Establishment of the technological factors contributing to the sustainability of the Farmers Field School (FFS) in Busia County, Western Kenya: A Case of Farmers Field Schools in Busia County

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ABSTRACT
Farmers Field Schools have been in operation as an alternative Agricultural extension approach from South East Asia, Philippines under Integrated Pest Management (IPM) from 1989. This study was on Examination of the differences between staff run and farmer run Farmers Field School on attainment of sustainability in Busia County in Western Kenya region. Kenya is among the over 90 countries in the world that have implemented Farmers' Field School as an agricultural extension approach from its introduction. The problem addressed by this study was that of the 305 Field Schools funded within the study area, they remain unsustainable after the learning cycle. The objective of the study was to establish the technological factors contributing to the sustainability of Farmers' Field Schools (FFS) in Busia County. The literature review revealed that in other nations, many such funded schools don't break up after the end of the learning cycle. Multi-stage random sampling method was used to select field schools at each sub County, while purposive sampling was used to select key informants from program managers and FFS facilitators. Primary data was collected using pre-tested structured questionnaires administered to the 200 selected field schools, face-to-face interview with key informants FFS facilitators, program managers and focus group discussions with the field school's network that is the apex body representing all the field schools was done. Secondary data including content analysis were obtained from publications, journals newspapers and internet access. The hypotheses were tested at 5% level of significance. The data analyzed by statistical package for social science (SPSS) version 20 were presented in tables, chi-square, frequency tables, percentages and pie chart. The following technological factors were identified as the ones contributing to the FFS sustainability: mechanization, conservation agriculture and farm inputs use. The findings revealed that FFS in Busia County could easily attain sustainability if they adapt to use of appropriate mechanization, employ conservation agriculture and internalize in the use of improved agricultural inputs. This will lead to sustained production that will lead to food and nutritional security and hence poverty reduction.

Key words: Sustainability, Farmers Field Skills, factors, agro-ecosystem analysis

1.0 Introduction

Kenya has a well-established extension service and a long history of extension programmes. In spite of this, the performance of Kenya's agricultural sector has been declining which worsened in the 1990-2003 period (GoK, 2005). The causes of the decline were due to lack of appropriate technologies, inefficient extension delivery systems, past extension delivery systems that did not build the capacity of local farmers and inadequate research extension farmer linkages (Purcell and Anderson, 1997).

The sustainable strategies to address the above scenario include patterns of social relationships embodied in adequate institutional arrangements and capacity at the community level. According to Uphoff (1999) and GoK (2005) agricultural extension services play a pivotal role in enhancing empowerment, sustainability of informal and formal farmers and farmer groups by capacity building their ability to participate in group activities and demand for services from external agencies to the community. Food and Agriculture Organization (FAO) introduced Farmer Field Schools (FFS) in 1989, in South East Asia, in Indonesia, as Integrated Pest Management (IPM) program in irrigated rice Khisa (2010). By use of the chemicals, the farmers in Indonesia endangered their crops, their health and their environment through massive use of highly toxic pesticides. These were promoted aggressively by private industry and government. Farmers through a decentralized programme were trained to become experts in managing the ecology of their fields to get better quality yields, fewer problems because of reduction in use of pesticides, increased profits and less risk to their health and environment. The Integrated Pest Management Farmer Field School (IPM-FFS) and a corresponding large-scale Indonesian programme were developed in response to these conditions. The FFS made farmers experts to manage their ecology in a sustainable manner (Braun *et al*., 2006). They carried out systematic comparative observation in the crop fields under respectively conventional and new technological management by using group methods with emphasis on discovery-based learning (DBL) and hands-on experimentation. The FFS brings together concepts and methods from agro-ecology, experiential education and community development. As a result, hundreds of thousands of rice farmers in countries such as China, Indonesia, Philippines andVietnam were able to reduce the use of pesticides and improve the sustainability of crop yields. FFS networks in a number of countries are involved in a wide-range of self-directed activities including research, training, marketing and advocacy. According to Khisa (2010) initiation of FFS has led to more than two million farmers across Asia participated in this type of learning.

Due to its success in empowering farmers, FFS was tried in other countries of the world. In the Kenyan case, the FFS approach was first introduced in 1996 on a pilot basis by the Special Program for Food Security (SPFS) of the FAO in collaboration with public extension service of the Ministry of Agriculture Livestock, Fisheries and Irrigation (MALF&I). In 1999, the global IPM facility launched an East African sub-regional pilot project for FFS for Integrated Production and Pest Management (IPPM) covering the counties of Bungoma, Kakamega and Busia in Kenya and the Nations of Uganda and Tanzania (Khisa, 2003).

1.1 Statement of Problem

In the past, technology transfer models adopted by most agricultural extension systems were top-down in approach (Röling, 1988). The Training and Visits (T&V) extension system was such a model introduced in India and Africa (Bindlish *et al*., 1993) that was expected to bring researchers and extension staff closer in the process of technology transfer. In these systems/models, smallholder farmers were merely recipients of agricultural messages often presented as technological packages. These systems required huge capital outlays to run, especially in terms of staff and transport which many development countries could ill afford (Anderson *et al*., 2006). FAO therefore looked for an alternative approaches to the T& V approach. FFS was tried in South East Asia.

Farmer Field School (FFS) groups have been widely scaled-up in many Asian and African countries by using either staff run or farmer run FFS. Despite many development partners assisting several nations worldwide, there is a concern world over on how to sustain funded activities at the end of project cycle as many such funded activities still break up leaving beneficiaries still expecting to receive handouts from the donors. However, for the FFS from its inception in Busia County in 1996, there has been no in-depth study to examine the contribution of human factors in the sustainability of FFS in Budalang'i, Funyula, Butula Nambale and Matayos Sub Counties. The FFS that are funded at the end of the learning cycle still break up, just like other projects that break up after the end of funding cycle, it is therefore necessary to examine what human factors of the FFS in Busia County are responsible for the sustainability of the FFS.

1.3 Research objective

To establish the technological factors contributing to the sustainability of FFS in Budalang'i, Funyula, Butula, Nambale and Matayos Sub Counties of Busia County.

1.4 Research question

In order to achieve the purpose of the research, the following guiding question was adopted. What are the technological factors contributing to the sustainability of FFS in Budalang'i, Funyula, Butula, Nambale and Matayos Sub Counties of Busia County?

1.5 Significance

This study is necessary since it will generate a body of knowledge to assist academia, research as well as extension to establish the technological factors contributing to the sustainability of FFS in Busia County. The study will also be vital in guiding policy formulators at the National and the County Governments levels to come up with policies that will guide stakeholders in implementing FFS in a more sustainable manner and in cost effective way. The findings were documented and it will contribute to the body of knowledge done by other researchers.

1.6 Scope of the study

This study was confined to the five Sub Counties of Bunyala, Funyula, Nambale, Butula and Matayos as they were the only Sub Counties in Busia County where FFS were established between 1996 and 2018. Hence, Teso North and Teso South were not covered as there were no Field Schools conducted in them. The data was collected between April 2018 and September 2018.

2.0 Literature Review

2.1 Global perspective of Farmers Field Schools

According to FAO, (2017), FFS were first introduced in 1989 in Asia; they then spread to other continents of Africa and Latin America and Europe. Currently over 90 Countries are using or have adapted FFS under various systems and enterprises. The production systems have been from various high yield irrigated system to rain fed or semi-arid to agro pastoral production systems. FFS have been run starting on IPM on rice then adaptation to IPPM on vegetables, cotton and multiple other crops and other aspects of FFS on livestock, perennial crops, Soil and water conservations and agro biodiversity, Fisheries, flowers and pastoralists. FFS have been used as post disaster to assist the victims recover and reconstruct their livelihoods. It has also been used in schools as farmers Field and life schools as well as forestry field schools and farm business schools. This therefore shows that field schools have been adapted to various aspects or disciplines, due to its flexibility to various challenges of life.

2.2: The origin and status of the FFS

According to Khisa (2002), the first FFS were conducted in 1989/1990 in Indonesia. These first FFS were designed to educate farmers on the principles of IPM in order to deal with major outbreaks of Brown Plant Hopper (BPH). Serious outbreaks of BPH occurred when abundant use of pesticides had wiped out populations of natural enemies (predators and parasitoids). In the absence of their natural enemies the BPH could multiple rapidly resulting in severe "hopper burn" and crop failure. The solution to this problem was to conserve the natural enemies by reducing pesticide use so that the beneficial insects could control insect pest population. According to Jaim *et al.* (2001), FFS educate farmer participants by analyzing agro-ecosystems, as it includes practical aspects of plant health, water management, weather, weed density, disease surveillance, plus observation and collection of insect pests as well as beneficial insects. The farmers normally look at the interactions of organisms in an environment and effect of one to the others in an ecosystem.

According to FAO (1998) traditional extension methods had failed to educate farmers on this concept of "natural pest control" and the new FFS approach was then developed, with assistance of FAO which managed to address it. According to Bunyatta and Mureithi (2004) FFS has proved to be an effective approach in empowering, farmers in their farms. This new extension approach uses four principles. The four principles are growing a healthy crop or keeping a healthy livestock, conserving natural enemies, conducting regular field observations and farmers becoming experts on their farms or fields. The FFS training approach is based on active participation of farmers' group members sharing knowledge with each other as guided by the facilitator. The FFS members are able to analyze trials or treatments in FFS that are called participatory technology developments (PTDs) and give recommendations on appropriate decisions for better performance. Farmers learn new concept by the facilitator through the experiential learning cycle in a process involving learning by doing. According to FAO (2017) the FFS learning process a bottom up approach with the FFS facilitators helping farmers to learn from each other by practical experience.

In FFS, farmers normally run their own experiments, which they usually share with other farmers during field days and exchange visit. According to Gallagher (2003) the FFS approach does not only equip farmers with knowledge on technologies but also empowers them with skills to experiment and to solve individual and community wide problems. According to FAO (1998) and Uphoff (1999) sustainability is defined as the ability of the FFS to continue with activities beneficial to members with less assistance from project proponents or external agencies making graduated farmers and FFS groups being self-reliant. FFS were as result of Asian farmers discovering that over use of conventional pesticides resulted in insect resistance and killing of natural enemies that led to insect pest outbreak hence reducing crop yields. As a result of this outbreak, IPM was then taken seriously which led to emergence of FFS in 1989 in Asia.

According to Leeuwis (1998) the FFS methodology has resulted in the creation of stronger research-extension-farmer linkages, while maintaining a vital link with modern science. The linkages are essential in empowerment of farmers in order to tackle the socio-cultural and political dimensions of agriculture that require advocacy and lobbying for better policies. The agricultural extension service in Kenya has in the past used a number of extension approaches to deliver research innovations to the farmers.

According to GoK (2005) past approaches include model farmers, T and V, farming systems approach, demonstrations in Agricultural Training Centers (ATCs) and the catchment approach. These approaches unlike FFS were top down and non- participatory. Due to the FFS success in training Asian farmers on IPM technologies, it was then first introduced in Kenya on a small scale in 1996 by the FAO's Special Program for Food Security (SPFS) to promote maize (*Zea mays*) based IPM production system in western Kenya, piloted in Busia, Bungoma and Kakamega Counties (Abate and Duveskog, 2003). It was mainly to address food and nutrition security. Since then, over 2000 FFS have been initiated in Kenya to promote IPPM-FFS technologies for maize, vegetable; poultry production, fisheries, soil fertility management, water harvesting, dairy cattle production, pastoralist and management of HIV/AIDS.

2.3: The technological factors contributing to the sustainability of FFS

According to Davis *et al.,* (2010) FFS participants increased income by 61 percent due to the technology transfer and skills received through the participatory learning during FFS learning cycle. Under technological factors, the study from the literature review identified mechanization, conservation agriculture and farm inputs use.

According to Bunyatta *et al.,* (2006) the farmers who participated in FFS were able to adapt to soil and water management technologies more than those who didn't participate. According Asiabaka (2002) the FFS as a group learning approach builds knowledge and capacity among farmers to enable them diagnose their problems, identify solutions, develop plans, and implement them with or without support from outside. FFS also requires multidisciplinary research agenda that aims at technology development and seeks ways of stakeholder participation in technology development, validation and dissemination. It concludes that this approach will not increase agricultural productivity; but it will also lead to sustainable agriculture in Africa.

2.4: Mechanization

According to FAO (2013) sustainable mechanization is the practice of introducing the proper machinery to farmers to ensure that their agricultural production is not only more environmentally sustainable but is more efficient in growing crops. Sustainable agricultural mechanization refers to all farming and processing technologies from basic hand tools to motorized equipment. It does looks at the technical aspects of farming as well taking into account the effect that tools have on a farmer's outputs, from crop production along the value chain to marketable products, and in turn, the impact this has on a farmer's income. However, for this study the researcher looked at the basic mechanization of tractors and ox plough that are mainly used by the FFS participants as this is basic to other mechanization. This is basic to higher yields that will later dictate the other post-harvest tools. Mechanization leads to achievement of better harvests and increased income or new jobs for farmers.

According to FAO (2013) farmers can move from subsistence farming to market oriented farming if they rely on mechanization. It relieves labour shortages, improve timeliness of agricultural operations, ensure the efficient use of resources, enhance market access by allowing farmers to sell more than just the raw product and contribute to mitigating environmental damage such as soil degradation. Machines can allow for better practices such as reduced tillage and inter-cropping, the practice of planting different types of crops (e.g. legumes/cereals) in one field that grow simultaneously and complement each other in their growth. Rotational and inter-cropping practices reduce the risk of pests, soil degradation and the effects of unfavorable climate conditions.

With the earth's growing population, there is greater demand for products from the farms at the same time, the planet is facing serious challenges from over exploitation of natural resources and the increasing effects of climate change. There is need design appropriate machines and tools for agricultural production value chain that are vital to increasing outputs in a sustainable way. The reduction of drudgery is a key element of sustainable mechanization and contributes to reducing women's hard workload by taking into consideration technologies apt to their needs and improving their access to appropriate forms of farm power.

FAO is working with private sector partners, governments and farmers to create and promote sustainable mechanization opportunities. Sustainable mechanization leads to the following outputs: increase land productivity by facilitating timeliness and quality of cultivation; support opportunities that relieve the burden of labour shortages and enable households to withstand shocks better; decrease the environmental footprint of agriculture when combined with adequate conservation agriculture practices; and reduce poverty and achieve food and nutrition security while improving people's livelihoods (FAO, 2013).

Since smallholder farmers are the main producers of the world's food, they will have to increase production by up to 100 percent by 2050 to feed the growing population. This will be achieved by preserving natural resources and this is why sustainable agricultural mechanization (SAM) is fundamental to the process. The need for seeders and planters that is capable of penetrating soil surface vegetative cover to deposit seed and fertilizer at the required depth and spacing; and equipment for management of cover crops and weeds. Improved information flows via smallholder farmer-friendly innovation platforms; and continuing development and testing of SAM technologies via regional centers of excellence will both be required especially for sub-Saharan Africa (Sims and Kienzle, 2017).

2.5: Conservation agriculture (CA)

CA is the minimal soil disturbance no-till and permanent soil cover (mulch) combined with rotations, as a more sustainable cultivation system for the future. Cultivation and tillage play an important role in agriculture. CA, mulch and rotation significantly improve soil properties and other biotic factors. CA is a more sustainable and environmentally friendly management system for cultivating crops. Agriculture in the next decade will have to sustainably produce more food from less land through more efficient use of natural resources and with minimal impact on the environment in order to meet growing population demands. Promoting and adopting CA management systems can help meet this goal (Hobbs *et al.*, 2017). CA requires comprehensive weed management strategies which involves improved cultural practices, herbicides applications, and crop nutrition. Small seeded and perennial weeds are more abundant in CA. According to Ayodele and Aluko (2017), integrated weed management compatible to cropping patterns and climatic conditions offers the best results in CA.

As per the 7th MDG, Nations pledged to ensure environmental sustainability, all UN member States pledged to halve the number of people without access to safe drinking water by 2015.This requires good environmental management by ensuring the biodiversity is not destroyed by human interference through exploitation. According to Corcoran *et al.*,(2010) reducing unregulated discharge of wastewater and securing safe water are among the most important interventions, for improving global public health and achieving sustainable development. The enormous impacts and high cost to the environment, society and thus to economies, that wastewater can have when inadequately or inappropriately managed is quite evident. Another perspective for using wastewater is wise investment and appropriate management of wastewater so that can be purified and put various uses. This is a resource tool that can help tackle the global water crisis; urgent health issues, food security and economic productivity, and maintains or improves environmental integrity.

According to Cardi (1997) and Dolly (2005), from 1997 to 2000, the HMB a highly invasive pest species from Asia threatened food security in the region by destroying many food crops. The first serious outbreaks of the pest in Indonesia in 1975 and 1977 caused estimated losses of US$1 billion. The plant hopper reappeared in the mid-1980s because of continued heavy insecticide usage (United Nations, 2011). The African Ministers of Environment declared that a green economy should be underlined by national objectives, social and economic development imperatives.

According to Swaminathan (1983) agricultural production is dependent on the environment together with seed quality, soil health, water quality for irrigation and quantity, clean atmosphere of proper composition of carbon dioxide, nitrogen and oxygen, in addition to support diverse micro-organisms, pollination insects, birds, earthworms, farm animals and other non-domesticated flora and fauna. This therefore requires a lot of care so that any human intervention should maintain the balance of biodiversity to have a healthy environment.

Most of the developing countries of our planet including Africa have vicious downward spiral between accentuating poverty and environmental degradation. In these circumstances, the Malthusian view that population increases beyond the Earth's carrying capacity would cause environmental degradation and outrun the growth of food production gains credence. However, it is also true that modern science and technology have so far thwarted the realization of Malthusian predictions (Trewavas, 2002).

The environmental management is quite pivotal to attainment of sustainable agricultural production and livelihoods. FFS provide a good forum for farmers to debate on how to avoid undertaking practices that are detrimental to the environment that can lead to sustainable natural resource management so that maintaining of biodiversity can be attained hence may lead to sustainable FFS. It was not clear whether FFS in Busia considered environmental sustainability during the implementation.

2.6: Farm input

According to the African Development Bank (2016) the most common challenges that farmers face relate to limited access to inputs and output markets, land tenure and management, access to credit, poor infrastructure and limited extension services. There is a call to the reductions in the use of chemicals and energy in farming, in order to protect the environment. The most of agricultural interventions have been geared towards use of synthetic fertilizers and pesticides that are detrimental to the environment and the ecosystem. The design of agricultural projects for smallholder farmers that do not cause long-term environmental damage must be based as much on a realistic assessment of the socio-economic factors that shape farmers' responses as on the introduction of farming techniques and practices that conserve the resource base. From the existing data, it was clear that the use of fertilizer in the absence of a range of complementary husbandry practices does not usually result in large increases in yields. This therefore means that for better results in production use of fertilizer must be accompanied by appropriate husbandry practices Farm-households will only change to The low-input, sustainable agriculture (LISA) methods if the prevailing circumstances change so that the value of the money saved per kilogram of food produced is greater than the loss in production plus the extra value of labour time required for manuring, composting, tied ridging and so on Low, (2012).

The current trend is to use new disease resistant hybrids, biological pest control, and reduced pesticide use. It also involves cultural practices that reduce the incidence of pests and diseases, better placement and reduced amounts of fertilizers. Insect specific chemicals and biological insect controls are now being utilized, instead of broad-spectrum pesticides leading to reduced number of sprays that reduces costs(Bale *et al.*,2008). According to NAAIAP Implementation Guideline, 2018/2019 financial year), the use of improved inputs has enabled beneficiary farmers to produce average 16.71 bags per acre up from 3 -5 bags of maize prior to the intervention. The National Accelerated Agricultural Inputs Access Programme (NAAIAP) as Government of Kenya program, from Ministry of Agriculture, Livestock, Fisheries and Irrigation, that seeks to address the problem of low farm productivity by offering targeted subsidy in the form of technical inputs to resource poor farmers. The increase in yield and production would meet the household food security and generate surpluses that can be traded and increase household incomes thus enabling investment in agriculture.

3.0 Research Methodology

Description of the Study area

This study was conducted in Busia County found in western part of Kenya in the five sub Counties of Budalang'i, Funyula, Butula, Nambale and Matayos that were the only sub Counties in Busia County where FFS had been conducted by the time of the study. The County boarders the Republic of Uganda to the West, Bungoma County to the north, Kakamega County to the east and Siaya County and Lake Victoria to the South. It falls within the Lake Victoria basin with a range between 1130m to 1375 m above sea level and lies between latitude 0°25.3' and 0°53.2' N & longitude 34° 21.4' and 35° 04' East. The Humidity is estimated to be 84% recording a mean temperature range of16.2ºc to 28.7ºc, while the annual average rainfall ranges from 1080 to 1940mm. The rainfall comes in two seasons, March to May/June as the long rain season and August to October as short rain season. This rainfall pattern supports two crop-growing seasons. The soils in the County are moderately deep sandy loam, but valley bottoms are black cotton soils.

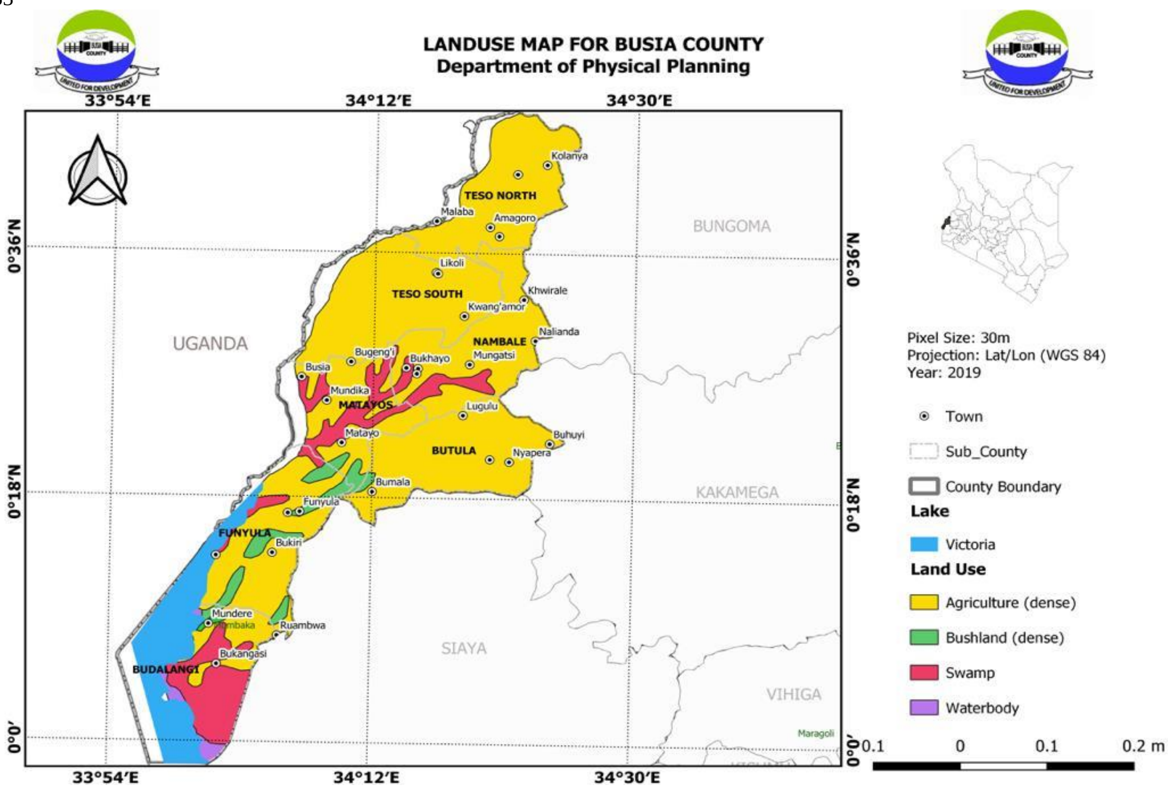

Figure 3.1: Map of Study area

Source: GoK (2019)

The study adapted a cross-sectional survey approach. A cross sectional survey studies the relationship between different variables at a point in time. The study was to establish the technological factors contributing to the sustainability of FFS in Budalang'i, Funyula, Butula, Nambale and Matayos Sub Counties of Busia County. According to TrochimW. (2006) unlike time series, cross-sectional survey relates to how variables affect each other at the same time. The study focused on the FFS by the time of the study that had completed their thirty weeks learning cycle in relation to the type of facilitator that capacity built a given FFS. A purposive sampling method was employed to select the Sub Counties and the key informants and FFS managers that implemented FFS. Purposive sampling allows the researcher to use cases that have the required information with respect to the objectives of the study Mugenda and Mugenda, (1999). A sample of 200 was chosen from the target population of 305 which was done proportionately according to number in the five sub Counties. Samples were taken proportionately from the five Sub Counties with the corresponding numbers of FFS as follows; Budalang'i -48, Funyula-75, Butula-55, Nambale-35, Matayos-92 totaling 305 FFS. The sample size for the FFS was determined by using the modified Cochran's (1977) formula for sample size calculation for small populations. Sample was calculated using the equation below:-

n= no/1+ {(no-1)}/N

Where;

no is Cochran's sample size recommendation of 385

N is the target population, which was the total FFS of 305

n is the new adjusted sample size, which is the sample size used for the study

Therefore, n= no/1+ (no-1)/N = 385/1+ (385-1)/305= 385/2.3= 167

The sample size from the Cochran's formula for small populations was 167, but to take care of dropouts and the non-response the researcher used 200 as the sample size for the study. In-depth interviews were conducted in person with key informants composed of one FFS facilitator, one Sub County FFS network official and the area village elder *(Liguru)*. The key informants were identified through a combination of simple random and purposive sampling techniques. The appointments for interviews were done through phone calls for respective FFS chairpersons who planned for the FFS members' presence during the interview. The items on the questionnaire were developed based on the objectives of the study. Primary data collection was to the selected proportional FFS per Sub County on which focus group discussions was undertaken and for every selected FFS administration of questionnaire was done. Some primary data was also got from the key informants for FFS managers and for FFS facilitators. Data collected was used to determine the human factors influencing the sustainability of FFS in Busia County.

The Secondary data collection was by reports from the County Agricultural and Livestock Directors as well as the Sub County Agricultural and Livestock and Regional Project FFS coordinator offices. This was through data collected from existing and relevant literature review even from internet access and publications. The FFS were randomly selected and the interviews conducted.

According to Wiersma (1995) Validity is the accuracy, soundness, or effectiveness with which an instrument measures what it is intended to measure.The data collected was coded and scored in order to facilitate analysis using the SPSS. Descriptive statistics included frequency and modal distributions, means, standard deviations and percentages. The results from that analysis was used to establish the technological factors contributing to the sustainability of FFS in Budalang'i, Funyula, Butula, Nambale and Matayos Sub Counties of Busia County. The inferential statistics involved the use of Chi-square and factor analysis. The Chi-square and f-test were used to separate the means

3.2 : Ethical Consideration

A research permit was also obtained from the National Council of Science of Science and Technology (NACOSTI). The researcher obtained permit from the County Government of Busia to collect data from FFS. The information obtained was handled with caution since it referred to people and their livelihoods. The purpose of the research was explained to the selected FFS. The collected Data was kept private, confidential and was used only for matters pertaining to the research.

4.0 : Results and Discussion

The establishment of the technological factors contributing to the sustainability of FFS in Budalang'i, Funyula, Butula, Nambale and Matayos Sub Counties of Busia County.

4.1: Mechanization in FFS

The machinery usage in FFS was not quite evident, but one cannot overlook the importance machinery plays in reduction of drudgery, leading to higher production that can address problem of food insecurity and poverty reduction. Table 4.1 indicates the mechanization situation in the County as was captured at the Sub County level. FFS were asked how their undertook land preparation and the results as in table 4.1.

Table 4.1: FFS that had adopted machinery (either use of tractor or ox-drawn implements)

Name of S. County	No. of FFS Selected	FFS adopted mechanization	% of FFS in County
Budalang'i	32	08	04
Funyula	50	17	09
Butula	36	26	13
Nambale	22	26	13
Matayos	60	51	26
Total	**200**	**128**	**64**

Source: GoK (2018)

From the table 4.1 on machinery usage, it was clear that the FFS in Matayos sub County adopted use of machinery more than other Sub Counties but Budalang'i Sub County adopted the least. The reason of less adoption for Budalang'i Sub County could be due to the main activity in that Sub County being fishing as it's along the Lake Victoria. One has to realize that there is a variety of machinery that could be adopted at various levels and along the value chains in production process to utilization, marketing and processing.

According to FAO (2013) farmers can move from subsistence farming to market oriented farming if they rely on mechanization. It relieves labour shortages, improve timeliness of agricultural operations, ensure the efficient use of resources, enhance market access by allowing farmers to sell more than just the raw product and contribute to mitigating environmental damage such as soil degradation. Improved information flows via smallholder farmer-friendly innovation platforms; and continuing development and testing of sustainable agricultural mechanization technologies via regional centers of excellence will both be required especially for sub-Saharan Africa Sims Brian (2015), Busia County having higher poverty levels should adopt to higher mechanization so that more land can be opened and timely operations are achieved. The county should exploit the available mechanization for easy of work. Sustainable mechanization should be embraced by the FFS to ensure agricultural production is not only more environmentally sustainable but is more efficient in the growing crops. Farmers in Busia County should be encouraged to use various machines to easy the operations in the efforts of agricultural modernization. If farmers remain poor then there will be a greater challenge to adaptation of mechanization. This call for farmers within FFS to undertake farming as business so that income got from farming can be reinvested in mechanization.

4.2: The conservation agriculture in FFS

The environmental matter is quite important if sustainability is to be attained. In fact, in the FFS, participants undertake observations on how organisms interact in a given environment, either positively or negatively. This in itself is good setup as farmers in FFS undertake regular observations and employing the right decision to be undertaken to reverse any situation that may be a danger to the environment.

From the Table 4.2 it is seen that majority 37.5% of the FFS addressed environmental matters as an aspect of sustainability through planting indigenous trees, while 25.0% of them did it by conserving water sources, but 18.8% of them started tree nurseries at individual level while 12.5% had no response. This implies that the FFS addresses the issue of environment conservation, which is necessary for attainment of sustainable development. All the variables in table 4.2 had a statistically significant distribution views on environmental conservation since the calculated chi-square was 90.2>7.81 at 3 degree of freedom. According to Kesavan and

Swaminathan (2007)agricultural development is dependent on environmental management; this implies that no sustainable development can be realized without taking care of environment.

According to Cardi (1997) and Dolly (2005), during the period of 1997 to 2000 the HMB a highly invasive pest species from Asia threatened food security in the region by destroying many food crops. To avoid spending much as it was in Indonesia in 1975 and 1977 where estimated loss of US$1 billion was realized, there is need to use appropriate technologies to arrest the situation (United Nations, 2011). There is therefore for a need to use appropriate technologies to ensure no harm is done to the environment. If this is done then sustainability can be attained as the environment remains healthy to produce higher yields and hence sustained income and food can be attained to avert hunger and poverty.

Conservation agriculture is gaining a lot of importance with time; this is because most of the farming does not consider environmental conservation this has led to the pollution of environment hence affecting the agro ecosystem. Table 4.3 is a summary of the situation in Busia.

Table 4.2 Environmental aspects

	Frequency Observed(N)	**Frequency Expected(N1)**	**Residue (Re)**	**$(Re)^2$**	**$(Re)^2/N_1$**
No response	27(12.5%)	45 (50%)	-33	1089	24.2
Do tree nurseries on individually	40 (18.8%)	45 (50%)	-27	729	16.2
Conserve water sources	47 (25%)	45 (50%)	-24	576	12.8
Plant indigenous trees	73 (37.5%)	45 (50%)	-12	144	3.2
Didn't learn about it	13 (6.3%)	45 (50%)	-39	1521	33.8
Total	**200**				**90.2**

Source**:** Researcher (2019)

From table 4.3 on farmers Field Schools practicing Conservation agriculture, the Sub County of Matayos had the highest adaption while Budalang'i and Nambale Sub Counties had the lowest. Conservation agriculture is important if Sustainable Development Goals (SDG) are to be attained. The 15th SDG states that there is need to protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification and halt and reverse land degradation, and halt biodiversity loss. If the FFS embrace conservation agriculture, then environment will be used sustainably.

Table 4.3: Farmers practicing conservation agriculture

Name of S. County	**Total no. of FFS surveyed**	**FFS adopted conservation Agriculture**	**% of the total in the County**
Budalang'i	32	09	05
Funyula	50	21	11
Butula	36	16	08
Nambale	22	10	05
Matayos	60	26	13
Total	200	82	41

Source: Field data (2019)

According to Kesavan and Swaminathan (2007)agricultural production is dependent on the environment together with seed quality, soil health, water quality for irrigation and quantity, clean atmosphere of proper composition of carbon dioxide, nitrogen and oxygen, in addition to support diverse micro-organisms, pollination insects, birds, earthworms, farm animals and other non-domesticated flora and fauna. The Busia FFS didn't adapt the judicious use of chemicals, which endangers the environment.

It is important to note that the FFS is more placed to handle conservation agriculture due to its nature of being participatory so farmers within the FFS can debate and find the best conservation agricultural method to be adapted in their respective environment. This in fact has a track record from inception of FFS it has helped sustain production by applied climate smart technologies. There is need for the County of Busia to incorporate environmental management in FFS so that if can also address climate change which is the current concern world over.

4.3: Use of improved farm inputs

Improved input is important in attainment of more production. As depicted in table 4.4, FFS were asked to indicate whether they were able to use improved inputs and the result is as indicated in table 4.4

Table4.4 FFS use of farm inputs

Name of S. County	Total no. of FFS surveyed	FFS adapted improved farm inputs	% of the total sampled in Busia County
Budalang'i	32	05	03
Funyula	50	17	09
Butula	36	18	09
Nambale	22	10	05
Matayos	60	25	13
Total	**200**	**75**	**38**

Source: GoK (2018) and Researcher, (2018)

From the results of table 4.4, the total usage of improved inputs within Busia County is 38%. This is quite low and hence could be one of the causes of poverty in Busia County. From the table 4.4 on use of improved farm inputs, it revealed that Budalang'i Sub County had the least adoption with percentages of five. This could be explained by the fact that Budalang'i Sub County is the driest part of Busia County and has an alternative livelihood of fishing. Matayos Sub County had the highest adoption rates of 25 percent. Generally, from this study, the County of Busia has a lower usage of improved input, which could be attributed by the higher poverty levels. According to NAAIAP program, GoK (2017), use of fertilizer and improved seed coupled with good agronomic practices gives better yield that can make farmers reinvest in farming sustainably. According to GoK, (2018) the use of improved inputs has enabled beneficiary farmers to produce average 16.71 bags per acre up from 3 -5 bags of maize prior to the intervention. If Busia farmers have to address food insecurity, therefore this requires the farmers to increase their usage of improved farm inputs. If the farmers are poor as most are then there is a need to jump start them by having a grant as NAAIAP does or subsidizing the farm inputs. If this is done then more farmers will be able to access the inputs which will give better yields that could lead to sustained incomes and food and nutritional security.

5.0: The summary of the findings, conclusions and recommendations

5.1: Summary of findings

The research was conducted in Busia County within the five sub Counties of Budalang'i, Funyula, Butula, Nambale and Matayos in which the FFS had been conducted by the study period. The study was on the technological factors contributing to the sustainability of FFS in Busia County. The study findings were compared with the literature related study in line with the objective. The literature was obtained from journals, books, magazines, internet and some policy documents. Chapter three on research methodology dealt with description of the study area, study population, research design, sample size and sampling procedure, instrumentation, data collection, validity and reliability of the data instrument, data processing, analysis and presentation and the ethical considerations. The study was on technological factors contributing to the sustainability of FFS in Busia County.

5.2: Conclusion

The technological factors were identified that contribute to the FFS sustainability in Busia County were mechanization, conservation agriculture and farm inputs use. If farmers are to have sustainability in the FFS program, then there is a great need to adapt to sustainable agricultural mechanization, use of conservation agriculture technologies and make use of improved farm inputs.

5.3: Recommendations

FFS in Busia County can easily attain sustainability if they adapt to use of appropriate mechanization, employ conservation agriculture and internalize in the use of improved agricultural inputs. This will lead to sustained production that will lead to food and nutritional security and hence attainment poverty reduction.

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