a sense of empowerment. The project offered insights between learning and youth empowerment in rural communities for community development (Huriya, 2021). Besides, the findings of the DVVGs project in schools showed that shared a mutual relationship that provided an opportunity to further support agriculture development in the area. The findings showed that this was a perfect opportunity for agricultural extension to device into new strategies to improve vegetable production as seen in Table 5.

Table 5

Baseline and Endline Survey Perception Scaled Measure for Farmers and Students

Item	Respondents' Perception Score		
	Baseline Survey	Endline Survey	
	Mean (SD)	Mean (SD)	*P*
Students			
It is a good concept and I like it	3.30 (1.085)	4.43(.776)	.000
Require a lot of skills	3.41(1.232)	2.97 (1.397)	.009
It's expensive	3.12 (1.261)	2.31 (1.247)	.000
It is time-consuming	3.14 (1.322)	2.60 (3.791)	.000
Should be done by girls/women	2.48 (1.511)	2.02 (1.379)	.015
Ugly and dirty work	2.26 (1.284)	1.65 (1.057)	.000
Require a huge space	2.80 (1.356)	1.96 (1.240)	.000
Would like to learn more about them	4.32 (1.005)	4.18 (1.132)	.383
Has taught me more about environmental education	3.81 (1.262)	4.31 (1.003)	.001
Smallholder farmers			
It's not allowed where I live	1.84 (1.139)	1.59 (.872)	.000
Everything seems to die	2.28 (1.261)	2.11 (.944)	.000
Time-consuming	2.87 (1.651)	2.50 (1.216)	.046
Lack of resources	3.02 (1.519)	3.80 (1.040)	.000
Expensive	3.12 (1.548)	2.44 (1.285)	.620
'Require a lot of skills	3.14 (1.472)	2.44 (1.103)	.000

SD = Standard Deviation, Perception score range 1=strongly disagree to 5 strongly agree, *P-value* calculated using Wilcoxon sign-rank test

Objective 2: To assess the readiness of agricultural extension and secondary schools in promoting DVVGs among smallholder farmers in Teso South Sub County, Kenya.

4.10. Readiness of Relevant Institutions to Embrace Secondary School-based Approach

The concept of agricultural extension and its role in food and nutrition security was new in all four sampled schools. Analysis of the survey on awareness of agricultural extension

showed that 83% of the student respondents were not aware of agricultural extension. The findings of the observation guide showed that the schools had agriculture farms, but the farms were less available for use by form 1, 2 and 3 students. Outdoor hands-on agricultural learning activities and efficient utilization of empty spaces within the school compound were also minimal. There was no evidence of how the schools allowed smallholder farmers to access agricultural information from school farms. Moreover, the survey on the awareness of learning opportunities in school farms showed that 95% of the smallholder farmers were not aware of the learning opportunities that existed in school farms, as 0% of the respondents got agricultural extension referrals to school farms for learning. At the endline survey, there was a significant difference in school visits by smallholder farmers and increased agricultural extension referrals for agriculture learning. In this case, the agricultural extension referrals are done by students.

On the other hand, results of the thematic analysis of semi-structured key interviews with agricultural extension providers showed, that public agricultural extension and schools operated as independent institutions. There was minimal information on agricultural extension activities through schools. However, there were scenarios where agricultural information was informally disseminated through schools in Teso South. In 2012, students played a key role in disseminating information on maize necrosis during the maize necrosis outbreak. The dissemination was done through brochures. Nutrition mainstreaming had also been promoted through schools by agricultural extension. Between 2013 and 2015 as a way of promoting consumption, adoption and market of new finger millet varieties developed by International Crop Research for Semi-Arid Tropics (ICRISAT) and Kenya Agriculture Livestock and Research Organization (KALRO), agricultural extension on finger millet was done through schools. The finger millet porridge program was implemented in schools to promote the consumption of nutrient-dense porridge among students. All the above-mentioned extension approaches in schools were a result of County pilot programmes. The lack of a suitable guiding policy on secondary school-based agricultural extension approaches contributed to this. According to Chelule et al. (2022), improving agricultural extension policies after devolution can help improve service deliveries while exploring existing opportunities to enhance agricultural extension. However, the analysis of the survey on the relationship the schools had with the community and agricultural extension showed that the three shared a mutual relationship which provided an opportunity to support the approach through schools.

4.11. Access to Agricultural Extension on Vegetable Production and Consumption

There was minimal public agricultural extension on vegetable production and consumption in Teso South Sub County. Smallholder farmers physically interacted with field extension officers (61%), however, the ease of accessing agricultural extension on vegetable production was somehow difficult (42%) and hence smallholder farmers rarely (48%) got to interact with field extension officers Table 6. The result was conforming to the research done in Caribbean, on farmers' satisfaction with extension services in the organization of Eastern Caribbean States. The result showed that farmers preferred physical contact with extension agents and that face-to-face interaction had a significant effect on farmers' satisfaction with extension services provided.

Table 6

Access to Agricultural Extension on Vegetables Production and Consumption

Item	Response	n (%)
Interaction with field extension officers	Physically	76 (61)
	Through phone call	11 (9)
	Through SMS	3(2.4)
	Facebook	35 (28)
Ease of accessing agricultural extension services	Very difficult	34 (27)
	Difficult	31 (25)
	Somehow difficult	52 (42)
	Not difficult at all	8 (6)
Frequency of interaction with agricultural extension officers	Always	7 (6)
	Sometimes	35 (28)
	Rarely	60 (48)
	Never	23 (18)

Thematic analysis of semi-structured interviews showed that public agricultural extension focused on present county government pilot projects. Forums such as Agricultural Training Centre (ATC), extension farm visits and field days also had their focus on pilot crops being promoted by the present county government. On the other hand, the findings of agricultural

extension on DVVGs showed that there was no instance where DVVGs had been used to promote vegetable production and consumption by agricultural extension in the study area. There were also no records of using other extension approaches to promote vegetables among smallholder farmers. Smallholder farmers obtained information on vegetable farming from fellow farmers, through farmer-to-farmer extension. These findings shows the importance of how farmer-to-farmer agricultural extension in knowing which traits are of priority in variety selection in rice production.

Since the study aimed at engaging the students to offer extension services, the endline survey on transfer/dissemination of information on DVVGs from school's demonstration plots to smallholder farmers changed from mean = 2.81, (SD=1.183) at the baseline survey and mean = 2.24, (SD=1.011) at endline survey Table 7. The significant change could be attributed to the participatory approach which has a higher probability of triggering students' interest in learning and practicing new concepts. This agrees with the study done by Mugambi et al. (2022), that there is a relationship between students participating in YFCK activities and the establishment of the learned projects at home.

Table 7

Baseline and Endline Survey Transfer of Agricultural Information by Agriculture Students

	Change of Frequency of Transfer of Information					
	Baseline Survey			**Endline Survey**		
Item	**Mean**	**SD**	**Mode**	**Mean**	**SD**	**Mode**
Transfer of DVVGs	2.81	1.183	4	2.24	1.011	2
Any agricultural information given in school	2.39	1.244	1	2.03	1.157	1
Field days	3.22	1.084	4	3.29	1.007	4
Agricultural workshop	3.84	0.429	4	3.86	0.396	4
Agricultural shows	3.48	0.921	4	3.48	0.921	4
Agricultural exhibitions	3.75	0.631	4	3.75	0.631	4

SD= Standard Deviation, Scale measure for mode, 1=often, 2=sometimes, 3=rarely and 4=never, *(1) Often means at least once a week; (2) Sometimes means at least twice or more in a month; (3) rarely means once in a term (4) have never.*

Objective 3: To assess the extent to which a secondary school-based training approach to agricultural extension can be used in promoting DVVGs technology among smallholder farmers in Teso South Sub County, Busia County, Kenya.

4.12. The Practicality of the Secondary School-based Agricultural Extension Approach

This study focused on identifying alternative approaches that can be used by agricultural extension to improve access and use of agricultural information by smallholder farmers. The findings of objectives one and two were used to discuss objective three of the study. Some of the challenges that affected vegetable production through access to vegetable production information identified at the baseline survey showed a need to diversify into other applicable strategies and approaches as seen in Table 2. While the role of youths in agricultural extension has been investigated before, the study compared the role of youths in secondary schools in agricultural extension on vertical gardening to an ideal agricultural extension approach that has been tried.

The change in the level of technology acceptance was attributable to the *multiple delivery channels that were made available through the intervention and the approach used in the study. From* the findings, channels of communication were *(*i), youths in schools directly disseminated the information to smallholder farmers as they tried the technologies at home; (ii) through their YFCK, youths in schools utilized forums such as school annual general meetings, field days, and agricultural shows to share their work with the public; (iii) the schools being communal institutions, the demo plots in schools became learning opportunity for anybody who happened to visit the school, which offered a wider geographical location through the expected interactions between the youths and their immediate community.

From the findings, the approach proved to offer a cost-effective way to reach a wide range of smallholder farmers to promote vegetable production and offer additional benefits. This agrees with the findings of the study that was carried out in Siaya County, Kenya which showed that student's participation in environmental clubs offered benefits beyond environmental education (Okumu, 2020). At the closure survey, there was a significant change in the overall level of vertical vegetable gardening technology acceptance, at $P = 0.000$ from 1% to 22% of smallholders at the baseline and closure surveys. There could be more beneficiaries that got vertical gardening information from the schools other than the targeted population since the schools are communal institutions.

On the replicability and performance of individual vertical gardening technologies that were promoted in the study, second wall and primary tower performed well, while mound bed had low technology result demonstration. The gunny bags (second wall and primary tower) that were facing the east direction thus receiving morning sun rays and shade in the afternoon performed better than the structures that were receiving sun rays in the afternoon because they were facing the west direction as seen in Figure 2.

Figure 3

Vertical Vegetable Gardens after Establishment

Therefore, the findings on assessing the extent of information dissemination on individual technology acceptance using the observation guide, the majority of the respondents (90%) preferred vertical gardening using the second wall technology, with 10% using the primary tower and 0% using the mound bed. 10% of smallholder farmers who appreciated the use of the primary tower adapted the technology.

The participatory approach to training on three vertical vegetable gardening technologies interventions that were used in the study showed a significant increase in access to information on vegetable production at the closure survey. At the baseline survey, 1% of the respondents were aware of vertical vegetable gardening as a vegetable production technology and its role in improving vegetable production. However, by taking part in establishing, field management, and harvesting the produce in the vertical vegetable garden demo plots in schools, the students

acquired skills and were able to translate the same at home as seen in Table 3 on the change of agricultural information transfer.

Based on resource availability at home, the hands-on approach triggered their creativity and gave both the students and smallholder farmers a chance to observe, reflect, and learn, and they were able to tell the difference between the recommended new practice and the traditional practice. According to the study done by Kansanga et al. (2021), farmer-to-farmer participatory training on soil and land management (SLM) improved access to knowledge on SLM which significantly bridged the gap in low agricultural extension in Malawi. The ultimate result of the participatory approach to vertical vegetable gardening was a change in the level of technology acceptance by smallholder farmers from 1% to 22% at the baseline and closure surveys. These findings agree with the study done by Bourne et al. (2021), which showed that a participatory approach to agricultural extension enhances the adoption of technologies compared to other traditional approaches.

Another aspect that was used to assess the practicality of the approach was the *scope of learning of agricultural extension activity. From* the study, the baseline survey, participatory vertical vegetable gardening training, and closure survey were all done within five months, which was within the secondary school learning calendar. Vegetable production is within the scope of secondary school learning. The study adopted the participatory learning model, which enhances the use and application of knowledge as knowledge brokerage to a scope recommended for the secondary school education level. The interactions of youths in schools and the farming community offered a wide geographical area for an extension activity. Schools are communal and strategic; hence they offer a learning opportunity to many people.

The clear identification of the training need and scope probably increased the proper targeting of information which in return enhanced its diffusion. This also made the approach timely and it easily fitted into the tight school schedule, increasing acceptability by the school administration and the students, as well as ease of accessing information by both youths and smallholder farmers. As a result, there was increased use and application of the knowledge gained from the demo plots offering an immediate impact on the farming community. Previous studies have shown that proper identification of the scope of agricultural extension activities enhances access to information and other developmental opportunities; allows for the use or

application of the information, and offers an almost immediate impact on the targeted beneficiaries (Norton & Alwang, 2020).

Lastly, in the secondary school-based approach to agricultural extension, a time frame is key. It was necessary to assess the time frame of agricultural extension through schools since the approach targeted youths in schools where learning activities follow specified guidelines and time frames. In the study, planning and preparatory activities, implementation, management, and harvesting of the produce by the youths, were completed within a short period. This made it easier to work with the youths, allowing them to try the technology at home and assess the outcome. It also allowed smallholder farmers access to other essential information on vertical gardening, such as reliable sources of improved agro-gunny bags and vertical garden management information within the life of the project. While "rethinking technological change on smallholder farmers" Glover et al. (2019) explained the importance of framing agricultural extension activities from conceptual to technological change evaluation as they play a key role in enhancing impact on the farming community.

CHAPTER FIVE
SUMMARY, CONCLUSIONS AND RECOMMENDATION

6.1 Introduction

This chapter describes the summary of the findings, conclusion and recommendation based on each objective/research question. It has also provided suggestions for further studies that can be done to improve the secondary school-based agricultural extension.

6.2 Summary of the Findings

The study was carried out along three objectives, that is to document the status and use of the vertical garden in secondary schools in promoting DVVGs among farmers, to assess the readiness of agricultural extension and secondary schools in promoting DVVGs among farmers and to assess the extent to which a secondary school-based training approach to agricultural extension can be used in promoting DVVGs technology among farmers in Teso South Sub County, Busia County, Kenya.

Major findings on the status of vegetable production and consumption showed that smallholder farmers relied on weather-dependent vegetable production technologies. This resulted in seasonal vegetable production that greatly affected the intake of vegetables at the household level. After the intervention, there was a significant change in the type of technologies used in the production of vegetables. There was a significant change perception of respondents on DVVGs. The intervention increased the ease of accessing information on DVVGs, which boosted the confidence of smallholder farmers. As a result, there was an increased level of technology acceptance (1% - 22%) at $P=.000$ at the endline survey. This significantly increased household availability of kale and black nightshade at 50 to 68% and 83 to 89% respectively.

On assessing the readiness of various institutions to embrace the secondary school base approach to agricultural extension, the findings showed the viability of the approach as an alternative agricultural extension approach. The schools, public agricultural extension and the farming community shared a mutual relationship that provided an opportunity that would support the implementation of the secondary school-based agricultural extension approach. This was a good opportunity to be explored agricultural extension as there was no public agricultural extension on vegetable production and consumption.

Therefore, while assessing how the approach could be deployed, the findings showed that the secondary school-based approach to agricultural extension was viable. A good niche was through the YFCK. However, it required a guiding policy, to provide guidelines on how entry and extent of involvement by agricultural extension and other relevant organizations.

6.3 Conclusions

The following were the general conclusions of the study;

i. The findings of objective one showed that the use DVVGs in vegetable production was the less practiced technology among farmers, schools and agricultural extension in Teso South Sub County, Busia County. This had led to low access and consumption off-season of vegetables among households, especially exotic vegetables. The use of intervention through school demonstration proved to be a suitable approach to creating awareness of DVVGs through a secondary school-based approach to agricultural extension. As a result, there was an increased level of technology acceptance at the endline survey. This shows that the youth extension approach was a suitable alternative to creating awareness for agriculture development.

ii. The findings of objective two showed that major components of the secondary school-based approach to agricultural extension shared a mutual relationship. The harmony provided an opportunity for agriculture extension to promote vegetables for sustainable vegetable production and consumption and offer other agricultural extension activities for agriculture development. Therefore, with a guiding policy, a secondary school-based approach to agricultural extension is an effective alternative agricultural extension approach

iii. The findings of objective three established that active YFCK was a suitable entry point for agricultural extension service providers and also an avenue for farmers to get to learn from the students. The findings on the approach's practicality, the approach meets the requirement of agricultural extension activities.

6.4.Recommendations

i. The use of DVVGs proved to be effective in increasing the production and availability of vegetables, off-season however, there were limited extension services on DVVGs, and therefore, this study recommends that public agricultural extension always incorporate agricultural extension on vegetable peri-urban systems in annual agricultural extension

activities. This will assist smallholder farmers boost production and bridge the gap of the limited supply of fresh vegetables.

ii. The use of youths in school in promoting DVVGs proved to be an effective alternative agricultural extension approach, however, it didn't have a guiding policy, and therefore, this study also recommends the development of a suitable policy that would guide the entry and extent of involvement of agricultural extension through secondary school and an alternative approach to agricultural extension. This should be mainstreamed in NASEP and other extension service delivery implementation strategies.

iii. The use of 4K clubs and YFCK proved to be a good entry point for an agricultural extension and also a good opportunity that could be utilized to enhance agricultural development among smallholder farmers through the young generation, however, the mode of operation of these clubs in schools could not accommodate the agricultural extension. On the sustainability of agricultural extension through schools, the study recommends restructuring essential societies such as YFCK and 4K clubs to accommodate other key stakeholders in the agriculture and advisory sector. This will assist in developing cost-effective agriculture extension approaches that would increase the level of technology acceptance among smallholder farmers and the youth, thus increasing youth engagement in agriculture.

6.5 Suggestions for further research

The study recommends the need for similar future research on suitable policy guidelines for secondary school-based approaches to agricultural extension through YFCK and 4K clubs.

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APPENDICES

Appendix A: Survey

Students Questionnaire

My Name is **Avoga Tabitha**. I am a student taking MSC agricultural extension from **Egerton University**. I am carrying out a study on **'assessing the use of secondary schools in agricultural extension in promoting DVVGs among farmers in Busia County, Kenya'**. I would like to request your time to provide me with the following information. The questions will take approximately 15 minutes of your time; your response to them will help in evaluating the topic of study.

You are instructed to answer questions concerning vegetable production, vertical vegetable gardening and agricultural extension. Your input will assist in addressing the issues that are affecting the diversified vegetable production in Teso south. Confidentiality is guaranteed, and no penalty for both participating and not participating.

Name of the school ……

QN NO.

General information

Age (in years): ……

Gender: Male (……) Female (……)

Which form are you: One (……) Two (……) Three (……)

Vegetable production

1. Do you have the following vegetables at home or in school? You can tick more than one vegetable if you grow more than one at home or in school

Sukuma wiki (……) Spinach (……) Capsicum (……) Carrot (……) Pumpkin (……) Spider plant (……) sunnhemp- *miro,* (……) cowpeas (……), pumpkin leaves (……) jute plant-*murere* (……) pig weed (……) amaranth (……) tomatoes (……) black night shade (……)

2. At home, do you grow the above-named vegetables thought the year Yes (……) No (……)

   If no why?

   ……

   ……..

3. Which method do you use to grow vegetables at home? (Tick where appropriate)

Vertical gardening (……) Kitchen gardening (……) Greenhouses (……). Planting in the open field (……)

Vertical gardening technologies

1. Have you ever heard of the term vertical vegetable gardening? Yes (……) No (……)
2. If yes,

   Where: In school (……). At home (……) At an agricultural show (……)
3. Do your school have/use vertical gardens in growing vegetables? Yes (…) No (…)
4. If given a chance, what do you expect to learn from vertical vegetable gardening?

How to grow vegetables using the technology (……) How the technology works (……) How to construct the structures (……) I don't know, I just want to learn (……)

5. Have you ever heard of the following technologies in vertical gardening that are used in growing vegetables?

   The second wall Yes (……) No (……)

   Planting tower Yes (……) No (……)

   Mound bed Yes (……) No (……)
6. Please complete the survey honestly. The purpose of this survey is to gather your opinions regarding your work on vertical gardening. Please use the following scale: 1 (strongly disagree), 2 (disagree), 3 (indifferent), 4 (agree), and 5 (strongly agree)

Item	**1**	**2**	**3**	**4**	**5**
Vertical gardening is a good concept and I like it					
Vertical gardening requires a lot of skills					
Constructing vertical gardening is very expensive					
It is time consuming to Establish and manage a vertical garden					
I would like to learn more about vertical gardening					

7. If given all the appropriate resources and materials, would you like to grow your own vegetables using vertical gardening and why?

   .....

   .....

8. What kind of support do you expect from the school to facilitate the use of DVVGs list them……
……...

Agricultural extension

9. Do you understand the meaning of agricultural extension and its role? Yes (…) No (……)
10. Have you ever interacted with an agricultural extension officer? Yes (……) No (……)
11. Has the school ever invited agricultural extension to teach the students more on Vertical vegetable production Yes (……) No (……)
12. Agricultural officers should be part of our agriculture club Yes (……) No (……)
13. What do you learn from the last agricultural show and exhibition

    I went there for Fun (……) livestock production (……), types of crops and how they are grown and maintained (……), how to earn more income from agriculture (……)
14. How often have you ever delivered agricultural information from school to your parents/guardians on the activities done in the following:

    N/B: (1) Often means at least once a week; (2) Sometimes means at least once a month; (3) rarely means once in a term (4).

Item	**1**	**2**	**3**	**4**
Agricultural exhibitions				
Agricultural shows				
Field demonstrations in schools				
Agricultural Field days				
Agricultural workshop				
Any agricultural information given in school				

Questionnaire for Farmers

My Name is **Avoga Tabitha**. I am a student taking MSC agricultural extension from **Egerton University**. I am carrying out a study on **'assessing the use of secondary schools in agricultural extension in promoting DVVGs among farmers in Busia County, Kenya'**. I would like to request your time to provide me with the following information. The questions will take approximately 30 minutes of your time; your response to them will help in evaluating the topic of study.

You are instructed to answer questions concerning vertical vegetable gardening and agricultural extension. Your input will assist in addressing the issues that are affecting the diversified vegetable production in Teso south. Confidentiality is guaranteed, and no penalty for both participating and not participating.

SECTION A: PERSONAL DATA

1. Age in years (……)
2. Sex: Male (……) Female (……)
3. Main source of Income: Farming (……), business (……), employment (……), other (……) (specify)
4. Education: Postgraduate (……) Bachelor/Diploma (……) Secondary (……) Primary (……) Did not go to school (……) Others (……) (specify) (……..)

Vertical vegetable production

5. Where do you get the vegetables, you consume at home?

From the farm (……) Bought (……) In-kind (……) Others specify (……)

6. At home, do you grow vegetables thought the year Yes (……) No (……)

   If no why?

   ……

   ……..

7. Have you ever heard of the term vertical vegetable gardening? Yes (……) No (……)
8. If yes

Where: In school (……). At home (……). At an agricultural show (……) others specify (……)

9. Do you have any vertical vegetable garden in your home? Yes (……) No (……)

10. The following are examples of vertical gardening, tick the ones that are familiar to you

Gunny bags (……), roof tops (……), planting buckets (……) balcony farming (……), hanging buckets (……), use of banana trunks (……) farm box (……) use of pipes (……)

11. Have you ever heard of the following vertical gardening technologies used in growing vegetables?

    Second wall Yes (……) No (……)

    Planting tower Yes (……) No (……)

    Mound bed Yes (……) No (……)

12. What are some of the problems you have with growing vegetables using vertical gardening technology? 1 (strongly disagree), 2 (disagree), 3 (indifferent), 4 (agree), and 5 (strongly agree) Check all that apply.

Item	**1**	**2**	**3**	**4**	**5**
I don't have the skills to maintain the gardens					
It's not allowed where I live:					
Everything seems to die					
I don't have the tools or supplies I need					
Maintaining a garden takes too much time:					
Cost: it's too expensive					

13. Have you ever visited any school near you to learn from the school farm? Yes (……) No (……)

If yes, how often

Very often (……) often (……) fairly often (……) less often (……) I don't visit the school

14. Other than, official functions of the school, how often do you visit the school near you

Very often (……) often (……) fairly often (……) less often (……) I don't visit the school

Agricultural extension

15. How often do you interact with extension officials to discuss issues concerning vegetable production?

    Always (……) Sometimes (……) Rarely (……) Never (……)

N/B: Always means at least once a week; Sometimes means at least once a month; rarely means once in a production season while never means none the whole production cycle and year.

16. How easy is it to access services on vegetables from extension personnel?

Very difficult (……) Difficult (……) Somehow difficult (……) Not difficult at all (……)

17. How did you interact with the extension officers?

Physically (…) Through phone call (……) Through SMS (……) WhatsApp (……) Facebook (……) others (specify) (……)

18. The last SMS you received from extension officer was about what

Vegetable production (……) others specify (……..…)

Questionnaires for School Administrators

My Name is Avoga Tabitha. I am a student taking MSC agricultural extension from Egerton University. I am carrying out a study on 'assessing the use of secondary schools in agricultural extension in promoting DVVGs among farmers in Busia County, Kenya'. I would like to request your time to provide me with the following information. The questions will take approximately 15 minutes of your time; your response to them will help in evaluating the topic of study.

You are instructed to answer questions concerning vertical vegetable gardening and agricultural extension. Your input will assist in addressing the issues that are affecting the diversified vegetable production in Teso south. Confidentiality is guaranteed, and no penalty for both participating and not participating.

1. Has the school ever involved the students in vegetable production other than implementing the normal school curriculum, if no why?
2. Has the school ever used DVVGs or any other technology in vegetable production?
   Yes (……) No (……)
3. Has the school ever supported the students in setting up their own project (agriculture related project) in the schools? Yes (……) No (……)

If yes which one

4. Has the school ever received any support from the agricultural extension in the county on vertical vegetable production? Yes (……) No (……)
5. If the school could adopt the vertical vegetable gardening, could you expect external support from agricultural extension? What kind of support?
6. What kind of support can the school expect in order to be able to disseminate the technology to the community?
7. What is the kind of relationship does the school have with the following groups: use the likert scale rating :*1(fair) 2(neutral) 3(good)*

	Fair	Neutral	Good
School and parents/farmers (who have students in the school)			
School and parents (who don't have			

students in school)			
School and agricultural extension			

8. Has the school done any joint agriculture project with the community? Yes (……)No (……)

   If yes which one

9. If support is given, the school can create a way to educate the community on vertical gardening? Yes (……) No (……)

   If yes how

10. Has your school ever interacted or partnered with the ministry of agriculture in secondary school agricultural extension? Yes (……) No (……)

Appendix B: Farmers Focus Group Discussion Guide

1. Do you understand the importance of vegetables in your diet?
2. What types of vegetables do you grow?
3. Are you aware of seasonality in vegetable production? How do you grow vegetables during the dry season?
4. Do you have knowledge on growing vegetables off season? If yes, how do you go about it? Let farmers share their expertise and experiences here for comparison with what you taught to the school children.
5. How do you understand growing multiple vegetables in one sack? Have you ever practiced that?
6. What do you think about this technology of growing vegetables in sacks/gunny bags? Are you willing or are you already having such at your home? If no? Are you aware of the benefits that the technology has in off season vegetable production? Variety of vegetables that can be grown on one sack? Its benefits in terms of nutrition and income generation?
7. Your child/ren have leant about this technology in school, can you allow them practice the technology at home and learn from them?
8. For those who have already adopted the technology, are there any modifications/improvisations they have done?
9. Are there any lessons they have learnt that they can share with others?
10. How do you access agricultural information/services on vegetable production?
11. How are your experiences on agricultural extension services from both public agricultural extension service delivery and private agricultural extension? Which methods do they use or how do they disseminate information to you?
12. Are you willing to teach your fellow farmers or allow them learn from you on how to establish and manage the technology? (Farmer-to-farmer extension)
13. Any support they may need in adopting the technology
14. What can be done to ensure the technology gain widespread acceptance in your community?

Appendix C: Interview Guide Extension Officers

My Name is **Avoga Tabitha**. I am a student taking MSC agricultural extension from **Egerton University**. I am carrying out a study on: **Assessing the use of secondary schools in agricultural extension in promoting DVVGs among farmers in Busia County, Kenya.** I would like to request your time to provide me with the following information. The interview will take approximately 30 minutes of your time; your response to them will help in evaluating the topic of study.

The responses will be very confidential. Therefore, your comments will be shared by the research teams only. I'll be analyzing the information you and others have given me and preparing a report which I will submit to the university. I will be glad to share my findings with you if you so wish

Are you willing to participate in the interview?

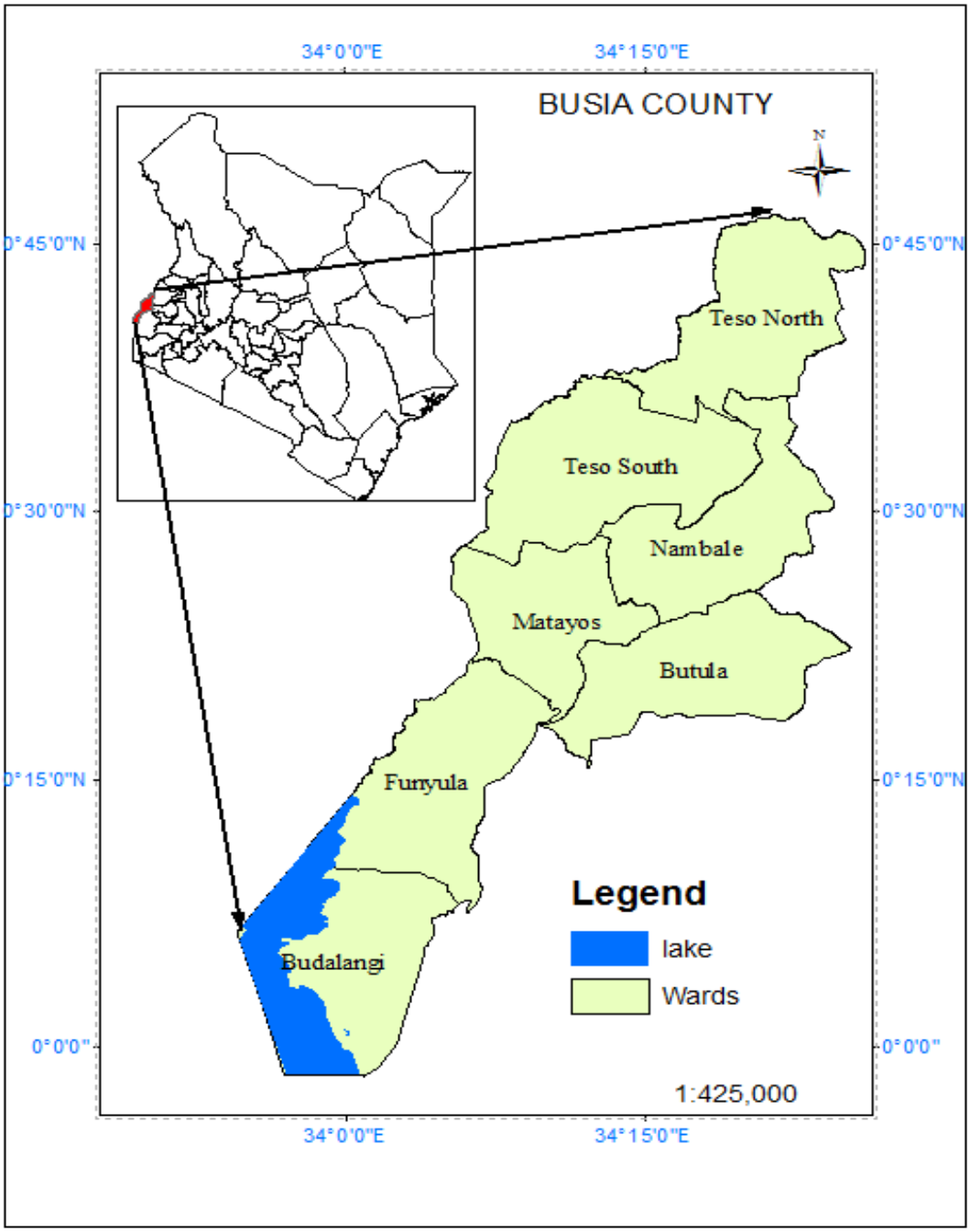
Interviewee…… Witness ……... Date …….

1. By what extent can the agricultural extension work with secondary schools in promoting DVVGs among farmers in Busia County, share your opinion on this
2. Have you ever encountered a scenario where agricultural extension has worked with secondary schools to disseminate information to farmers? If yes, kindly explain how it was done
3. Do (es) you(r) department support youth in secondary schools to participate in vegetable production in Busia County? If yes, how? If no why?
4. Do (es) you(r) department have a way of working with the secondary schools to enhance agricultural extension? If yes, how? If no why?
5. Do you think having active demonstration in secondary schools can be a way to disseminate agricultural extension information farmers?
6. Do you work in coordination with other agricultural institutions to support vegetable production in Busia County? If yes, which organizations or associations? If No, why?
7. Do you think your department and the school administration can have a platform where students can learn from the officers and disseminate the information to farmers? If yes how? If no why

Appendix D: Observation Guide

Item	Available	Not available	Description
Vertical gardens in schools			
How are the free spaces in school and at home utilized			
Resources available in schools for participatory learning among students			
Any other available resources that can be improvised to promote DVVGs in schools and homes			
Students' ability to work and learn in groups			
Vegetables grown: *sukuma wiki*, spider plant, capsicum, carrot			
DVVGs activities carried out on-site: (e.g. establishing the structures, growing, field management, harvesting,			
DVVGs technologies: Second wall, primary wall, mound bed			
Activities on DVVGs done. Skills on DVVGs applied.			
Skills farmers learnt from their children			
Vegetable diversity per household			
Land allocated for DVVGs			

Appendix E: Map of Busia County



Source: Republic of Kenya, (2013)

Figure 4

Map of Teso South in Busia County

Appendix F: Research Permit

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **134453**

Date of Issue: **15/December/2020**

RESEARCH LICENSE

This is to Certify that Miss., Tabitha Avoga of Egerton University, has been licensed to conduct research in Busia on the topic: ASSESSING THE USE OF SECONDARY SCHOOLS IN AGRICULTURAL EXTENSION IN PROMOTING DIVERSIFIED VERTICAL VEGETABLE GARDENING AMONG FARMERS IN BUSIA COUNTY, KENYA for the period ending : 15/December/2021.

License No: **NACOSTI/P/20/8140**

134453

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Verification QR Code

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ence

pace,

Appendix G: Vertical Vegetable Gardening Brochure

Vertical gardening is growing plants on a support such as, stake, trellis, cage, and fence or growing in bags. Vertical vegetable garden is a simple way to boost growing space, reduce insect and disease problems.

Benefits

1. Saves on space – one can grow more in the same amount of space
2. Grow in nontraditional spaces – makes use of spaces where one couldn't grow anything like near walls of a buildings, near fences and utilized spaces within our homestead (balcony, rooftops etc.)
3. Add beauty and privacy – helps in creating privacy, hide unsightly areas
4. Easier to maintain – vertical gardens are unlikely to have problems weeds, ground dwelling pest and soil borne disease
5. More sun exposure – if you have a shady garden, plants in vertical gardens can grow up and into the sun. They can thrive better than those left on the ground
6. Disease prevention –
7. Better air flow – there is good air flow among crops that grow vertically. The leaves dry faster (after the rain and morning dew) – this prevents problems with fungus and diseases
8. Pest prevention – especially hungry dwelling pest- it's easy to encircle the VG with a chicken wire or any other garden fencing to protect them from hungry animals
9. Larger harvest- Vertical Gardening provides more growing space than traditional garden plot hence larger harvest
10. Easier to harvest – bring crops to eye level hence easier to harvest
11. Gorgeous vegetables – one is unlikely to find ugly yellow spots on heavier vegetables, which usually happens when they are left lying on the ground
12. Cleaner environment and crops – when plants grow vertically, soil wont splash on them
13. Easier way of providing food/ balances diet – it gives great satisfaction and saves your money
14. Increase accessibility - They are easily available for consumption at home
15. One spends less time weeding, pruning, spaying, feeding and watering your garden hence suitable in and out of season

Types of vertical gardens

i. Gunny bags- fitted with soil and either perforated pipes, a column of small stones or a cotton cloth for irrigation
ii. Hanging baskets at varying heights, a wall-mounted trellis, pots stacked on a bench, stake in a pot and a clay pot.
iii. Boundary fences - You can hang trellises, planters, wall pots, baskets, garden art and even brackets with shelves.
iv. Straight plain trunks of soft wood trees, perforated vertical pipes, hanging buckets, plant cages,
v. Perforated Banana trunks filled with soil (no need to water the plants)

Three technologies for the study

1. **Mound bed**

Definition- A raised garden bed that is built from the bottom up with logs, sticks and branches, wood chips, grass clippings, fresh and rotten manure, leaves, food scraps. Top it all off with a layer of topsoil where plants can grow

Materials required

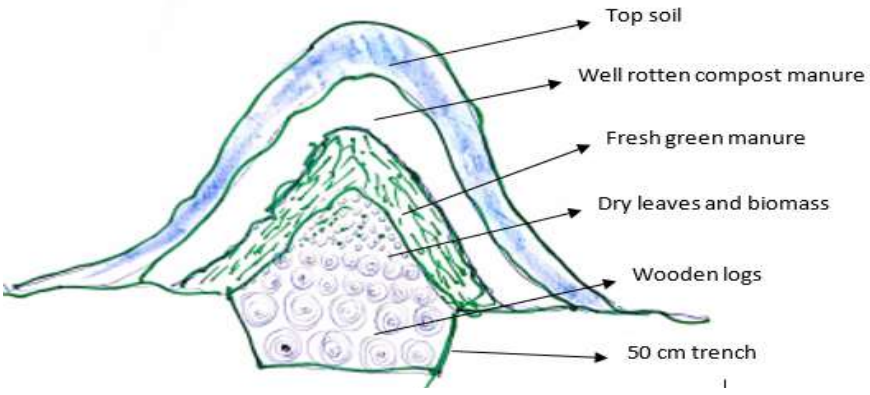
1. Stones
2. Rotting wood, sticks, dry grass (everything you would put in a compost heap)
3. Logs
4. Branches
5. Fresh/green manures
6. Grass clippings
7. Straw

N/B avoid grass straw that might contain seed, they might sprout in your garden, avoid diseased plants

How to construct

1. Assemble all the necessary materials
2. Clear the site
3. Dig a trench width convenient for you (50 cm deep)
4. Fill up the trench with the logs.
5. Place your logs in the trench horizontally and stacked on top of each other
6. Place dry leaves and biomass
7. Add a sizeable layer of green/fresh manure
8. Put all the rotting materials
9. Construct the mound with the soil mixture
10. Make holes on the mound for the seeds
11. Plant your seeds and over the mound with dry leaves as mulch

The technique



N/B A slow composting of the woody materials, releases nutrients contained within it to plants growing on or near the mound. While composting, warmth is generated. The generated warmth assist the plants to grow

Benefits: carbon sequestration, self-tilling, extended growing season

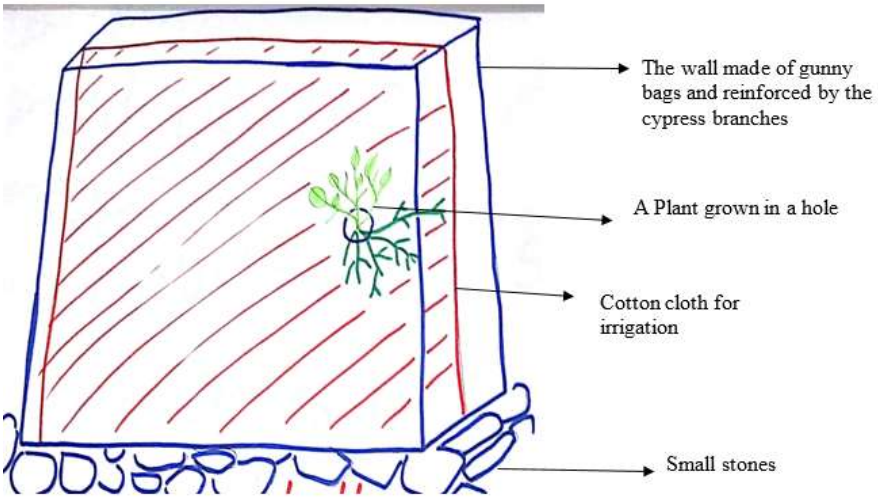
2. Second wall

Materials required

1. Straight eucalyptus branches
2. Bendable cypress branches or any flexible branch of a tree
3. Gunny bags or any sustainable material
4. stone (small stone)
5. Old cotton clothes
6. Soil mixture (20% manure)

How to construct

1. Take a straight eucalyptus branch and sharpen the ends
2. Put 4 eucalyptus on the ground and nail them horizontally
3. Repeat step two for the other side of the second wall
4. Weave the cypress branches
5. Fix the frames (3 branches) on the sides -
6. Put the gunny bags into the second wall
7. Hang on a cotton cloth on a branch
8. Fill the second wall with the mixture
9. Make holes in a slanting manner for planting seedlings
10. Cut the holes on the gunny bags and fix the plastic bottles (use of cut plastic bottles is optional)
11. Transplant seedlings the same depth they were in the nursery



N/B

1. Mulch on top to prevent water loss and weeds
2. Water in the morning- water the cotton cloth- it will retain water
3. Hand picks any weed that might emerge
4. Always check for pest and disease emergence
5. Use coriander, onions, marigolds or garlic as biological pest control plants

Primary tower

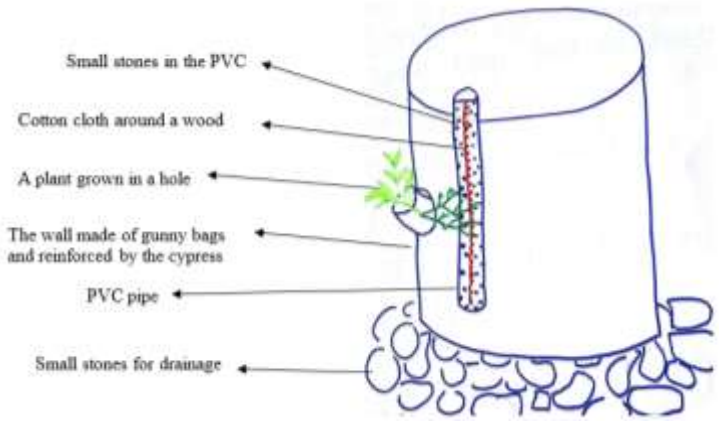
Materials

1. Straight eucalyptus branches
2. Bendable cypress branches
3. Gunny bags
4. PVC pipes
5. Stones
6. Old cotton clothes
7. Soil mixture (20% manure)

How to construct

1. Take straight eucalyptus branches sharpen them on one side
2. Harmer them into the soil
3. Weave the bendable cypress around and bind it fast
4. Put the gunny bags into the tower
5. Position 3 PVC pipes with holes
6. Wind a cotton cloth round a branch and put it in the PVC pipe
7. Fill the pipes with stones
8. Fill the tower with soil and manure mixture
9. Cut the holes on the gunny bags and fix the plastic bottles (use of cut plastic bottles is optional)
10. Transplant seedlings the same depth they were in the nursery

The technique



Appendix H: Training Program

Date/time	ACTIVITY/TOPIC	RESPONSIBLE
	Preliminaries	
Jan 2021 Jan 13, 2021, Jan 15, 2021	Seeking permission from relevant institutions Sensitization of schools	Eatsane team
Jan 2021 Jan 18, 2021, Jan 22, 2021	Baseline survey	Researcher
	Intervention (Feb 1, 2021 and Feb 9, 2021) two days for each school	
	Day one	
4.00 – 4.10 pm	Introduction and Climate setting	Researcher/agriculture teacher
4.10 – 4.30 pm	Definition and role of agricultural extension. What is vertical gardening? What is diversified vertical gardening? Examples of vegetables, herbs and spices that can be grown in vertical gardens	Researcher/agriculture teacher
4.30 – 4.45 pm	Need for diversified vertical vegetable gardening Benefits of diversified vertical vegetable gardening Examples of technologies used in vertical gardening	Researcher/agriculture teacher
4.45 – 5.45 pm	Three DVVGS (Mound bed, second wall and primary tower) • Definition • Materials required • How to set up • How to manage • Benefits	Researcher/agriculture teacher
5.45 – 5.50 pm	Question and answer	Researcher/agriculture teacher
	Day 2	
2.00 – 5.00 pm	Establishment of the three vertical gardening structures	Researcher/agriculture teacher/agriculture students

Appendix F: Abstract of the Manuscript

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YOUTHS AS RECIPIENTS AND PROVIDERS OF AGRICULTURE INFORMATION – THE VERTICAL VEGETABLE GARDENING CASE IN BUSIA COUNTY, KENYA

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ABSTRACT

The intent of this study was to assess the feasibility of engaging youths in secondary schools in disseminating agricultural information among smallholder farmers using a five-month vertical vegetable gardening technology case in Busia County, Kenya. The research employed mixed research design targeting smallholder farmers and youths in secondary schools. A sample of 132 smallholder farmers and 132 youths in their first, second, and third years of study were selected to participate in the study at the baseline survey, during the intervention, and at the closure survey. The baseline survey was used to identify gaps, followed by participatory training intervention on the mound bed, primary tower, and second wall, to create awareness about vertical vegetable gardening through young farmers' clubs, and a closure survey to assess the change caused by the intervention and the feasibility of the approach. The study used kales, black nightshade, swiss chard, capsicum and carrots as examples of vegetables suitable for vertical gardens. Data was analyzed using the Wilcoxon sign-rank test at $p<0.05$ level of significance, thematic and descriptive analysis. The results showed that there was a significant change in access and use of vertical gardening information by smallholder farmers. At $P = 0.000$, 22% of the smallholder farmers appreciated the use of vertical vegetable gardening at the closure survey, compared to 1% at the baseline survey. The dissemination of information through secondary school youths allowed for multiple delivery channels, was a good technology result demonstration approach for technology replication, and had sufficient agricultural extension activity learning scope. Significant change in the level of technology acceptance offer practical implications for policy makers to support the role of youths in agricultural extension. Future studies are needed to examine suitable agricultural extension policies and strategies to increase the successful implementation of agricultural extension through secondary schools.

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