ASSESSMENT OF THE EFFECTS OF USE OF GOOD AGRICULTURAL PRACTICES ON IRISH POTATO PRODUCTION AND MARKETING IN KENYA

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DECLARATION

I declare that this research thesis is my original work and has not been presented for examination in any other university.

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DEDICATION

I dedicate this work to my lovely and caring family Javan, Jeremy, and Jenelle. To Mom, whose unwavering support enabled me to pursue this course. I will not forget my brothers, sisters, and friends who supported me morally and financially to ensure that I cleared my studies at the University of Nairobi.

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ABBREVIATIONS AND ACRONYMS

"3G"	3-generation; a rapid potato seed multiplication technique
ADC	Agricultural Development Corporation
ASTGS	Agricultural Sector Transformation and Growth Strategy
CAADP	Comprehensive Africa Agriculture Development Programmeme
CIP	Centro Internacional de la Papa (International Potato Centre)
CSP	Certified Seed Potato
CGIAR	Consultative Group for International Agricultural Research
CIA	Conditional Independence Assumption
CRAAG	Centre de recherché en Astronomie Astrophysique et Geophysique
EUT	Expected Utility Theory
FAO	Food and Agricultural Organisation (of the United Nations)
GAPs	Good Agricultural Practices
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GOK	Government of Kenya
ILO	International Labour Organisation

IPM	Integrated Pest Management
IPPC	International Plant Protection Convention
KARI	Kenya Agricultural Research Institute
KALRO	Kenya Agricultural and Livestock Research Organisation
KENAPOFA	Kenya National Potato Farmers Association
KFA	Kenya Farmers Association
KG	Kilograms
KNBS	Kenya National Bureau of Statistics
LRM	Linear Regression Model
HCI	Household Commercialisation Index
MAAIF	Ministry of Agriculture Animal Industry and Fisheries (Uganda)
MOALF	Ministry of Agriculture Livestock and Fisheries
MoPND	Ministry of State for Planning, National Development and Vision 2030
MT/H	Metric Tons per Hectare
NAL	National Agricultural Laboratories
NBRM	Negative Binomial Regression Model

OECD	Organisation for Economic Cooperation and Development
OLS	Ordinary Least Squares
PLRV	Potato Leaf Roll Virus
PSM	Propensity Score Matching
PSDA	Private Sector Development in Agriculture
PVY	Potato Virus Y
WTO	World Trade Organisation
ZIP	Zero Inflated Poisson
ZINB	Zero Inflated Negative Binomial

ABSTRACT

The current trends of Irish potato production in Kenya are characterised by low yields that do not meet the increasing demand, especially in urban areas. This condition has been aggravated by using basic farming techniques, for example, uncertified seed, continuous cropping, and poor cultivation methods. Good agricultural practices (GAPs) have the potential of transforming low yields to high yields among smallholder farmers who can offer surplus produce to the market, especially in Sub Saharan Africa (SSA). These practices promote high agricultural productivity, which contributes to food security and better livelihoods. The low yield realised in potato production has been noticed by government and research institutions who have come up with innovations on GAPs to improve the yield and commercialisation of the farmers. This study assessed the effect of the use of GAPs on potato production and marketing in Kenya. Specific objectives addressed were to: i) examine factors that influence the intensity of use of GAPs by potato farmers; ii) assess the effect of intensity of use of GAPs on potato yield and iii) examine the effects of intensity of use of GAPS on market participation by potato farmers. The study focused on farmers in Bungoma and Nyandarua Counties due to the use of Irish potato as a cash crop in the regions. This study used a baseline survey where data was collected in 2016 by giving a structured questionnaire to 260 respondents who grew potato in the previous year. Data were analysed using the Poisson Regression model, Ordinary Least Squares, and Tobit Model. Results of the estimated Poisson Regression model showed that socio-economic factors influenced the extent to which smallholder farmers used good agricultural practices to increase their productivity. The results revealed that socio-economic factors such as the need for extension services, hired labour, the value of assets, and distance to the produce market significantly influenced the use of GAPs. Notably, results from OLS analysis indicate that plot size, access to credit, household size, and pest scouting positively influenced potato yield. On the other hand, the distance to the agricultural extension office, off-farm income, crop rotation, distance to all-weather road, and asset value, all negatively affected potato yield. Imperatively, results from Tobit analysis showed that the asset value, distance to the produce market and all-weather road, the total volume of potato yield, and the household size had a positive effect on the participation of potato farmers in the market. Comparatively, the age of the household head negatively influenced commercialisation. Grounded on these results, the study demonstrates that socio-economic factors, for instance, distance to the agricultural office, distance to the produce market, and the value of assets, are essential determining factors of the number of GAPs used by potato farmers. Similarly, potato yield is influenced by the availability of productive resources such as credit, off-farm income, and access to extension services. Intuitively, commercialisation is determined by the increase in the total value of assets that could favour the use of GAPs, consequently leading to a surplus in production that can be offered for sale. Therefore, the study recommends the sensitization of farmers through field days and farm visits to apply good agricultural practices to facilitate high potato yields. The findings also advocate the need for a collaborative effort by the County and National government in building infrastructure that would facilitate access to produce, output markets, and extension advice. The findings on the factors that influence potato yield indicate the need for collective action by encouraging farmers to form potato production and marketing groups to enhance their ability to acquire credit facilities.

CHAPTER ONE: INTRODUCTION

1.1 Background Information

In the recent past, Potato has ranked as the topmost consumed non-grain commodity food globally, with a yearly production exceeding 388 million tons in 2017 (FAOSTAT, 2018). In Kenya, it comes second as the most significant food crop after maize (Ministry of Agriculture Livestock and Fisheries (MOALF, 2016; Mutunga, 2014). The consumption of both fresh and processed potato increased in 2013 to 41.66 kilograms per capita per year from 34.64 kilograms per capita per year in 2011 (FAOSTAT, 2014). The increase in consumption could be attributed to the past food crisis experienced in developing countries, including Kenya, when food prices continued to escalate, thereby presenting potato as an alternative food crop. For instance, during the year 2008, rice prices doubled while maize and wheat continued rising (FAO, 2008).

The uncertainty in the supply and increasing demand for food globally has placed potato among the most preferred crops for food sustainability (FAO,2010; Lutaladio and Castaldi 2009; Waaswa et al., 2021). High food prices in 2008 increased poverty and malnutrition in low-income countries (FAO, 2011). A further increase in food prices of up to 21 percent in 2010-2011 favoured the consumption of potato due to its price stability (Hoffler and Ochieng, 2008; Tadasse, 2016) and nutrient diversity (carbohydrate, micronutrients such as Calcium and Phosphorus, vitamins B and C, proteins and antioxidants) (Burlingame et al., 2009; Kaguongo et al., 2010).

The potato price stability is influenced by demand and supply factors in the local market and is not influenced by the vagaries of global market assumptions (FAO, 2011; Devaux et al., 2018).

This factor can relieve the pressure of price volatility of cereal prices on poor farmers, contributing immensely to sustainability in food production and the improvement of livelihoods. The crop has a lot of production and utilisation potential that enhances food security, according to the Malabo declaration of 2014, to end hunger in Africa and halve poverty by 2025 in its third and fourth commitments, respectively. This further will enhance the accomplishment of Sustainable Development Goals (SDGs) 1 and 2, which postulates ending poverty and hunger, realising food security, better nutrition, and stimulating sustainable agriculture, respectively, by 2030 (D'Alessandro and Zulu, 2017).

Potato is produced and consumed locally with little trade in the world market; hence, the crop is more valuable as food in sub-Saharan Africa's developing economies. The crop matures in three to four months and has a yield potential of up to 40 tons per hectare (FAO, 2019). In sub-Saharan Africa, Kenya ranks fifth in potato production with 1.5 million metric tons yields in 2017 (FAO, 2018). The crop is a significant cash crop in moderate and high-altitude areas (FAO, 2019). There are approximately 800,000 growers, cultivating 192,341 hectares of land with an annual yield exceeding 3 million metric tons in two planting seasons (FAO, 2019).

The nationwide average potato yields for Kenya were reported at 7.7 tons per hectare in 2008 (FAO, 2008). However, the current data show the considerable fluctuation of the actual yield realised from 7.5 tons per hectare to 10 tons per hectare (FAO, 2019). The potato sector in the last decade was characterised by some production constraints that led to a tremendous decline in production and yield at the rate of 11 percent per annum (FAO, 2019). This was attributed to basic agronomic techniques, low use of inputs, particularly fertilisers, deteriorating soil fertility, limited access to certified seeds, the build-up of pests and diseases (mainly bacterial wilt, late blight, and viruses) (MOA, 2005; Kaguongo et al., 2010; Salami et al., 2010).

More current research attributes the decline in yield to smallholder farmers who produce over 75 percent of the total yield mainly for subsistence, using traditional technologies with small landholdings averaging 2.5 hectares (Harahagazwe et al., 2018). There are only a few smallholder farmers who engage in semi-commercial or commercial production due to low asset base, labour and resource constraints, as well as low literacy levels (Parker et al., 2019).

According to Mwangi et al., (2014), rainfall disparity was the primary cause of declined potato yield at 45 percent, while the unavailability of clean seeds and crop diseases were at 33 and 6 percent, respectively. Other factors, such as inaccessibility to field officers, cash constraints, and small land sizes inhibit the realisation of higher yields (Harahagazwe et al., 2018). Consequently, the low yield has also affected the level of market participation by potato farmers (Olwande and Mathenge, 2012; Muricho, 2015). However, with the adoption of Good Agricultural Practices (GAPs), there is potential for an increase in potato yield and, consequently, farmers' participation in the market.

Good Agricultural Practices in this study are regulations applied to on-farm production and post-production practices aimed at enhancing optimum agricultural yield while considering economic, social, and environmental sustainability (FAO, 2008; Wollni et al., 2010). They include the use of certified seed, land preparation, weeding and hilling, crop rotation, and integrated pest, disease, and weed management systems; fertiliser application, use of manure, and spacing (Zhongqi et al., 2012). The use of GAPs would provide an opening for farmers to increase potato yield, offer their produce for sale in the market, translating to higher income. Diversification of their revenues would consequently reduce poverty and enhance food security.

1.2 Statement of the Research Problem

The current trend of potato production in Kenya is characterised by low supply, which is insufficient to meet the aggregate demand in urban regions. This has further been aggravated by the use of traditional methods of farming, notably planting non-certified potato seed, continuous cropping, application of low ratios of inputs, and rudimentary seedbed cultivation techniques (Olanya et al.,2012; Okello et al., 2019). Traditional farming systems have made farmers susceptible to the vagaries of weather and, in turn, contribute remarkably to the decline in the potato yield and, consequently, low levels of market participation.

To mitigate the constant realisation of low potato yields, GAPs have been incorporated in production as well as post-harvest activities. It has been shown that Good Agricultural Practices (GAPs), particularly the use of certified seed, fungicides, and fertilisers, when adopted as prescribed, could result in more than doubling of the current potato yield (Wang'ombe and Van Dijk, 2013). This will consequently increase the household level of commercialisation.

Past research on GAPs focused on the individual effect of each GAP on yield, for instance, use of fungicides to control bacterial blight (Champoseau et al., 2009), use of certified potato seed (Okello et al., 2016, 2017), Integrated Pest Management (IPM), crop rotation (Larkin et al., 2011) and fertiliser application (Zebarth et al., 2009). The above studies found that the GAPs applied appropriately led to effective pest and disease control and an increase in soil fertility as well as a tremendous increase in potato yield (Senanayake and Rathnayaka, 2015; Okello et al., 2016). These studies only concentrated on the individual effects of each GAP and omitted the collective impact of selected GAPs on yield as well as market participation.

The government and research bodies have acknowledged the decline in potato yield and have come up with modern technologies that improve productivity. Specifically, CIP has invested in the development and dissemination of GAPs geared towards improving potato yield. More so, investment in advanced technologies such as “3G revolution” rapid multiplication (aeroponics and tissue culture) of pre-basic seed has been funded and actualised by CIP (Okello et al., 2016), GIZ (GIZ-PSDA Kenya, 2011), and KALRO-Tigoni (Kaguongo et al., 2010). GAPs have, therefore, been developed over time, but their collective effects on production and marketing have not yet been established.

Further, the use of the GAPs has not been adopted wholly, and their contribution to yield and market participation is still not established. Equally, the driving force in the adoption scenario of GAPs and the effects of the level of adoption have remained unclear. Therefore, it would be prudent to examine the empirical evidence on the effect of the use of selected GAPs on yield and volumes sold.

1.3 General Objective

The primary objective of this study is to assess the effects of the use of Good Agricultural Practices on potato production and marketing in selected areas of Kenya.

1.3.1 Specific Objectives

The specific objectives of the study are:

1. To examine factors that influence the intensity of use of GAPs by potato farmers.
2. To assess the effects of the use of GAPs on potato yield.
3. To examine the effects of the use of GAPS on market participation by potato farmers.

1.4 Hypotheses

1. Socio-economic factors (age, gender, and level of education) do not influence the intensity of use of GAPs by Irish potato farmers.
2. The intensity of use of GAPs does not influence potato yield.
3. The intensity of use of GAPs does not influence the level of market participation by potato farmers.

1.5 Justification of the Study

According to the potato strategic plan 2009-2014 (KARI, 2009), the constraints of the potato sector are aggravated by a poorly established seed potato system, an insufficient supply of quality seed, and porous international borders tolerating unlawful entrance of seed and ware potato. The above constraints in the seed sector have been addressed by the budding local, regional, and global markets for seed, ware, and value-added potato products. The expansion of production to low altitude and marginal areas liberalised the market for seed and ware potatoes, which is further supported by the membership to international bodies such as International Labour Organisation (ILO), Organisation for Economic Cooperation and Development (OECD) seed schemes, International Plant Protection Convention (IPPC), and World Health Organisation (WTO).

Good Agricultural Practices are essential in increasing yield and the sustainability of the potato sub-sector (Otim & Mwesigwa, 2020). This is in line with Kenya's vision 2030, which seeks to spur economic growth through agriculture (Ministry of Planning, National Development and Vision 2030 (MoPND, 2008; Nyagaka et al., 2010). The government's Big 4 Agenda is centred in Kenya's Agricultural Sector Transformation and Growth Strategy (ASTGS) that is aimed at eliminating hunger, food insecurity, and malnutrition (Kirimi, Makau, and Ochieng, 2019).

GAP principles ensure that potato production is economical and efficient, therefore contributing to food security by providing a constant supply of food. This is in line with the realisation of the regional Comprehensive Africa Agriculture Development Programme (CAADP) on the execution of the Malabo Declaration on promoting food security and SDGs 1 and 2 by ending poverty and promoting sustainable agriculture (D'Alessandro & Zulu, 2017; Makombe, Tefera and Benin, 2018). GAPs will also encourage proper post-harvest management, value addition, and soil and water conservation.

The outcomes of the study addresses policy issues on the importance of potato as a source of food security, production of quality ware potatoes, empowerment, and active involvement of farmers in potato marketing (The Government of Kenya, 2008). It also offers guidance on public-private partnerships, i.e., non-governmental organisations and the private sector, to meet the needs of consumers such as growers and processors.

Further, the results of this study benefits smallholder potato farmers in the area of research since it encourages them to use Good Agricultural Practices. This will, in turn, increase potato yield and consequently enable the farmers to have a higher volume of sales hence market participation. It will also inform development projects in the area, such as those put in place by GIZ-CIP, for instance, to enable farmers to access certified seed and the market for their ware and seed potato production.

1.6 Study Area

The study was conducted in two areas of Kenya, i.e., Bungoma and Nyandarua County (see appendix 3). Notably, the Bungoma region is a high-altitude area generally characterised by smallholder farming and has poor infrastructure. Bungoma region is located on the south-eastern slopes of Mt. Elgon. The region has an area of 944 square Kilometres, with a populace of 78,873 (KNBS, 2019). Bungoma is also characterised by extensive potato cultivation; however, the linkages to the produce market are poor. The farmers have limited resources hence postulated to have a low adoption rate of GAPs.

Nyandarua County, on the other hand, ranks highest in potato production and has good support linking farmers to the input and output market. Moreover, the farmers are well endowed with resources hence hypothesised to have a higher adoption rate of GAPs. Nyandarua County has a population of 638,289, with 179,686 households and an area of 3,285.7 square Kilometres. The Population density is 194 people per square kilometer. The area is divided into two sub-counties: Nyandarua-North and Nyandarua-South (KNBS, 2019). The two Counties Nyandarua and Bungoma, were selected for the study because of significant potato production in the area.

CHAPTER TWO: LITERATURE REVIEW

2.1 Overview of Potato Production in Kenya

2.1.1 History of Potato Production in Kenya

The crop was first introduced in the central highlands of Kenya, in Kiambu, Murang'a, and Nyeri counties, in the late 19th century for subsistence, then later for export. Improved potato varieties were introduced in the country in 1903. Seed potato production was further presented in National Agricultural Research Laboratories (NARL), Kabete, and Plant Breeding Station Njoro in 1927 (Republic of Kenya, 2011).

In 1963, the Government of Kenya promoted potato production by introducing modern varieties from Germany. The Potato Development Programme in 1967 rationalized the production of certified seeds and disease-resistant varieties. In 1979, the Agricultural Development Corporation (ADC) collaborated with the Kenya Farmers Association (KFA) and established a commercial seed potato programme to produce and market seed potatoes. After 1990, seed potato production faced setbacks due to reallocation and fragmentation of ADC and Kenya Agricultural Research Institute (KARI) farms, which were previously used for research and production (Republic of Kenya, 2012). Certified Seed Potato (CSP) produced in Kenya at the turn of the decade was less than one percent of the grown seed (Muthoni et al., 2013), and the shortage of clean seed makes farmers obtain seeds from informal sources, for instance, self-supply, local markets or neighbours (Nyongesa & Schulte-Geldermann,2015).

The shortage in supply of potato seed was attributed to limited funding of government agencies mandated to breed seed, insufficient land for multiplication of basic seed, and low capacity of cold rooms for storage of basic seed awaiting dispatch (Riungu, 2011). More recent data shows that the informal seed supply system translates to the use of inferior seeds, which trigger the spread of seed-borne diseases, for example, bacterial wilt and, consequently, low yields (Okello et al., 2017, 2019).

The problem of seed shortage can be addressed through modern seed propagation techniques such as tissue culture to raise potato plantlets and aeroponics and hydroponics for rapid tuber multiplication (Ministry of Agriculture Livestock and fisheries (MOALF, 2016). Sustainable potato production relies on modern varieties and a vigorous seed certification scheme, which assures both the breeders and seed suppliers that their products are safe and high-quality (MOALF, 2016). Further, the use of clean seed alone is not sufficient to realise optimum yields; hence the need for improved agronomic practices in potato production cannot be overemphasised (Kaguongo et al., 2010; Nyongesa et al., 2012). The recent initiatives by CIP, specifically the development of GAPs, aim to increase potato yield in the study area (Okello et al., 2019).

2.1.2 Current Trends of Potato Production in Kenya

The potato is predominantly grown in high-altitude areas of 1500-3000 meters above sea level in Kenya. They thrive well where maize has no comparative economic advantage. These areas include Nyeri, Kiambu, Murang’a Tharaka- Nithi, Nyandarua, Bungoma and Kirinyaga counties. Potato also thrives well in the highlands, such as Mau Narok, Taita, Molo, Nandi, Kericho, Kisii, and Cherangani hills (FAO, 2019). In the highlands, farmers cultivate up to three planting seasons in a year (3 to 4 months per season) compared to maize, which has only one planting in areas such as Molo and Bungoma.

The current yields in Kenya stand at an average of 7.8 tonnes per hectare (FAO, 2019). However, using modern farming practices, progressive farmers can produce 25 tonnes per hectare in similar rain-fed conditions as their neighbours, who realise 5-6 tonnes per hectare (Schulte-Geldermann, 2013). This difference in yield is attributed to the use of uncertified seed potato (Okello et al., 2017), low yielding varieties, poor disease control (Olanya et al., 2012), and poor soil fertility management (Kamau et al., 2019). Further, variations in rainfall, soil degeneration due to continuous cropping, and lack of contact with field officers, have contributed tremendously to the realisation of low potato yields (Mwangi et al., 2014).

Lack of clean seed potato further has resulted in using of low-quality seed as reported by Okello et al., (2016). They observed that 65 percent of the respondents planted seed potato mainly from the neighbours as well as the local market. About 95 percent of the seed potato that was purchased locally was of low quality. Such tubers propagated using low-quality seed have poor keeping quality after harvesting; thus, they cannot cushion farmers against low selling prices offered by middlemen during glut season (Muthoni and Nyamongo, 2009). Diseases, on the other hand, such as potato blight and bacterial wilt, are the most common diseases encountered by farmers in Nyandarua and have also contributed to pre and post-harvest losses (Karanja, 2018).

According to Muthoni and Nyamongo (2009), Irish potatoes contribute to national food and nutritional security. This was also echoed by Wambugu et al., (2010) and Abdeldaym et al., (2018), who stated that GAPs used in potato production could improve yield and therefore offer a consistent source of livelihood when planted as a cash crop and source of food by farmers.

2.2 Good Agricultural Practices (GAPs)

Good agricultural practices are farmer practices that are applied during production and post-harvest activities to enhance the realisation of high yield while ensuring cost minimisation as well as environmental conservation (Rockstrom et al., 2009; Wollni et al., 2010). The two leading GAP principles are soil and water management practices, which mitigate and assist farmers in adapting to the vagaries of weather (Delgado et al., 2011). This is achieved through minimum tillage, hand-weeding, and incorporating crop residue in the seedbed to promote the conservation of natural resources (Issahaku & Abdulai, 2020).).

To enhance sustainability in potato production through maintaining viable farming practices and contributing to livelihoods, the adoption of GAPs could result in higher potato production. GAPs can be applied to a vast category of farming systems of different scales through improved agricultural sustainable practices, for example, integrated pest, weed, and disease control, soil and water conservation, as well as fertiliser management (Nyongesa et al., 2012; Kassie et al., 2013).

Some of the GAPs that merit consideration in this study include crop rotation, ideal land preparation, correct spacing, and the use of certified seeds. Others are weeding, hilling, pesticide application, and fertiliser application. All these can increase potato yield, enhance soil productivity, decrease the build-up of pests and diseases and enhance the addition and recycling of nitrogen (Larkin et al., 2011; Abdeldaym, 2018).

Potato can be grown in rotation with cereals before leguminous crops and not with plants of the Solanaceae family that are susceptible to the same pests, weeds, and diseases. Current studies indicate that rotation with brassica, perennial rye grass, and mustard reduced the incidences of soil-borne diseases such as powdery scab by 31-55 percent (Larkin and Lynch, 2018; Uwamahoro et al., 2018).

Land preparation should be carried out with minimal soil disturbance. The most suitable soils are deep, well-drained, aerated, and enriched with organic matter. Similarly, correct spacing is determined by the potato variety, tuber size, and cultural practices such as slight ridging. The use of low-quality seed potato has been a significant setback to productivity, according to Kinyua et al., (2001). The unavailability of clean seed has led to a tremendous deterioration in the quality and quantity of produce, as well as the continuous spread of pests and diseases (Riungu, 2011). The application of certified seed obtained from breeders, multipliers, seed merchants, or through positive selection (Gildelmacher et al., 2007) can improve yield by 70 percent (Muthoni et al., 2013). The seed plot technique also empowers farmers to produce seed potato free of bacterial wilt (Kinyua et al.,2005). Current data also shows that the use of CSP by farmers has the potential to increase potato yield by 2975 to 9521 kilograms per hectare (Okello et al., 2017).

Weeding should be done after one month of planting or at the height of 20cm to smother weeds and give the crop a good start. Weeding also reduces the crop's susceptibility to Irish potato pests and diseases, as documented by Korres (2018). Further, weed control can be done with hilling to protect tubers against greening and prevent the stolons from being aerial crops.

Pesticide application through chemical spraying should be done only when necessary as a precaution against insect pests (potato tuber moth, potato beetle, and leaf miner fly) and diseases such as bacterial wilt (Champoseau et al., 2009). This can help avoid high yield and quality losses. IPM practices (pest scouting, crop rotation, clean seed, use of resistant varieties, and use of natural enemies) to reduce agrochemical application costs cannot be overemphasised (Arslan et al., 2014; Waaswa et al., 2021).

Fertiliser application during land preparation, planting, and topdressing should be done appropriately to minimise fertiliser residue in the ware potato (Belanger et al., 2003). This can be achieved by analysing soil and crop nutrient requirements; for instance, potato crop requires potassium, phosphorus, and magnesium, which are deficient in acidic soils (Muzira et al., 2018). To enhance the quality of tubers, the most recommended complete fertiliser ratio is NPK 1:1:1 applied in splits (Burton et al., 2008) after soil analysis to evaluate the soil nutrient content. In addition, organic manure can be used to provide the right nutrient balance, improve soil structure, and control soil erosion. Organic manure can be applied at the start of a new rotation programme to enhance crop growth and yield productivity, as explained by Achiri et al., (2018) and Johnston and Poulton (2018), independently.

2.2.1 Selected Studies on Good Agricultural Practices

The control of common potato pests and diseases, for example, bacterial wilt, late blight, potato blackleg, viruses such as Potato Leaf Roll Virus (PLRV) and Potato Virus Y (PVY), is cumbersome since they are transmitted through infected seed and soil (Champoseau et al., 2009). When viruses are disseminated in tubers, yields are reduced by 50 percent (CIP,1996; Kakuhenzire et al., 2013). IPM practices consist of environmentally friendly pest management strategies, which include: phytosanitary measures (use of clean planting material and isolation), cultural practices (crop rotation, intercropping, and timely planting), use of agrochemicals, and biological control (Champoseau et al., 2011).

Conversely, most of the above measures are ineffective, impractical, and expensive; hence many farmers do not use them (Otipa et al., 2010 and Riungu, 2011). In this scenario, the use of disease-resistant seed could enhance sustainability and the integration of farmers through participation in rural appraisal forums, selection of varieties, and plant breeding. The farmer preferred traits that breeders often fail to capture (high yield, resistance to late blight and bacteria wilt, cookability, chipping quality, taste, early maturity, high market demand, tuber size, and drought tolerance) often translates to low use of certified seed (Fukuda and Saad, 2001; Okello et al., 2017).

Further, the principal objectives that have been captured by breeders recently include good yield under both conventional and improved soil fertility practices. Similarly, the right diameter, good processing quality, resistance to late blight, and cookability have equally been considered during breeding (KARI, 2009). Other breeding traits, such as those suitable for smashing, are found in the *Asante* variety (Kaguongo et al., 2010). These breeding objectives have failed to capture the influence of cultural practices on potato productivity. It will, therefore, be prudent to focus on the collective effect of the use of pest and disease scouting, crop rotation, and pesticide application, amongst other GAPs, on potato yield. A study by Kaguongo et al., (2010) established that 53 percent of farmers in Kenya had implemented improved varieties in comparison to 77-88 percent of farmers in Uganda. The farmers grew improved varieties as pure stands, although some farmers practiced mixed cropping. They observed that the percentage of area under high yielding varieties was higher for Uganda compared to Kenya.

The farmers in both countries chose their varieties based on specific traits that matched their production and marketing conditions. Such characteristics were as follows: yield level, taste, time of maturity, marketability, suitability for smashing, drought tolerance, big tubers, and resistance to late blight. The low adoption rate of high-yielding varieties in Kenya has contributed to the decline in potato yield (Okello et al., 2017). It is imperative to further examine the use of certified seed as one of the GAPs and its formed effect on yield as well as market participation.

Crop rotation has been an integral practice of potato production since the agrarian revolution. Extended rotations and fallow periods between potato growing times of the year were developed by the Incas in South America to intensify soil fertility and reduce the build-up of soil-borne pests and diseases (Champoseau et al., 2011). A study by Larkin et al., (2011) showed that Canola and rapeseed rotations portrayed significant differences in the control of common scab with average disease severity significantly lower than continuous potato, leading to 25.3 percent disease reduction. Barley rotation led to the lowest levels of wilt among rotations. The actual use of crop rotation by potato farmers in Kenya is not precisely known. Further, its effect on potato yield has not been documented in the study area.

Organic manuring is the application of plant and animal residue into the soil to enhance soil fertility, according to Johnston and Poulton (2018). Application of green manure and farmyard manure resulted in improvement in soil fertility and structure and a substantial increase in soil microbial community activity (Achiri et al., 2018). According to Muthoni et al., (2013), green manure from Sudan grass led to a 30-80 percent reduction in Verticillium Wilt and improved tuber quality and yield. Similarly, poultry manure increased crop vigour and yield, as explained by Johnston and Poulton (2018). Examining the actual use of organic manure and its influence on potato production in the study area is inevitable.

Fertiliser management (nitrogen fertiliser) is essential for the realisation of high tuber yield and quality (Zebarth et al., 2009). Studies done in Eastern Canada gave recommendations of general nitrogen fertiliser of between 125 Kg per hectare and 200 Kg per hectare (Centre de recherché en Astronomie Astrophysique et Geophysique (CRAAG), 2010). Nitrogen deficiency symptoms include stunted growth, small tuber sizes, and reduced yield (Belanger et al., 2003), while excessive Nitrogen application can lead to delayed crop maturity, low tuber quality, and excessive leaching of nitrates (Burton et al., 2008). Fertiliser application levels were projected to represent at least 40 percent of the production costs for potato, according to Wambugu et al., (2010). The timely application of fertiliser with the correct formulation was paramount. The actual use of fertiliser in reference to the quantity and timing of application by Irish potato farmers in Kenya is not precisely documented. This study examines the use of fertiliser as one of the GAPs; its subsequent effect on potato yield is important.

A study by Senanayake and Rathnayaka (2015) used the level of adoption to measure the intensity of use of GAPs. The study used values (0-100 percent) influenced by the number of practices implemented by each farmer of the recommended fifteen practices. They divided levels of adoption into three categories; good adopters had more than 73 percent, while poor adopters had less than 53 percent. They found that majority of the farmers (40 percent) had a moderate level of adoption, while the good and poor adopters were 27 percent and 33 percent, respectively. They also observed that the high adopters had a higher income, which resulted from higher potato yield; the returns versus costs are, however, not quantified. The findings of this study will be applicable in examining the intensity use of GAPs in the current study area.

However, the current research further investigates the effects of these GAPs on potato yield and farmers' market participation.

2.3 Selected Literature on Market Participation

As defined by Jaleta and Gebremedhen (2010), market participation is the amount of produce offered to the market and the use of purchased inputs by smallholder Irish potato farmers. Market participation is limited by institutional and standard production constraints (capital, land, labour, technology). This defines the choices made by farmers considering transaction costs and hence the effectiveness and practicability of market participation (Jagwe et al., 2010; Emana et al., 2015). Wambugu et al., (2010) found that producer organisations that were more heterogeneous performed better than homogenous ones due to the presence of social capital. However, this study examines the effect of membership to groups on the use of GAPs and the level of market participation by the potato farmers.

The farmers that operate on a small scale have a competitive advantage over large-scale farmers because of their local awareness and ability to obtain inexpensive labour from household members (Obare et al., 2010). However, they are exposed to relatively higher production costs, decreasing their motivations for market participation because they purchase inputs in small quantities involving recurrent transactions (Okello et al., 2017). Small scale farmers have often circumvented this phenomenon by forming activity groups, like cooperative societies. It became necessary to analyse if indeed there was any effect of group membership on market participation by small-scale farmers in the study areas, a mechanism for lowering transaction costs and bargaining for better prices for their output in the market.

Substantial literature (see: Markelova and Mwangi, 2010; Fischer and Qaim, 2011a, b; Olwande and Mathenge, 2010; Wambugu et al., 2010) indicates that group membership among smallholder farmers enables them to overcome market imperfections. According to Mukundu et al., (2013), membership in producer groups had a positive impact on market participation by smallholder sweet potato farmers in western Kenya. The variable was statistically significant at 10 percent. This implied that membership to a group increased the probability of a farmer offering the produce for sale.

Their results were consistent with Jagwe et al., (2010) and Okello et al., (2017), who also argued that membership to producer groups could provide avenues for forming social capital through which farmers could acquire market information at lower costs. Membership to potato production or marketing group was also included as a variable in the current study.

CHAPTER THREE: METHODOLOGY

3.1 Conceptual Framework

Figure 1 is a representation of the variables explored in this study.

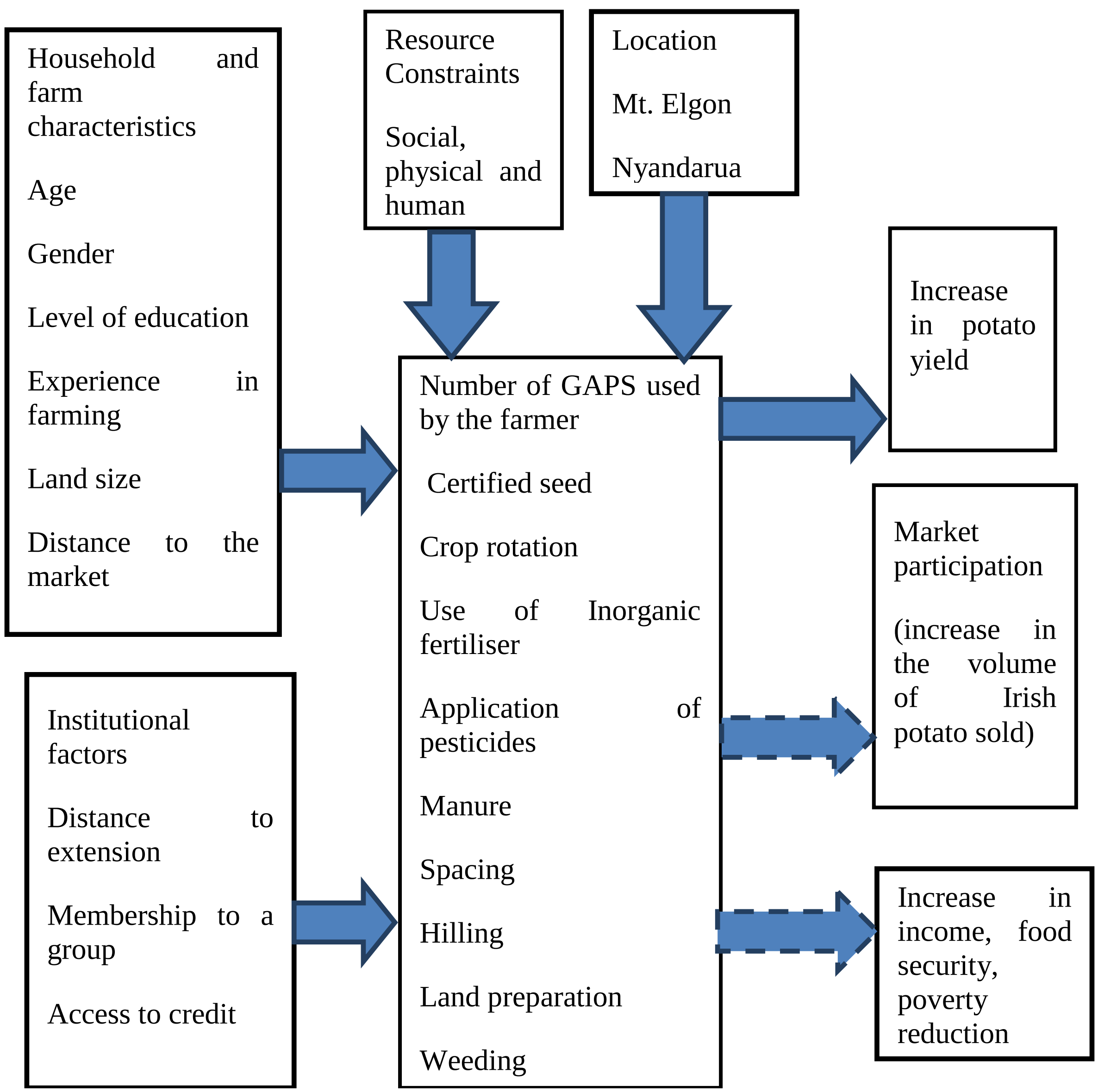

Figure 1: Conceptual Framework

Source: Author's conceptualisation, (2016) This study was conceptualised as a decision-making practice, where farmers who use the selected GAPs were expected to realise high yields and therefore participate in the market. The variables explored in this study were hypothesised to influence the number of GAPs used by farmers. An independent variable causes the changes in the dependent variable, which the researcher wishes to explain (Kothari, 2004; Kirui et al., 2012). From the conceptual framework, the number of GAP practices that the i^{th} farmer wished to adopt would be determined by the location dummies, farm characteristics such as land size and distance to the input and output market, socio-demographic characteristics, institutional factors, and cost constraints.

Further, farm characteristics such as distance to the market captured travel time and related costs that influenced commercialisation, as explained by Muricho (2015). Extensive distances were postulated to lower farmers' involvement in the market because of transportation costs. According to Gebre et al., (2019), institutional factors, for instance, access to extension agents, positively affected both the use of GAPs and market participation since it increased the availability of market information essential for decision making.

Location, on the other hand, i.e., Bungoma and Nyandarua County, were included to cater for any agro-potential variations and socio-economic differences that could be present within the household across the sub-regions of the research. Geographical location was also expected to influence proximity to major markets, hence affecting the farmers' decision and intensity of market participation (Jagwe et al., 2010).

Socio-demographic factors such as the age of the household head were used to account for the farmer's attitude towards risk. An increase in age was expected to have a significant effect on the use of GAPs since older farmers could make critical decisions that would have an impact on the welfare of the family (Sebatta et al., 2014). However, this variable was projected to negatively affect market participation since older farmers naturally tend to be risk-averse. Gender was anticipated to capture the variations in tastes and preferences that exist between men and women. For instance, women were postulated to have a higher likelihood of joining groups, which in turn enhanced the use of GAPs but less inclined to market participation (Mukundi et al., 2013). Also, a higher percentage of males were hypothesised to make decisions on participation and the volume of products offered for sale (Okonya et al., 2019).

Household size, conversely, affected the supply of family labour and household consumption levels (Mathenge et al., 2010). A larger household size was expected to enhance participation in the market if they were labour efficient and vice versa. The number of years of formal education of the household head measured the capital endowment of the household. Many years of formal education were expected to empower farmers to make informed decisions and identify existing market opportunities (Sebatta et al., 2014). This would increase market participation because farmers could utilise market information hence reducing transaction costs, thereby making market participation worthwhile.

Experience in Irish potato farming was expected to influence the use of GAPs as well as market participation. This would influence the social networks and linkages with agricultural agents and market players, which are built with time. Such relationships reduce fixed transaction costs incurred while searching for buyers, contracting, discussing, and enforcing contracts (Jagwe et al., 2010). Land size represented by the number of acres is a physical production resource; hence a larger parcel of land was expected to give a larger yield (Prarakar et al., 2010). It was also considered as security for credit that would heighten the use of GAPs and increase agricultural productivity. On the other hand, off-farm income was considered an indicator of household income diversification, which could increase the use of GAPs and lower market participation (Osmani and Hussain, 2015). Therefore, the use of GAPs was considered to be influenced by socio-economic characteristics, institutional factors, regional and farm-specific characteristics.

3.2 Theoretical Framework

Expected Utility Theory (EUT) postulates that a farmer compares a new technology with the traditional and adopts the former if the expected utility from adopting it is higher than the expected utility of the conventional technology (Batz et al., 1999). Since the utility function cannot be observed, the relationship between the expected utility to each alternative is hypothesised to be a function of the vector of explanatory variables and an error term (Adesina and Zinnah, 1993; Batz et al., 1999).

The EUT views farmers as rational with the aim of maximising utility, which is achieved through profit maximization (Edwards-Jones, 2006). By including the attitude towards risk, farmers maximise the expected utility of profit, rather than the expected profit (Ghadim and Pannell, 1999). In EUT, variables such as farm, household, and farmer characteristics, farming context, and access to information are expected to influence the decision to adopt a technology or an innovation.

EUT was used in this study in conjunction with the production theory of the firm as it expounds on the maximum utility a farmer can obtain by using the i^{th} number of total GAPs considering the following explanatory variables: farm and household characteristics, socio-demographic characteristics, distance to market, social network and extension.

3.3 Empirical framework

The study defined linkages between the intensity of use of GAPs, potato yield, and market participation. The variables that were explored in this study include: the intensity of use of GAPs, yield, market participation, socio-demographic, farm-specific, asset endowment, institutional factors, and geographical characteristics

3.3.1 Dependent variables

- Intensity of use of GAPs – this count variable considered the total number of GAPs used by farmers in the previous cropping season.
- Yield- this count variable was measured in Kilograms per acre of land as the total amount of potato harvested in one year.
- Market participation- household commercialisation index (HCI)- this was estimated as ratio of the volume of a total potato sold to the total volume of potato produced.

3.3.2 Independent variables

The independent variables that were postulated to influence farmers' use and intensity of use of GAPs were categorised into five, namely socio-demographic, farm-specific, asset endowment, institutional factors, and geographical characteristics.

i. Socio-demographic variables

The variables explored in this category were age and gender**.** Previous studies indicated that the age of the household head had a substantial influence on the adoption of new technologies (Doss and Morris, 2001). Older farmers tend to have more resources compared to the younger ones; therefore, resource endowment could lead to an increase in the use of GAPs (Kassie et al., 2013). Age was consequently conceptualised to increase the utilisation and intensity of the use of GAPs. However, at some old age, the use of new technology was expected to decline due to risk aversion that increases with age (Doss and Morris, 2001; Marete et al., 2019).Gender, on the other hand, was coded as a dummy, signifying the sex of the household head (1=male, 0 = female). Earlier research showed that gender influenced the decision making regarding the use of new technology (Doss and Morris, 2001; Nkomoki, Bavorová, and Banout, 2018). In Sub-Saharan Africa, males had more access to productive recourses than their female counterparts (Adesina and Zinnah,1993; Muriithi et al., 2018). It was therefore assumed that male-headed households would use more GAPs, specifically fertiliser and certified seed, more than their peers (Lamontagne-Godwin et al., 2018).

ii. Farm-specific characteristics

Distance to the nearest market, a continuous variable, was measured in walking minutes. The farmers' proximity to the market reduced transaction costs of time and labour spent by the farmer while transporting their produce to the market. The other advantage expected was that farmers closer to the market gained more knowledge about the market and, therefore, a reduction in transaction costs of market research (Olwande and Mathenge, 2012; Tirkaso and Hess, 2015).

Consequently, it was expected that the distance to the nearest market would positively affect the household's extent of use of the GAPs.

Distance to the agricultural extension office was also measured in walking minutes. It was theorised that nearness to extension officers (and hence more contact) would enhance the likelihood and intensity of adoption of GAPs. Following Wossen et al., (2017), closer proximity to the agricultural extension office was used as a proxy for access to extension services, facilitating awareness and usage of the practices.

The variable harvested immature potato was used to identify the farmers' knowledge of the potato production cycle. It was hypothesised that farmers who harvested potato before maturity had a lower likelihood of adopting GAPs (Waxman et al., 2018). Potatoes harvested early have thin skins and tend to rub off easily, compromising storage quality and market prices.

iii. Resource constraints

a) Value of assets, specifically possession of physical assets and off-farm employment, was conceptualised to meet the costs of adoption and therefore affect the likelihood and intensity of using GAPs as documented by Tirkaso and Hess (2015) and Jelsma et al., (2019).
b) Human capital was captured through the level of education of the household head and experience in farming. Education level was estimated by the number of years of formal learning. Consistent with previous studies, the education level was anticipated to have a significant effect on the extent of the use of GAPs. It was assumed that farmers with more years of education could understand the benefits of GAPs and therefore use them (Gars & Ward, 2019).

c) Social capital (membership to farmer group) was coded as a dummy variable (1= farmer group member, 0= Otherwise). Farmers formed groups for collective action (pool resources together). Previous studies indicated that membership to groups had a positive effect on the adoption of new farming techniques. (Kassie et al., 2013; Nkomoki et al., 2018).

iv. Regional characteristics

County of the survey: this was either Bungoma or Nyandarua. The survey regions were entirely different regarding socio-economic and cultural backgrounds and on the level of market participation. Bungoma is characterised by smallholder potato farmers with limited resources and poor infrastructure linking production zones to output markets. Comparatively, Nyandarua is well endowed with resources and proper infrastructure that links the region to significant output markets. It was therefore conceptualised that this variable would influence the use and intensity of use of GAPs.

v. Institutional factors

Group membership, credit access, and interaction with extension officers were postulated to significantly affect the use of GAPs and market participation by potato farmers. The need for and getting credit was used as a proxy for access to credit facilities following Donkoh (2020). Ease of access to credit facilities improved the technical efficiency of sample farmers in Nicaragua, according to the findings by Abdulai and Eberlin (2001) and Alene and Manyong (2006) for farmers in Nigeria.

Additional research in Haiti also found out that farm households who had access to credit were more technically efficient than their counterparts (Dolisca and Jolly 2008). Availability and accessibility of credit enabled farmers to attain efficiency in production by providing capital, which increased their purchasing power and implementation of farm management decisions on time, thereby increasing productivity. Donkoh (2020) also found out that access to credit significantly determined the adoption of sustainable agricultural practices.

An increase in human capital would boost farmer productivity through the allocation of family-supplied and purchased inputs better; the use of the right quantities and application of accessible and acceptable techniques increased farm income (Abdulai and Eberlin, 2001). The study observed that regular visits by extension agents had a positive influence on technical efficiency. According to Bozoglu and Ceyhan (2007), extension agents inform, motivate, and educate farmers on the current technologies, as seen on vegetable farmers in Turkey. In a study conducted by Seyoum et al. (1998) in Sasakawa- Global 2000 project, there was a 14 percent variance in technical efficacy between farmers who accessed extension agents and those who did not.

3.3.3 Empirical Literature

Several studies have been conducted, concerning the constraints facing the potato subsector and the continuous decline in yield. For instance, Wang'ombe and Van Dijk (2013) studied low potato yields in Kenya anchored on whether the traditional use of inputs led to a disparity in yield. They used Linear and non- Linear Regression models. The results indicated that input innovations such as good quality seeds had the highest effect on yield, followed by irrigation, fungicides, and fertiliser use in that order. However, only 45 percent of the respondents used clean seed; irrigation was at 20 percent; fertiliser and fungicide use was at 92 percent and 96 percent, respectively. The variables with potentially good effects do not seem to have equally good adoption, a phenomenon that raises curiosity.

Wang'ombe and Van Dijk (2013) also found that level of education and farm visits by extension officers had positive and significant effects on the use of input innovations. Land size, number of cows, gender, age, employment status, and location were negative and not significant. The current study would benefit from examining a similar set of explanatory variables and their effect on the intensity of use of GAPs, yield as well as the level of market participation by potato farmers.

Other studies by Ghebreslassie et al., (2014) also observed that 98 percent of the farmers practiced crop rotation with legumes and vegetable crops. Farmers mostly used Di-ammonium phosphate (DAP), Urea, and Farm Yard Manure (FYM). Farmers also used insecticides and fungicides for pest and disease control. However, these studies did not examine the collective effect of GAPs such as certified seed, fertiliser, and pest and disease control on potato yield and farmers' market participation in the study area. Okello et al., (2017) found a positive effect of using CSP on yield, application of inputs, and food security. They observed that farmers who used certified seed produced more yield per hectare of land, sold more, and hence earned more income from sales than the non-users. They used linear regression and PSM to determine the effect of CSP on yield. The use of OLS to determine the effects of GAPs on potato yield is given due consideration here.

Socio-economic factors, for example, access to credit, extension services, plot size, off-farm income, and farmer characteristics such as education level, age, and gender, were significant in determining farm yield in Siaya County (Obiero, 2013). Descriptive statistics were applied to explore the effect of socio-economic factors on farm yield. It would be interesting to explore the influence of farm and farmer characteristics on the use of GAPs as well as potato yield and volume sold in Kenya

A study by Sebatta et al., (2014) was done using Ordinary Least Squares (OLS) regression and two-stage Heckman model to determine the decision of farmers' participation in the market. The study results showed that gender, the price of potato, access to the village market centre, extension agents, and level of education were significant in the decision to participate in the market. Conversely, off-farm income had a significant adverse effect on the level of market participation. Gender and group membership significantly influenced the volume of produce sold in the market by smallholder farmers. However, the influence of GAPs on the volume of potato sold have not been examined in the study area. Also, the present research used a Tobit model instead of OLS because some of the farmers did not offer any produce for sale. Mutai et al., (2013) used cross-sectional data and Multinomial Logit to identify the factors influencing the choice of different markets in Vihiga County, Kenya. They found that access to credit and extension agents, income, mode of transport to the marketplace, age, value addition, and amount of sweet potato offered for sale influenced market participation in the local market. On the other hand, the mode of transport, land size, volume of sweet potato, and gender affected participation in the regional market. The current study examined these factors, including GAPs, on their influence on potato volumes sold by small-scale farmers.

Muricho (2015) studied the determinants of agricultural commercialisation and its impact on welfare among smallholder farmers in Kenya. He used two-step switching regression models on panel data to determine the effect of agricultural marketing on household food security and poverty. He also used the household commercialisation index to measure the proportion of the value of agricultural yield sold in the market and purchased inputs in the total value of agricultural production. He found that 75 percent of the surveyed farmers were commercialised.

The mean commercialisation intensity was 37 percent, with the commercialised households selling about 37 percent of the value of all the crops they produced. Explanatory variables such as gender, level of education(years), asset ownership, and farm size were found to be significant in determining Agricultural commercialisation. The approach used seems desirable hence can be adopted in similar studies. Kirui et al., (2012) used the Negative Binomial Regression Model (NBRM) and Poisson Regression Model (PRM) to examine the use of the mobile phone to transfer money among small-scale farmers in Kenya. The study found that the number of crop enterprises, occupation, age, distance to output market, and level of education, the value of assets, household size, crop income, and ownership of mobile phones influenced the intensity of use of mobile phone transactions for agricultural purposes. NBRM tends to predict zeros for counts from one to three; however, when compared together with PRM using the dispersion parameter α, NBRM is reduced to PRM when α =0, illustrating that the models are nested (Greene, 2008). It is imperative to consider the possibility of overdispersion against the suitability of other models than PRM in investigating the intensity of use of GAPs among smallholder potato farmers in Kenya.

3.4 Intensity of Use of GAPs: Estimation of Count Variable Regression Model

The farmers were faced with multiple options (n=1,…,9); therefore, the intensity of adoption of GAPs was measured by the number of GAPs used by a farmer in the past cropping year. The number of GAPs a particular farmer used in one planting year assumed statistical values of distinct character. According to Madalla (2001), the non – normal distribution of count data overruled its accurate estimation using the OLS regression model.

Kirui et al., (2012) explained that the conventional models used in analysing count data comprise; the Poisson Regression Model (PRM), the Negative Binomial Regression Model (NBRM), the Zero-Inflated Poisson (ZIP), and the Zero-Inflated Negative Binomial (ZINB). Greene (2008) suggested that Poisson and NBRM encompassed the regular models for studying response variables without negative integers. ZIP and ZINB could be used to explain the existence of more recurrent zeros as opposed to the case in either Poisson or NBRM, which was not anticipated in this study. According to Greene (2003), both PRM and NBRM were almost similar to OLS regression models compared to other choice models because optimal conditions could be gotten from PRM, just like in OLS. More so, the assumptions of variance violations could not bring out incoherent estimators but coefficient estimators that were inefficient and potentially biased standard errors. Therefore, the justification for the use of PRM was done by testing for overdispersion and underdispersion (Wooldridge, 2002).

3.4.1 Poisson regression model

PRM involves characteristics of variables that are numerical (Greene, 2003) with an assumption that the dependent variable $\boldsymbol{y_i}$ given a set of explanatory variables $\boldsymbol{x_i}$ has a Poisson distribution (Kirui et al., 2012). The probability density function of $\boldsymbol{y_i}$ given $\boldsymbol{x_i}$ is completely determined by; the conditional mean $E(y_i|x_i) = |\lambda_i$, which is equivalent to the variance $Var[y_i|x_i] = \lambda_i$ (1)

Therefore, following Famoye (2015), the PRM density function;

$$f(y_i|x_i) = \frac{e^{-\lambda(x)}\lambda_i(x)^y}{\Gamma(1+y_i)} \quad (2)$$

Where $\lambda_i = \exp(\alpha + X'\beta) \quad y_i = 0,1,...,i$ (3)

Greene (2003; 2008) reiterates the specifications of PRM, i.e., each observation $\boldsymbol{y_i}$ is gotten from a Poisson distribution with mean $\boldsymbol{\lambda_i}$, that is linked to some explanatory variables X'.

The PRM is estimated as follows: Greene (2008), y_i, the number of GAPs per year:

$$E(y_i|x_i) = \mathrm{var}[y_i|x_i] = \lambda_i = \exp(\alpha + X'\beta) \text{ For } y_i = 1, 2, \dots, 9 \quad (4)$$

Intensity of use of GAPs = number of GAPs used ([exp (α+X' (distance to the produce market, distance to all-weather road, household size, distance to the nearest agricultural extension office, experience in potato farming, hired labour use, value of assets, level of education, need credit facilities, harvested immature potato, county) β + e]) (5)

Where y_i is the number of GAPs chosen by farmer *i*, X' is the vector of explanatory variables that determine the number of GAPs used by farmer i, and β is a vector of unknown parameters to be estimated. The primary assumption of PRM (Greene, 2008) is that the conditional mean is equal to the conditional variance. According to Winkelmann and Zimmermann (1995), the assumptions of PRM include: (i) the conditional mean is equal to the conditional variance, which could lead to inefficiency and biased estimates of nonnegative data contributing to heteroscedasticity. (ii) Non-negativity and discrete nature of data. (iii) It allows for the treatment of zeros using the log-linear model.

The Poisson regression model has been used in past research; for instance, Gitonga et al., (2010) used it to analyse the determinants of the number of *Liriomyza* leaf miner control strategies used by farmers. Otieno et al., (2011) used PRM to assess the effect of varietal attributes on the number of pigeon pea varieties adopted by farmers in Kenya. Similarly, Kirui et al., (2012) used it to determine the number of times farmers received and sent money via mobile phones in Kenya.

Despite its many applications, PRM has its share of limitations in empirical studies. For instance, its restrictions on the conditional means of the exogenous variable often limit its use because of the observed variables, in most cases, display Overdispersion (Greene, 2008). As defined by Berk and MacDonald (2007), Overdispersion is the excess variation than the expected mean, which results from the following assumptions :(a) the deterministic functions of explanatory variables do not allow for unobserved differences. (b) The events that constitute each count occur over time randomly and are independent (Winkelmann and Zimmermann, 1995). This does not consider the possibility of future occurrences being influenced by the present (Berk and Macdonald, 2007).

According to Wooldridge (2002), overdispersion results in a larger variance in coefficient estimates than the expected mean. This could lead to inefficient and biased estimates with small standard errors. Violation of the results of the assumptions in underdispersion where the conditional mean is greater than the variance occurs when the actions that make up the counts are negatively associated (Berk and MacDonald, 2007). According to Famoye (2015) and Greene

(2008), under- or overdispersion leads to inefficient and biased estimates. The tests for overdispersion justify the need to use models other than PRM (Xiang and Lee, 2005). There were no problems with under-or overdispersion in the study; hence PRM was used (Wooldridge, 2002; Famoye 2015; Berk and MacDonald, 2007; Greene, 2008).

3.5 Effect of intensity of use of GAPs on potato yield

3.5.1 Ordinary Least Squares (OLS)

OLS is commonly used in empirical studies when the model error term is normal, independent, and identically distributed (Ramirez et al., 2002). It yields the most efficient unbiased estimates for the model's coefficients with small standard errors. Its limitations occur if there are inconsistent sampling uncertainties in the dependent variable occurring in all the observations. The regression errors will be heteroscedastic, and therefore OLS will produce inconsistent estimates (Lewis and Linzer, 2005).

The effect of the use of GAPs on potato yield was determined by the assumption that farmers who used more GAPs were likely to get a higher yield than their counterparts. Okello et al., (2017) reiterate that the use of CSP increased potato yield and further improved the livelihoods of potato farmers. The effect of intensity of using GAPs on potato yield was estimated as a linear function of some explanatory variables Z_i and continuous variable D_m. Following Ogutu et al., 2014:

$$Y = \beta Z_i + AD_m + \mu_i \qquad (6)$$

Where Y is the amount of potato yield, Z_i is the set of explanatory variables; D_m is the intensity of use of GAPs, and μ is the error term. The LRM was specified as follows:

Potato yield=f β (distance to the nearest input store, distance to the closest agricultural extension office, household size, experience in farming, off-farm income, the value of assets, level of education, distance to produce market, need credit facilities county) +A (intensity of use of gaps) +error term (7)

3.6 Effect of Use of GAPS on Market Participation by Irish Potato Farmers

The effect of the use of GAPs was determined by evaluating its influence on market participation. This was hypothesised to be determined by the realisation of high potato yield. According to Sebatta et al., (2014), market participation is the percentage of harvested produce that is marketed. Therefore, the level of market participation by households in this study was calculated as a ratio (Household Commercialisation Index (HCI) of the volume of a total potato sold to the total volume of potato produced.

$$HCI = \frac{Total\ volume\ of\ potato\ sold}{Total\ volume\ of\ potato\ produced} \qquad (8)$$

Since HCI was a ratio, OLS could be used to estimate the model connecting market participation to a set of explanatory variables. However, some households did not offer their produce for sale resulting in zero commercialisation indices (Sigei et al., 2014). In this case, the Tobit model (Tobin, 1958) was used. The Tobit model was considered appropriate since the response variable (such as level of market participation) was censored at some upper or lower bounds (Sebatta et al., 2014). In this study, the level of market participation was within 0 to 1.

Tobit model explaining the effect of the use of GAPs household level of market participation was estimated as (Tobin, 1958):

$$Y_i = \beta_0 + \beta_i X_i + \beta_m D_m + u_i \qquad i, m = 1, 2, \ldots\ldots n \qquad (9)$$

Where; Y_i is the HCI, β_0 is the constant term that could be zero, β_i is the set of parameters to be assessed. X_i is a set of the explanatory variables such as socio-economic and demographic characteristics of the household (e.g., age, level of education, size of the farm, value of assets, access to credit and farm characteristics (for example, distance to the produce market and the nearest all-weather road in walking minutes). D_m is a continuous variable indicating the use of GAPs, and u_i is the error term.

$$use\ of\ gaps = \frac{number\ of\ recommended\ GAPs\ followed\ by\ farmers}{total\ number\ of\ recommended\ GAPs(9)} \qquad (10)$$

This gave us the level of use of GAPs. The good users would have over 0.733, the poor 0.533, and the moderate between 0.533, and 0.733 (Senanayake and Rathnayaka, 2015).

In equation 9, the continuous variable (D_m) has a constant factor (β_m), which provides the average effect of treatment on treated (ATT) (Heckman et al., 1999). When the explanatory variables X_i control for the other factors influencing market participation (farmer and marketing characteristics), the ATT estimated by equation 9 above is termed unbiased. Inherent in this method is the proposition that the treatment does not depend on the process of realising outcomes (i.e., Dm and u_i are not correlated). Nevertheless, the use of this method results in biased estimates when the hypothesis of the absence of any selectivity bias is relaxed outside the observation made by the statistician (Wooldridge, 2000). Table 1 presents the definition of each of the variables in this study, along with their hypothesised signs.

Table 1: Expected Signs for Independent Variables

Variable	Description	Measurement	Hypothesised sign
Hheadage	Age	Years	+/-
Gender	Gender of the household head	Dummy 1=Male 0=Female	+
Education _Years	The education level of the household head	Formal education where 0=No Primary 1=1; primary 2=2; Secondary school: form 1=9; form 3=11; University/college year 2=14 etc.	+
HHsize	Household size	Number of people in the household	+/-
OffFarmIncome	Household income outside the farm	Amount earned in thousand Kenya shillings per year.	+
LnExperiencePotatoFarming	Natural log of years of experience in farming	Years	+
Lnplotsize	Natural log of the size of plot under potato production in a year	Acres	+
Dist.Agric.Office	Distance to extension agent	Walking minutes	+/-
Group	Membership in farmer group/association/cooperative	Dummy where: 1=Membership 0=Otherwise	+
NeedCredit	Farmer needed and got credit as a proxy to access of credit	Dummy where: 1=Needed credit 0=Otherwise	+
Location	Region where potato farmer is located	Nyandarua or Bungoma	+/-
Certified seed	Farmer used certified potato seed	Dummy where: 1=Yes 0=No	+
LnAssetValue	Natural log of the total value of assets	Value of assets in thousand Kenya shillings	+
LnDistProduceMarket	Natural log of distance to produce market	Walking minutes	+/-

LnDistAllWeatherRoad	Natural log of distance to an all-weather road	Walking minutes	+
Lntotalvolyieldpotato	Natural log of the total volume of potato yield harvested	Tonnes	+
DistInputStore	Distance to input store	Walking minutes	+
HarvestedImmaturePotato	Farmer harvested potato before maturity	Dummy where: 1= Yes 0= No	+/-
Need Extension	Farmer needed and got extension services	Dummy where: 1= Yes 0= No	+
HiredLabourUse	Farmer used hired labour	Number of hired labourers	+/-
NumberGAPs	Number of GAPs used by the farmer	Number	+
HCI	Household commercialisation index	Ratio	+
PestScouting	Farmer used pest scouting	Dummy where: 1= Yes 0= No	+
CropRotation	Farmer practiced crop rotation	Dummy where: 1= Yes 0= No	+
Manure	Farmer applied manure	Dummy where: 1= Yes 0= No	+
Rogueing	Farmer practiced rogueing	Dummy where: 1= Yes 0= No	+
SafePesticides	Farmer safely used pesticides	Dummy where: 1= Yes 0= No	+
PositiveSelection	Farmer practiced positive selection	Dummy where: 1= Yes 0= No	+
Fallowing	Farmer practiced fallowing	Dummy where: 1= Yes 0= No	+
Thinning	Farmer practiced thinning	Dummy where: 1= Yes 0= No	+

3.7: Methods of Data Collection

3.7.1 Sampling Procedure and Sample Size

The sample size was determined as follows following Cochran (1963:75).

$$n_0 = \frac{z}{e^2} pq \tag{11}$$

This formula could only be valid where n_0 was considered as the sample size, *Z* the abscissa of the normal curve that cuts off an area α at the tails, and e^2 the desired level of precision. *p* was the estimated proportion of an attribute that was present in the population, and *q* (1-*p*). The value for *Z* was found in statistical tables, which contain the area under the normal curve.

According to this study, there was an assumption of a large population, but variability in the proportion who would adopt GAPs was unknown. Therefore, assuming p=.5 with a 95% confidence level and ±5% precision, the resulting sample size would be:

$$n_0 = \frac{z^2}{e^2}\text{pq} = \frac{(1.96)^2\,(.5)(.5)}{(0.5)^2} = 385 \text{ farmers} \tag{12}$$

However, based on the budget constraints, only 260 farmers were selected for this study. The respondents were selected through a multistage sampling technique. This method was considered cost-effective and could collect data from geographically dispersed groups where face-to-face interviews were required (Tiamiyu et al., 2018). The selection process started with purposive sampling of Bungoma and Nyandarua Counties. This was followed by the purposive selection of two sub-counties (Ol Kalou and Laikipia) in Nyandarua based on the significance of potato. Similarly, in Bungoma County, one sub-county, Mt. Elgon, which had significant potato production, was also selected. A list of all sub-locations within the sub-counties was obtained with the help of the local administrative officials, and five sub-locations were chosen randomly.

Further, for every selected sub-location, one village was randomly selected for the survey. The last stage involved obtaining a list of all potato growers from the headmen in every village and a random selection of 13 households for personal interviews. The sampling process gave 130 respondents per county and 260 interviews in total. Random errors were corrected using the Heckman test. The formula for determining sample population gave room for the addition of 10 percent to take care of unreached respondents or failed interviews.

3.7.2 Data collection and analysis

The Data used in this study was collected as part of the baseline survey conducted by the International Potato Centre to assess the nutrition and household income conditions of the study respondents. Each response was documented using personal interviews with pre-tested questionnaires programmed in Survey Solutions software. Data was collected on household demographics, asset endowments, farm, institutional, and regional characteristics, and intensity of use of GAPs. This study used primary data that was obtained from the sampled smallholder potato farmers in Bungoma and Nyandarua counties. Twelve interviews were, however, not adequately completed and hence dropped from data analysis. This gave a response rate of 95%. A pre-test was conducted in different sub-county to avoid contamination. The respondent was a potato farmer who had grown and utilised potato in the previous year and could be a household head or spouse. Data was analysed using SPSS and STATA Software. Diagnostic tests were also done to check for multicollinearity, heteroscedasticity, normality, and model parsimony.

3.8 Model Diagnostics

3.8.1 Multicollinearity

Multicollinearity results when a direct relationship exists between a few or all of the independent variables. This leads to an increase in the variance and coefficients; thus, the confidence interval widens, and the conclusions drawn are not realistic. Variance Inflation Factors (VIF) were calculated to test for multicollinearity for the variables. According to Gujarati (2004), any variable whose VIF was greater than ten demonstrated the presence of Multicollinearity. Results for this analysis disclosed that there was no multicollinearity as no variable had a VIF more than or equal to 10; the mean VIF was equal to 1.29 (Appendix 1).

3.8.2 Equi-dispersion

One limitation of PRM is equidispersion, where the variance is equal to the mean. This was examined using the Pearson chi-square ratio, which indicated that chi^2 (15) = 40.74 and Prob > chi^2 = 0. 000. Thus the model was found to be fit, and the null hypothesis that socioeconomic factors do not influence the use of GAPs would be rejected if *P* is less than 0.05.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Characteristics of Respondents

The results demonstrate that 91 percent of the respondents were males, while 8 percent were females. This suggests that the majority of the household heads were males who made decisions concerning the production and marketing of potato. The results are consistent with those of the African Potato Association (2016), who reiterated that crucial decisions on production and marketing of the produce are made by men even though women provide the labour required during the initial stages of production. In Uganda, specifically, women are involved in the tilling of land, planting, and weeding, whereas men control harvesting and the sale of the crop. The percentage distribution of males and females in this study was skewed; therefore, this variable was omitted in the entire analysis.

Results also indicate that 76 percent of the farmers accessed extension services, suggesting that the role played by the agricultural officers in potato production cannot be overemphasized. However, the distance to these agricultural facilities mainly affected the access to extension service, which contributes to the low yield of potato. Respondents in Koimugul, Bungoma County, reported an average walking distance of 5 hours to the agricultural office, indicating poor road infrastructure and challenging terrain. The results correspond to the findings of Olwande and Mathenge (2010), who said that long distances to the agricultural extension facilities negatively affect potato production because of the travel time and associated costs. Summary statistics of respondents and GAPs used in the study are presented in Tables 2 and 3, respectively.

Table 2: Summary Statistics of Respondents

	Pooled sample (n=254)		Nyandarua (n=128)		Bungoma (n=126)		Difference
	Mean	SD	Mean	SD	Mean	SD	p-value
Hheadage	44.66	11.69	47.09	11.13	42.20	11.78	0.001
Education_Years	9.15	3.23	8.97	3.54	9.34	2.89	0.373
HHsize	6.28	2.58	5.20	1.73	7.38	2.84	0.000
AssetValue	148.38	128.34	161.82	134.19	134.73	121.11	0.095
OffFarmIncome	836.36	194.27	484.52	187.12	119.38	195.60	0.003
TotalVolYield	5.24	30.00	100.09	41.61	0.32	0.47	0.011
HarvestedImmature Potato	0.46		0.49		0.43		0.310
HiredLabourUse	0.85		0.80		0.90		0.034
Plotsize	533.92	8356.84	1049.99	11723.40	0.80	1.12	0.326
NeedCredit	0.18		0.16		0.20		0.412
DistProduceMarket	52.11	40.93	58.35	34.66	45.83	45.69	0.015
DistInputStore	44.75	32.78	44.57	29.17	44.93	36.18	0.932
ExperiencePotatoFarming	11.73	9.64	13.62	10.45	9.81	8.34	0.002
DistAgricOffice	75.11	49.45	75.91	51.31	74.31	47.69	0.798
Dist.AllWeatherRoad	20.99	38.17	12.03	19.98	30.02	48.69	0.000

Table 3: Summary Statistics for the GAPs

	Pooled sample (n=254)		Nyandarua (n=128)		Bungoma (n=126)		Group Difference
	Mean	SD	Mean	SD	Mean	SD	p-value
NumberGAPs	3.45	1.22	3.45	1.30	3.45	1.14	0.963
PestScouting	0.80	0.40	0.80	0.40	0.79	0.41	0.709
CropRotation	0.80	0.40	0.70	0.46	0.91	0.28	0.000
Manure	0.32	0.47	0.48	0.50	0.16	0.37	0.000
Rogueing	0.80	0.40	0.70	0.46	0.89	0.32	0.000
SafePesticides	0.35	0.48	0.43	0.50	0.27	0.45	0.007
PositiveSelection	0.17	0.38	0.02	0.12	0.33	0.47	0.000
Fallowing	0.05	0.21	0.07	0.26	0.02	0.13	0.081
Thinning	0.15	0.36	0.23	0.43	0.06	0.24	0.000

Source: Survey data (2016)

Figure two, crafted from Table 3, shows that the most common GAPs used by farmers include crop rotation at 80 percent, rogueing at 78 percent, pest scouting at 79 percent, and safe handling of pesticides at 34 percent, and use of organic manure at 32 percent. Notably, farmers did not use natural enemies to control pests due to the cost and lack of knowledge concerning technology.

Further, only 1 percent of the farmers used certified seed, as witnessed by vast distances to the suppliers of clean seed. Similarly, Figure three illustrates the number of GAPs adopted by farmers in Bungoma and Nyandarua. The results show that the farmers adopted an average of three GAPs in both Counties, suggesting existing production constraints that limit the use of these practices. These results were similar to those obtained by Okello et al., (2017), where 50 percent of the respondents reiterated that scarcity and high prices of certified seed, as well as the availability of poor quality planting material, contributed to their use of (uncertified) seeds which directly lowered their yield.

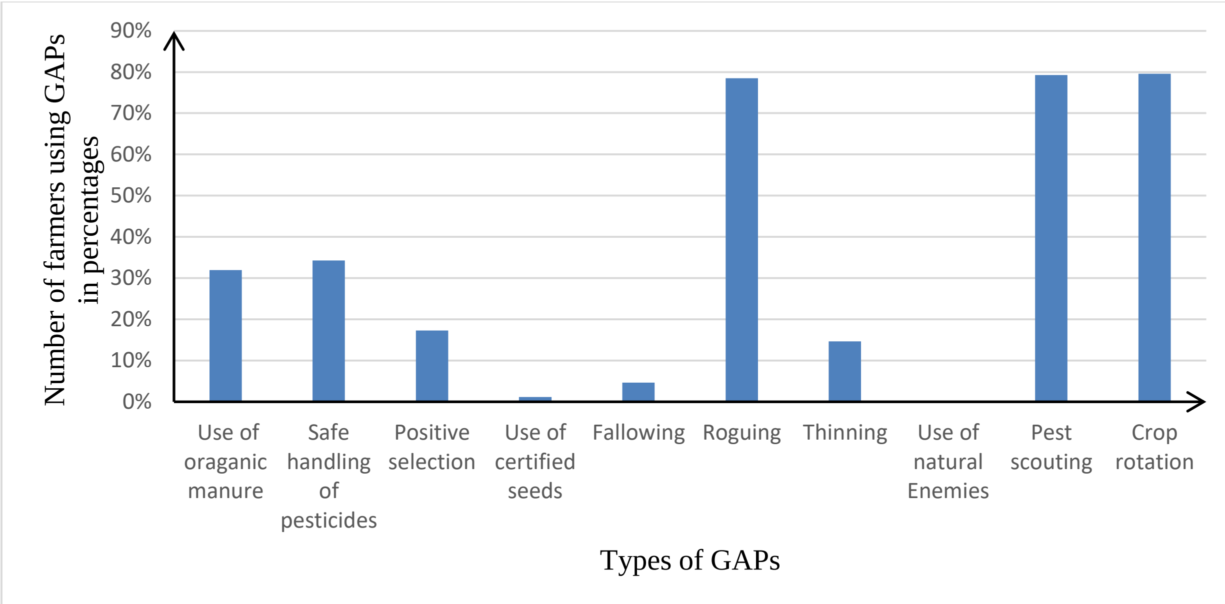

Figure 2: Common GAPs Used by Smallholder Potato Farmers in Nyandarua and Bungoma

Source: Survey data (2016).

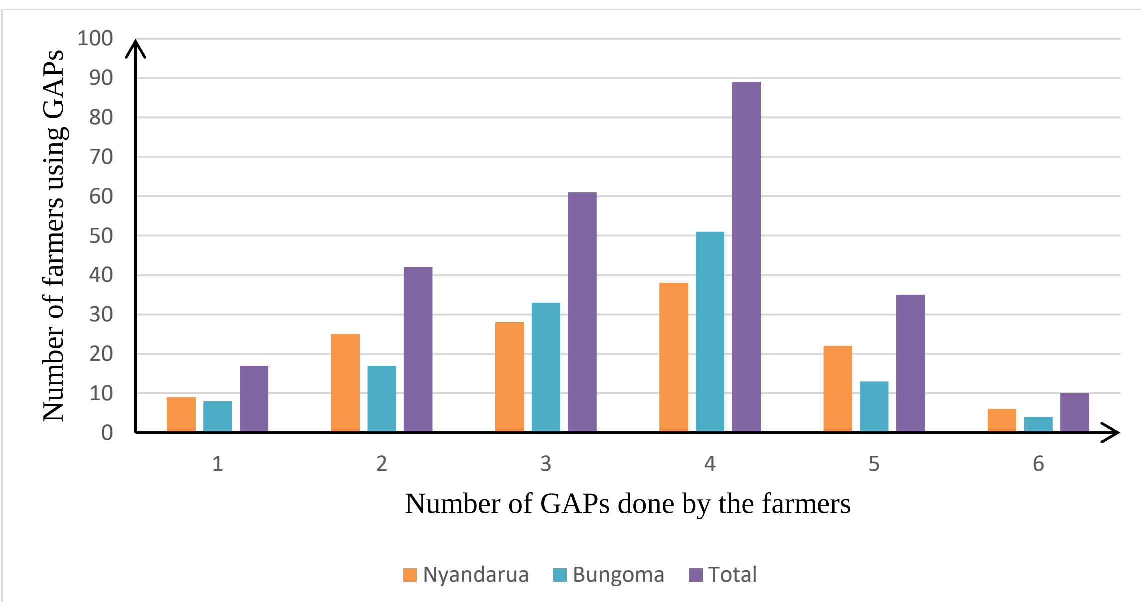

Figure 3: Number of GAPs Used by Smallholder Potato Farmers in Nyandarua and Bungoma

Source: Survey data (2016).

Results in Table 2 show that only 18 percent of the farmers needed credit, while 82 percent did not need it. Out of those who needed credit, 69 percent got which was used for buying seeds (39 percent), buying fertiliser or manure (34 percent), buying pesticide (19 percent), buying farm equipment (4 percent) and buying or leasing potato field (2 percent), as shown in Figure 4, credit is known to increase the purchasing power of the farmer regarding the acquisition of inputs, hiring labour, and shouldering transport costs to the market.

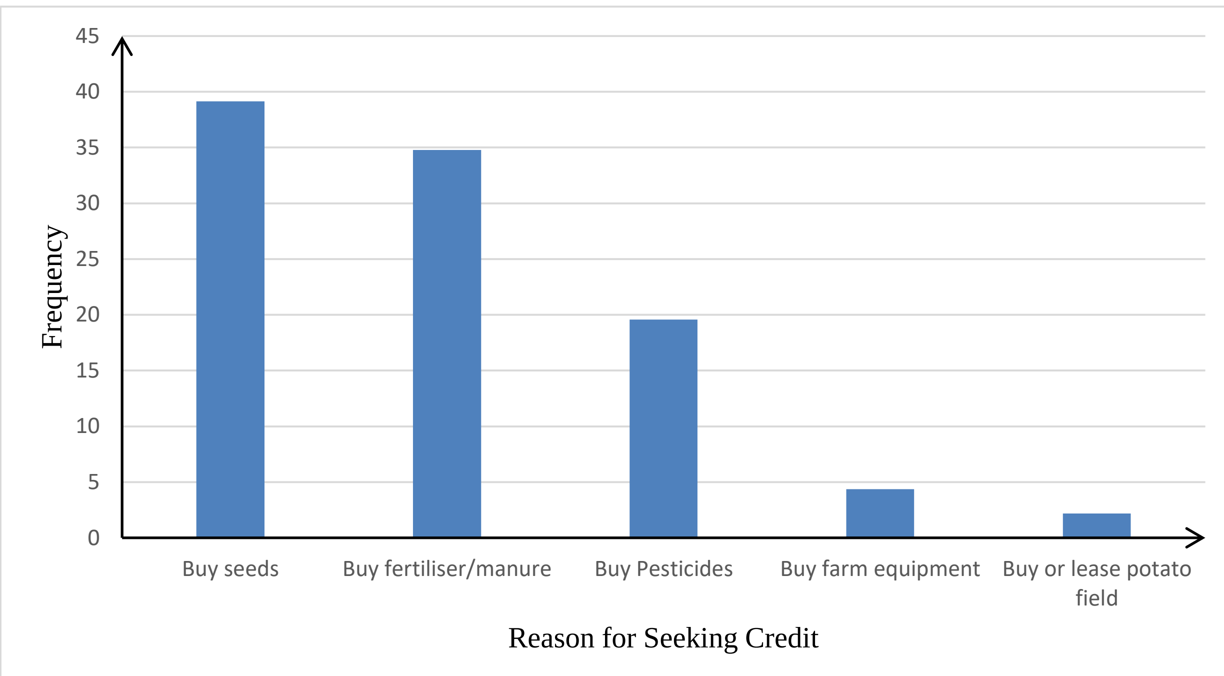

Figure 4: Use of Credit by Smallholder Potato Farmers in Nyandarua and Bungoma

Source: Survey data (2016)

Further analysis indicated that 76 percent of the farmers needed extension services on practices such as timely planting 10 percent, safe handling of pesticides 12 percent, earthing up 25 percent, and harrowing at 8 percent. Notably, only 6 percent of the farmers were members of a potato production or marketing group. Farmers (90 percent) stated that such groups were not available, while 5 percent did not want to join any group. One percent of the respondents indicated corruption as a significant hindrance to joining potato groups. Intuitively, farmers had other sources of income apart from potato production, such as milk, renting out land, off-farm income, and proceeds from other crops.

4.2 Factors Influencing the Use of GAPs: Poisson Regression Model

Table 5 presents the factors that influence the use of GAPs by potato farmers. The results show that R-squared is at 7 percent hence within the acceptable level, as suggested by Chin (2010). The model also adhered to Falk and Miller's standards for the level of explicated variance, which requires an R-squared that is greater or equal to 0.10 (Falk and Miller,1992). The *p*-value =0.000 illustrates a positive association between factors and the number of GAPs used by farmers, which satisfies the model's validity.

Results from the model in Table 4 illustrate the factors that influence the number of GAPs used by farmers. Specifically, the results show that several factors positively influence the use of GAPs; hence the first hypothesis that socioeconomic factors do not influence the use of GAPs is rejected. The distance to the produce market was significant at 1 percent, hired labour at 1 percent, cured potato 5 percent, experience in potato farming 5 percent, the value of assets 5 percent, and distance to the produce market at 10 percent.

Further, the need for extension was significant at 10 percent in Bungoma County. The distance to the all-weather road was also significant in both Nyandarua and Bungoma Counties. This implies that farmers who needed agricultural advice required more knowledge on the production and marketing of potato and were more likely to use the stipulated GAPs as compared to those who did not require extension services.

Table 4: Factors Influencing the Use of GAPs among Smallholder Potato Farmers in Nyandarua and Bungoma

Dependent Variable = Number Gaps	Pooled sample (n=234)		Nyandarua (n=119)		Bungoma (n=115)	
	Coefficient	p-value	Coefficient	p-value	Coefficient	p-value
Education_Years	-0.004	(-0.38)	-0.002	(-0.16)	0.002	(0.10)
HHSize	-0.002	(0.72)	0.013	(0.38)	0.003	(0.69)
lNplotsize	0.007	(0.84)	0.039	(0.34)	-0.198	(0.32)
lNAssetValue	0.135***	(0.01)	0.089	(0.19)	0.106	(0.13)
DistProduceMarket	-0.148***	(0.01)	-0.009	(0.94)	-0.174***	(0.00)
lNDistAllWeatherRoad	0.008	(0.84)	-0.140**	(0.04)	0.218***	(0.00)
DistAgricOffice	0.000	(0.86)	-0.000	(0.57)	-0.000	(0.85)
HiredLabour	-0.130**	(0.02)	-0.248***	(0.00)	0.160**	(0.04)
INExperiencePotatoFarming	0.1401**	(0.03)	0.1772**	(0.04)	-0.001	(0.99)
Need Credit	0.0808*	(0.06)	0.0313	(0.68)	0.0921	(0.14)
HarvestImmaturePotato	0.0146	(0.71)	0.0697	(0.23)	-0.0615	(0.26)
Need Extension	0.017	(0.75)	-0.024	(0.77)	0.141**	(0.02)
Constant	0.615**	(0.03)	0.742*	(0.08)	0.391	(0.32)
Observations	234		119		115	
Chi2	31.972		50.458		34.525	
P	0.001		0.000		0.000	
r2_p	0.010		0.025		0.024	
Akaike Information Criterion (AIC)	785.948		411.920		386.921	
(Bayesian Information Criteria (BIC)	827.412		445.270		419.861	

Source: Survey Data (2016)

* p<0.10, ** p<0.05, *** p<0.01

The results show that an increase in the asset value by 1 percent increases the expected number of GAPs to be utilised by 19 percent, other factors being constant. This implies that assets directly influence the capacity for the use of GAPs. Similarly, the distance to the produce market negatively affects the use of GAPs by 29 percent in the pooled sample and Bungoma County. This means that an increase in the distance to the produce market in walking minutes would lower the use of GAPs due to the transaction costs involved.

As expected, the access to extension proxied by the need for extension positively influenced the use of GAPs in Bungoma. A unit increase in the need for advice from extension agents increased the use of more GAPs by 21 percent. These results were similar to those of Olwande & Mathenge (2010), who argue that extension agents provide helpful guidance that increases the use of technologies specifically on those farmers who require the services.

The distance to the all-weather road in walking minutes was significant in both counties. A unit increase in the distances to all-season road lowered the use of GAPs in Nyandarua by 0.24. This was attributed to the longer time of travel and transport costs, which greatly influenced the use of technologies, as reported by Olwande & Mathenge (2010). Conversely, Bungoma had a positive coefficient, which implied that a unit increase in the distance to all-weather roads increased the likelihood of the use of more GAPs. This could be attributed to the resilient nature of farmers in the area and the diffusion of technologies through information from the neighbours (Muthoni et al., 2013). On the same note, the inverse relationship between hired labour and the use of GAPs by a magnitude of 26 and 43 percent in the pooled sample and Nyandarua respectively indicate that an increase in paid labour would decrease the capacity of farmers utilising GAPs due to an increase in the production constraints. However, the variable had a positive significance in Bungoma County, which could be attributed to the availability of the workforce that could implement the selected GAPs.

Experience in Irish potato farming was positive and significant at 5 percent in the pooled and the Nyandarua sample. A unit increase in the number of years of experience in potato farming was expected to increase the use of GAPs by 0.26 and 0.39 in the pooled and Nyandarua, respectively. The farmers who had been producing Irish potato for several years had gained a wealth of knowledge concerning agricultural practices that enhanced yield and were likely to adopt more agricultural practices. More so, the experience by farmers enhanced the social networks and linkages with agricultural agents. It also reduced transaction costs in negotiating and enforcing contracts (Jagwe et al., 2010).

4.3 Effects of Intensity of Use of GAPs on Irish Potato Yield: OLS

Table 5 presents the effects of the intensity of the use of GAPS on Irish potato yield. The results of the model diagnostic tests, as illustrated in Table 5, showed that the goodness of fit index R-squared=0.3787 while Adjusted R-squared=0.3455; this means that the model effectively estimated the effects of the use of GAPs on potato yield. The Probability is greater than F =0.0000, which suggests that the relationship between the model and the response variables is statistically significant. The P-value is less than 0.05; hence the null hypothesis that the use of GAPs does not influence potato yield is rejected.

Table 5: Effect of Use of GAPs on Potato Yield

Dependent Variable = *Log total volume of potato produced*	Pooled sample (n=234)		Nyandarua (n=119)		Bungoma (n=115)	
	Coefficient	t-statistics	Coefficient	t-statistics	Coefficient	t-statistics
PestScouting	0.085	(0.54)	0.561**	(2.36)	-0.328*	(-1.83)
CropRotation	-0.580***	(-4.03)	0.018	(0.09)	-0.356**	(-2.29)
Manure	-0.233	(-1.59)	0.000	(.)	-0.602***	(-3.75)
Rogueing	0.000	(.)	0.902***	(3.58)	0.000	(.)
SafePesticides	-0.186	(-1.39)	0.293*	(1.67)	-0.537***	(-3.41)
PositiveSelectio	-0.349***	(-3.10)	0.419	(0.92)	-0.175**	(-2.26)
Certified Seed	-0.483	(-1.41)	-0.469	(-0.72)	-0.314	(-1.20)
Fallowing	0.217	(1.23)	0.104	(0.46)	-0.343	(-1.62)
Thinning	0.247**	(2.10)	0.019	(0.12)	-0.019	(-0.13)
Lnplotsize	1.076***	(10.38)	0.874***	(7.10)	2.180***	(9.74)
LnAssetValue	0.280***	(2.69)	0.208	(1.25)	0.274***	(3.01)
LnDistProduceMkt	0.188*	(1.73)	0.036	(0.15)	-0.005	(-0.07)
LnDistAllWeather Road	-0.266***	(-3.47)	-0.094	(-0.67)	-0.001	(-0.01)
HHSize	-0.013	(-0.80)	0.072**	(2.03)	-0.015	(-1.16)
LnExperiencePotatoFarming	0.064	(0.50)	-0.085	(-0.43)	0.030	(0.26)
NeedCredit	0.176*	(1.69)	0.434***	(0.006)	0.077	(0.392)
OffFarmIncome	-0.000***	(0.000)	-0.000***	(0.000)	0.000	(0.215)
DistAgricOffice	-0.002**	(0.025)	-0.0013	(0.248)	-0.002**	(0.045)
Constant	0.796	(1.42)	1.017	(1.06)	0.147	(0.31)
R^2	0.526		0.535		0.583	
P	0.000		0.000		0.000	
AIC	418.758		236.323		98.367	
BIC	477.499		280.796		142.286	

t statistics in parentheses * p<0.10, ** p<0.05, *** p<0.01

Source: Survey Data (2016)

The results indicate that pest scouting was positive and significant at 5 percent in Nyandarua County. This suggests that more farmers in Nyandarua County could allocate time and resources for the practice that enhanced timely intervention on pest and disease control strategies, enhancing an increase in yield. On the other hand, the use of pest scouting was significant at 10 percent, but with a negative coefficient in Bungoma. This can be attributed to the use of family labour and capital that could have been used in other activities such as hilling. The results were similar to those of Lien et al., (2010), who argued that resource endowment influenced the use of GAPs, and consequently, the yield realised.

Crop rotation was significant at 1 percent in the pooled sample and 5 percent in Bungoma but had a negative effect on potato yield. This could be attributed to the fact that farmers did not have large plot sizes (average 2.5 ha) to favour following an ordered sequence in crop management. The results differed with those of Larkin et al., (2011), who argued that long rotations between potato growing seasons would increase soil fertility and consequently increase potato yield. Therefore, more application of rotation programmes implies that more farmers were producing potato in one season only hence contributing to a decline in potato yield.

The use of organic manure was significant at 1 percent in Bungoma since the farmers had various livestock that could provide the input. Organic manure increases soil fertility, soil structure, and tuber quality, as explained by Davis et al., (2004) and Achiri et al., (2018). Conversely, this variable had a negative coefficient, which could be attributed to low application rates as well as poor preparation and storage mechanisms (Burton et al., 2008; Johnston and Poulton, 2018).

The safe use of pesticides was significant at 5 percent in Bungoma; however, it had a negative coefficient. Pesticides were used to control common potato pests, such as the potato tuber moth (Champoseau et al., 2009). Some of the farmers used partial protective wear, either boots, nose masks, or overalls, became susceptible to pesticide poisoning, consequently declining productivity associated with ill health (Okello & Swinton, 2010).

Positive selection was significant at1 percent in the pooled sample and Bungoma. The practice was used to identify, mark, and monitor the healthy potato plants during their period of growth and later used as potato seeds. This practice negatively influenced yield since the farmers spent more time and resources in identifying them while most of them opted to use their seed or from the neighbour. The results differed from Kakuhenzire et al., (2013), who found out that the positive selection increased potato yield in Kenya by 52 percent. Positively selected seeds were seen to be free from PVY as compared to those sourced from the market, as reported by Kakuhenzire et al., (2013) and Priegnitz et al., (2020).

The distance to the agricultural office was significant at 5 percent, which implies that an increase in walking minutes to the agricultural officer's office would lead to a decline in the number of GAPs used and the subsequent potential decrease in yield. This will increase the transport costs of the officers while accessing the farmers who were far from their offices (Barret, 2008; Okello et al., 2017). Such farmers had limited information on GAPs and hence reported low yields.

Thinning was significant at 1 percent in the pooled sample. The practice was done by 15 percent of the members in the study area by ensuring that each plant was spaced at 75 by 30 centimetres. The procedure was done three weeks after emergence to prevent etiolation. Thinning increased potato yield since it provided enough space for tuber growth, expansion and facilitated ease of harvesting. The findings were similar to those of Lutaladio et al., (2009) and Stark et al., (2020), who found out that the use of GAPs improved potato yield since they enhanced tuber growth and protection of stolons.

Similarly, rogueing was significant at 1 percent in Nyandarua. The practice was carried out by 78 percent of the potato farmers as a mechanism to control the spread of diseases such as bacterial wilt and the potato virus. The farmers identified, uprooted, and destroyed the plants that showed visual symptoms of the disease, such as wilting hence protecting the healthy ones and increasing production. The findings were similar to those of Kassie et al., (2013), who found out that rogueing decreased the incidence of bacterial wilt and increased the yield per unit area in Tanzania.

Notably, asset value was significant at 1 percent, implying that an increase in the value of assets would influence potato yield positively, as seen in the pooled sample and Bungoma County. This variable was, however, not significant in Nyandarua County. The value of assets indicates the presence of resources that could be used to acquire farm inputs and pay for labour, which directly affects yield. The results were similar to those of Just and Zilberman (1983), who found out that physical assets enabled farmers to use sustainable practices that increased productivity.

Off-farm income was also significant at 1 percent in the polled sample and Nyandarua, while the variable was not significant in Bungoma. Thus an increase in off-farm income in Nyandarua County was attributed to diversification of income that would lead to declined investment in potato as a primary source of income. Further, the availability of an alternative source of livelihood prompts fewer investment GAPs and, consequently, low yields. These results contradict those of Jagwe et al., (2010) and Nonvide (2019), who found out that an increase in off-farm income allowed farmers to expand their scale of production that could cater for subsistence consumption and enable them to market their surplus produce. More so, the results were different from those obtained by Wang'ombe & Van Dijk (2013), who found out that off-farm income negatively influenced potato yield due to the amount of time dedicated by farmers in employment while giving potato production their little attention.

The need for credit was used as a proxy for access to credit. This variable was positive and significant at 10 percent in the pooled sample. This could be because only 12 percent of the farmers accessed credit, while 82 percent did not need credit. Further, out of those who needed credit, 70 percent of the farmers accessed credit used to purchase seed (39 percent) and fertiliser (34 percent); the amount obtained could be sufficient to implement all the GAPs hence increasing potato yield. The results were similar to a study by Abdulai and Eberlin (2001), and Mango et al., (2018) revealed that farmers in Nicaragua and Malawi, respectively, who were able to access credit, were more technically efficient and hence produced more yield for the market. This variable positively influenced yield because the farmers who accessed credit could utilise it to acquire inputs and implement farming practices that could positively increase potato yield. This would provide farmers with the necessary financial muscle to expand the scale of production.

Intuitively, the household size was significant at 5 percent and had a positive impact on potato yield in Nyandarua. An increase in the household size would increase potato yield by 7 percent holding all other dependent variables constant. The county utilised both hired and family labour in potato production. The families provided ninety-two percent of the labour in Nyandarua county, while 8 percent was outsourced. The findings were similar to those of Mathenge et al.,

(2010) and Jote et al., (2018), who claim that the household provides family labour utilised in the farm and the capital required to invest in GAPs that increase potato yield.

The distance to the all-weather road in walking minutes negatively influenced potato yield in the pooled sample but was not significant in the individual analysis of both Nyandarua and Bungoma Counties. This could be attributed to the increase in transaction costs and time of travel when purchasing farm inputs and delivering the produce to the output market, which cumulatively contributes to low yields.

Further, the distance to the produce market positively influenced potato yield in the pooled data. This was the opposite of the expectation since more considerable distances to the produce markets lower the morale of the farmers to produce more potato for sale, as explained by Waxman et al., (2018). However, the access to the output market, especially peri-urban markets, can be linked to the existence of proper infrastructure that would encourage the farmers to produce more potato with the projection of offering them for sale. These results were similar to Ghadim and Pannel (1999) and Tiamiyu et al., (2018). who found out that ease of access to outlet markets positively influenced yield since the farmers would be able to incur fewer transaction costs and therefore offer more of their produce to the market.

The plot size was also significant at 1 percent. Larger sizes of land allocated to potato increased the yield realised. The results were consistent with those of Prarakar et al., (2010) and Nkomoki et al., (2018), who realised that an increase in the size of land owned led to an increase in output. At the same time, land could be used as collateral for credit that would enable the farmers to use sustainable practices that increase productivity.

4.4 Effects if Intensity of Use of GAPs on Market Participation of Irish Potato Farmers

The third hypothesis of this study was that the intensity of use of GAPs did not affect market participation by Irish potato farmers. The analysis of household commercialisation indices of potato farmers indicated that the majority of farmers had low levels of commercialisation, with 80 percent of the farmers having a very low commercialisation index. In comparison, 0.4 percent was highly commercialised, as shown in Figure 5.

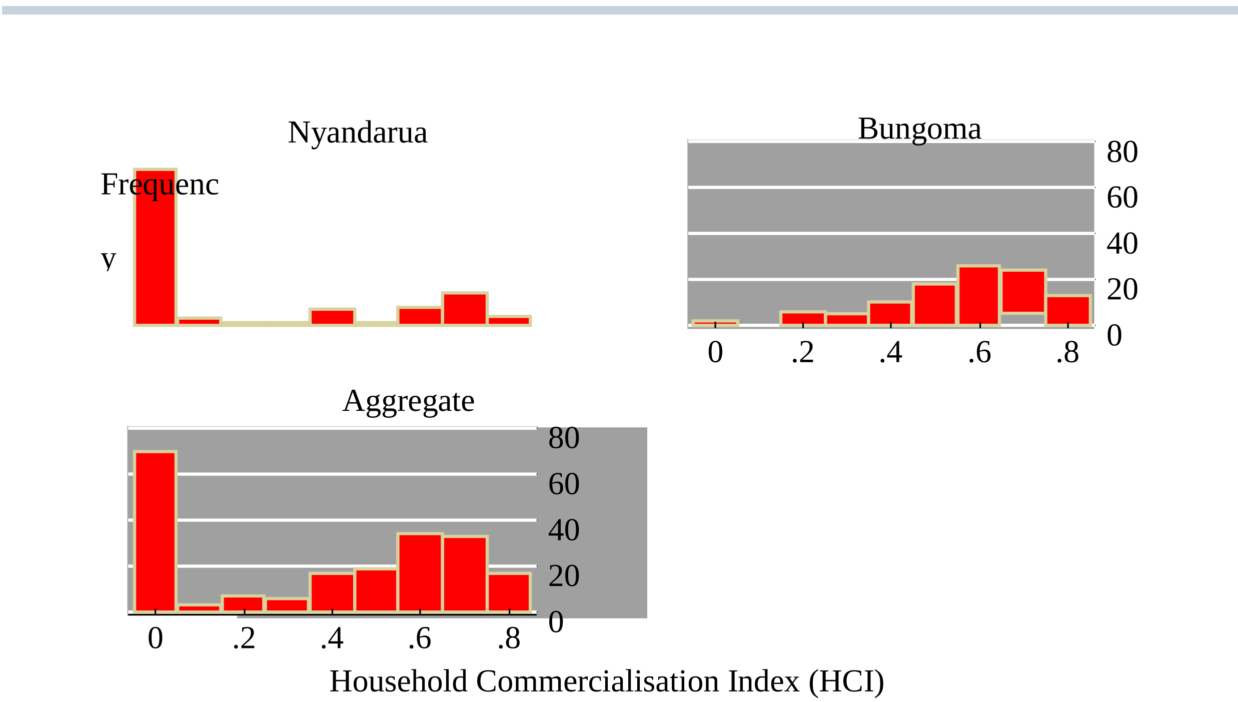

Figure 5: Household Level of Commercialisation Index by County

Source: Survey Data (2016)

The results of the Tobit model estimated to assess the effect of GAPs on market participation and test this hypothesis are shown in Table 6. The tests on multicollinearity revealed the lack of statistically significant correlation among all the variables since all the coefficients were less than 0.5. Hence there was no multicollinearity among the variables in the study. Further, the goodness of fit test showed a chi-square of 45 (44.68) with a *p*-value of 0.0000 in the pooled sample; this indicates that the model was fit for analysis. Besides, the mean value of VIF was less than 10, while the intolerance level (1/VIF) had values greater than 0.6, indicating a lack of multicollinearity (see appendix 3).

The results, however, indicate that the hypothesis is rejected at a five percent level of significance. The findings from the Tobit regression model showed that age, asset value, household size, number of gaps, the log of distance to produce market, distance to all-weather road, and the total volume of potato yield affected market participation significantly. Non-significant variables include the level of education of the household head in years, plot size, distance to agricultural office in walking minutes, experience in potato farming, and need for credit.

Age was negative and significant at 5 percent in the pooled sample. The coefficient shows that an increase in the age of household head decreases the level of market participation. This implies that older farmers tend to be risk-averse, and therefore commercialisation declines with age (Doss and Morris, 2001). The results were different from Kassie et al., (2013) and Lamontagne-Godwin et al., (2018), who argued that older farmers have more resources, use GAPs, and hence produce more yields that can be offered to the market for sale as compared to younger farmers.

Table 6: Effects of Use of GAPs on Market Participation of Smallholder Potato Farmers in Nyandarua and Bungoma

Dependent variable = HCI	Pooled sample Coefficient		Nyandarua Coefficient		Bungoma Coefficient	
Hheadage	-0.005**	(-2.34)	0.000	(0.07)	-0.003	(-1.23)
Education_Years	-0.001	(-0.14)	0.003	(0.33)	-0.006	(-0.69)
Lnplotsize	0.048	(0.68)	-0.009	(-0.14)	0.000	(0.00)
LnAssetValue	0.203***	(3.25)	0.167**	(2.17)	0.086	(1.22)
LnDistProduceMarket	-0.049	(-0.76)	-0.154	(-1.42)	0.114*	(1.80)
LnDistAllWeatherRoad	0.057	(1.31)	0.190***	(3.35)	0.190***	(-3.71)
Lntotalvolyieldpotato	-0.097***	(-2.67)	-0.0443	(-1.04)	0.243***	(3.46)
HHSize	0.017*	(1.91)	0.001	(0.03)	-0.010	(-1.00)
Dist.Agric.Office	-0.001	(-1.46)	-0.000	(-0.44)	-0.001	(-1.09)
LnExperiencePotatoFarming	-0.035	(-0.44)	0.029	(0.30)	-0.021	(-0.23)
NeedCredit	0.050	(0.85)	-0.051	(-0.66)	0.074	(1.18)
NumberGAPs	-0.064***	(-2.65)	-0.0822***	(-3.04)	0.023	(0.72)
_cons sigma	0.038	(0.12)	-0.179	(-0.41)	-0.147	(-0.43)
_cons	0.326	(19.49)	0.272	(13.94)	0.252	(13.74)
Observations	234		119		115	
Chi^2	44.676		36.269		49.990	
p-value	0.000		0.000		0.000	
Pseudo R^2	0.191		0.399		0.565	

Notes: t statistics in parentheses

* p<0.10, ** p<0.05, *** p<0.01

Source: Survey Data (2016)

Household size was positive and significant at 10 percent in the pooled data. This shows that an increase in household size by an individual led to a rise in the commercialisation of the household by 17 percent. The farmers with larger households provided family labour that could be used to integrate GAPs during potato production and further supported the family in offering the produce for sale in the market. The results are similar to Mathenge et al., (2010) and Jote et al., (2018), who argued that a large household size positively influenced participation in the market if they supplied family labour efficiently that translated into an output that is greater than household consumption and hence the surplus would be offered for sale.

Asset value was also positive and significant at 1 percent in the pooled sample and 5 percent in Nyandarua; however, the variable was not significant in Bungoma County. An increase in the value of assets increased the level of commercialisation of potato farmers. This relationship is depicted by the farmer's ability to use GAPs and acquire the means to transport the produce to the market (Jaleta et al., 2009). The results are consistent with those of Jagwe et al., (2010), who found out that the availability of capital lowered the transaction costs involved during marketing in Congo, Rwanda, and Burundi.

Intuitively, an increase in potato yield by one unit led to a decline in the level of commercialisation by 10 percent in the pooled sample. However, there was a definite significance in Bungoma County, which means that farmers who produced high yields could offer more of their produce for sale. It is expected that yield positively affects market participation, which is not the case in Nyandarua county. This could be attributed to farmers using harvested potato for subsistence and seed for the next planting season (Emana et al., 2015). The results differed from those of Okello et al., (2017), who observed that farmers with higher yields offered more of their produce to the market compared to those who had low yields.

Further, the number of GAPs utilised by farmers was negative and significant at 1 percent in both the pooled data and Nyandarua. The results show that an increase in the number of GAPs used by one unit negatively influenced participation in the output market by 6 percent in the pooled sample and 8 percent in Nyandarua County. This could be attributed to the cost constraints that limit farmers from using the recommended GAPs and, in turn, indirectly affect commercialisation because of low yields. The results differed from those of Ghebreslassie et al., (2014), who found that 98 percent of the farmers who used GAPs (crop rotation, organic manure, and pest scouting) realised higher yields and participated in the market more than those who did not use them. This implies that other factors, such as farm size, price of the commodity, and farming experience, influence market participation despite an increase in the number of GAPs by farmers (Daniel et al., 2018).

The distance to produce market was positive and significant at 10 percent in Bungoma and had no significance in Nyandarua County due to the presence of a good road network that reduced the cost of taking the produce to the market. The implication is that farmers in Bungoma County, who travelled more distances, were more likely to offer their produce for sale. This was contrary to the expectation but could be attributed to the availability of means of transport (donkeys and canters) that enhanced accessibility to Chwele market. The results differed from those of Olwande and Mathenge (2010) and Baraka et al. (2019), who found that the farmers' proximity to the market lowered transaction costs of time and transport and enhanced their market research. Similarly, Gebremedhin and Jaleta (2010) found that farmers in Ethiopia who had to cover larger distances to all-weather roads from the settlements had lower levels of market participation.

The distance to the all-weather road was positive and significant at 1 percent in the study area. This implied that greater distances to roads passable throughout the year increase market participation, which could be attributed to the ownership of the transport equipment. The results contradicted those of Gebremedhin and Jaleta (2010) and Chandio and Yuansheng (2018), who found out that smaller distances to all-weather roads lowered marketing costs and increased profitability hence encouraging market participation of farmers in Ethiopia.

CHAPTER FIVE: SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

5.1 Summary

The purpose of this study was to analyse the effect of the use of good agricultural practices in the production and marketing of Irish potato in Kenya. The effectiveness of the use of farming practices, to an extent, is conditional on knowing the factors influencing its application and how it can be up-scaled or modified. The study tested three hypotheses relating to GAPs, namely: i) Socioeconomic factors do not influence the intensity of use of GAPs; ii) Use of GAPs do not influence potato yield; iii) intensity of use of GAPs does not influence market participation by Irish potato farmers.

The first hypothesis was tested using a Poisson regression model, while the second and third were tested using Ordinary Least Squares and Tobit Model, respectively. The results indicated that several socioeconomic factors influenced the intensity of use of GAPs. The findings are in line with the expected utility theory, which suggests that farmers tend to use practices that can give them a higher level of utility as compared to the traditional methods.

The results illustrate that the most common GAPs used by farmers include crop rotation at 80 percent, rogueing at 78 percent, pest scouting at 79 percent, safe handling of pesticides at 34 percent, and use of organic manure at 32 percent. More so, the descriptive analysis showed that only 18 percent of the farmers accessed credit and used it to purchase farm inputs such as seeds, fertiliser, and pesticides, and farm equipment. Further analysis indicated that 93 percent of the farmers did not belong to a potato producing or marketing group, a phenomenon that could have contributed negatively to their access to seed, market, and even extension advice.

The findings further illustrate that farmers who had a higher value of assets could utilise the recommended practices in their farms because of the presence of a higher capital base that would cover the resource constraints limiting integration. Similarly, farmers who hired labour recorded a decrease in the use of GAPs attributed to financial implications compared to those who utilised family labour in Nyandarua. Those that used hired labour in Bungoma reported an increase in the use of GAPs, which could be attributed to the availability of resources to cater to the costs of adoption and labour.

Further, distance to the produce market and distance to the agricultural office influenced the number of GAPs used by farmers. Produce markets determine ease of access to inputs such as seed, fertiliser, and pesticides for potato. More so, it provides an institution where farmers can sell their produce. The need for extension advice plays an essential role in the use of GAPs. The findings reveal that the farmers who required guidance from extension agents were likely to use more recommended GAPs since they would acquire the knowledge of application and the subsequent benefits of the agricultural practices.

The distance to the all-weather road also influenced the use of GAPs due to the transaction costs of time and labour considered when purchasing manure, fertilisers, and transporting the produce to the output market. The years of experience in Irish potato farming equally enhanced the use of GAPs due to well-established social networks with extension agents and neighbours that enhance the likelihood of using more agricultural practices.

The effect of intensity of use of GAPs on potato yield was assessed using OLS. The results showed that distance to the agricultural office, distance to the all-weather road, household size, off-farm income, asset value, need for credit, pest scouting, crop rotation, manure, safe use of pesticides, and the positive selection all had a significant influence on potato yield. Similarly, the effect of the intensity of use of GAPs on market participation was examined using the Tobit model. Household commercialisation indices were used to estimate the level of market participation by potato farmers. The analysis showed that most farmers had low levels of commercialisation, while only 0.4 percent were highly commercialised. Further analysis showed that age, asset value, potato yield, household size, distance to the produce market, distance to all-weather road, and the number of GAPs had a significant influence on the level of market participation.

5.2 Conclusions

Results from this study validate the contribution of age, institutions, and other variables to the intensity of use of GAPs, to yield, and to market participation. Further, the results show that hired labour, the value of assets, distance to the agricultural office, distance to produce market and all-weather road, use of chemicals, curing of potato, experience in potato farming, and need for extension significantly influenced the use of GAPs. The variables illustrate that institutions such as the market, agricultural office, and input stores significantly contribute to the use of agricultural practices. Additional analysis showed that GAPs (pest scouting, crop rotation, manure, safe use of pesticides, positive selection and pest scouting), asset value, access to credit, distance to the agricultural office, off-farm income, distance to the produce market, and all-season roads significantly influenced potato yield. These variables indicated that access to productive resources affected potato yield. Moreover, intensified adoption of GAPs is vital to increase in potato yield per unit area.

Notably, age, asset value, and potato yield, as well as the number of GAPs, distance to the produce market, distance to all-weather road, potato yield, and household size, significantly influenced the household level of commercialisation. Intuitively, there were low levels of access to essential institutional services such as extension and credit, which show the need for promoting agricultural policies and strategies that increase equity in access to resources. The low levels of commercialisation witnessed in potato farmers indicate the need for investment in training and capacity building on the importance of market participation.

5.3 Recommendations

Based on the findings, the County governments of the respective study areas should carry out intense training and farmer sensitization on the need to use GAPS, notably certified seed. Results show that only 1 percent of the farmers used certified seed during the two planting seasons. The farmers stated that they could easily acquire seeds from the neighbours that were not considered as clean potato seeds. The county departments of agriculture should enhance their collaboration with seed multipliers (ADC and Kisima), who can produce certified seed at a lower price for the farmers.

Similarly, the County governments and the National government need to develop adaptive measures that can be applied to cope with variations of rainfall patterns. All the farmers in the region depend on rain-fed agriculture, which has been affected by climate change. In addition, campaigns for the use of certified seed by agricultural officers should be enhanced to caution farmers from growing the same potatoes harvested in the previous season.

The National Potato Council of Kenya recognizes the beneficial role of GAPs in enhancing potato productivity. The council in 2019 trained farmers in Nyandarua County on GAPs observed in the production of seed and ware potato production. As such, the council, through partnerships with CIP, Kisima farms, and AGRICO East Africa Limited, should endeavour to train farmers in other locations such as Bungoma on the use of certified seed, pest and disease management, and proper application of fertiliser. This will create a ripple effect through the neighbour transfer of information, which is instrumental in increasing potato yield. Further, the farmers should form potato production and marketing groups to bring out their collective ability to access loans from cooperatives, commercial banks, and government grants such as *Uwezo* and Women Enterprise Fund.

Going forth, the County governments should innovate ways of disseminating extension information through both public and private bodies can increase the delivery of extension services to potato farmers. Also, incorporating technologies such as Information Communication and Technologies (ICT) through mobile devices, radio, and television would enhance the dissemination of agricultural information to farmers. Farmer to farmer dissemination of technologies such as positive selection and pest scouting can also be encouraged through the use of demonstration plots and contact farmers. Land fragmentation has been on the rise as a result of an increase in population pressure on land. Therefore, the farmers may not adopt fallowing as a mechanism of nutrient regeneration as well as pest and disease control. In this scenario, the farmers should be encouraged to practice crop rotation, manure application, certified seed, and fertiliser use to increase yield per unit area.

Imperatively, the distance covered by farmers in Bungoma county (Masaek, Koimugul, and Kamoneru) to Chesikaki discourages market participation because of poor infrastructure and lack of means of transport. Similarly, the high-end market, such as the Chwele market in Bungoma County, can only be accessed by middlemen with appropriate transportation who exploit the potato producers. Thus, the county and national governments should work in tandem to build and maintain tarmac and feeder roads to increase access to markets by potato farmers.

5.3 Contributions to Knowledge

This study examined the effects of intensity of use of GAPs on the production and marketing of potato. It highlighted the effects of socioeconomic and institutional factors on potato production and commercialisation. The study also highlighted the effect of using good agricultural practices on potato yield. Notably, the study contributed to the literature by improving on previous research that focused on a blanket of issues contributing to the decline of potato yield.

This study was able to show low levels of use of GAPs and decreased market participation among potato farmers. These results can be used to inform decisions that increase access to support services such as extension and credit and, in turn, favour the intense use of GAPs and hence market participation. The results will also benefit the County and National government to prioritize institutional support services and infrastructural policies that enhance the utilisation of agricultural practices and commercialisation.

5.4 Suggestion for Future Research

The study showed that an increase in the use of agricultural practices led to the rise in yield and, consequently, the level of household commercialisation. The study endorses that more research should be done to assess the negative relationship between GAPs and market participation. Further, research should also concentrate on the gendered differences in the use of GAPs. More so, this study did not capture information on the definite cost implications while using particular GAPs due to time restrictions. Therefore, future research should investigate the effect of these elements on the intensity of the use of GAPs by potato farmers.

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APPENDICES

Appendix 1: Variance Inflation Factors for Test of Multicollinearity in OLS Model

Variable	VIF	1/VIF
Ln Plotsize	1.52	0.656373
OffFarmIncome	1.46	0.68618
Manure	1.36	0.73585
SafePesticides	1.34	0.745863
PositiveSelectio	1.32	0.759434
Rogueing	1.29	0.773288
CropRotation	1.28	0.779402
HHSize	1.28	0.783677
Ln Experience in potato farming	1.21	0.826229
Thinning	1.21	0.828958
Ln Asset Value	1.17	0.853847
Ln Dist. All-weather road	1.17	0.857118
PestScouting	1.16	0.86037
Dist.Agric.Office	1.12	0.895378
NeedCredit	1.11	0.899484
Fallowing	1.07	0.930615
Certified Seed	1.06	0.94495
Mean VIF	1.24	

Appendix 2: Variable Inflation Factors for Poisson Regression Model

Variable	VIF	1/VIF
Ln Asset Value	1.23	0.814252
Education Years	1.16	0.858922
Ln Plotsize	1.16	0.86057
Ln Dist. All-weather road	1.16	0.863846
Ln Experience in potato farming	1.16	0.86417
Ln Dist. Produce market	1.15	0.870376
Dist.Agric.Office	1.14	0.878206
Need Extension	1.13	0.884304
Hired Labour	1.13	0.886746

NeedCredit	1.08	0.923105
HHSize	1.08	0.9292
Harvest Immature potatoes	1.05	0.95244
Mean VIF	1.14	

Appendix 3: Variance Inflation Factors for Tobit Regression Model

Variable	VIF	1/VIF
Ln TotalVolYield	1.75	0.570635
Ln Plotsize	1.55	0.644734
Hheadage	1.24	0.804654
Education Years	1.23	0.815321
Ln Asset Value	1.21	0.829837
Ln Dist. Produce market	1.14	0.879463
Dist.Agric.Office	1.13	0.883579
NumberGAPs	1.11	0.901017
HHSize	1.11	0.903954
NeedCredit	1.1	0.909655
Ln Dist. All-weather road	1.1	0.912465
Mean VIF	1.24	

Appendix 4: Map of the Study Area

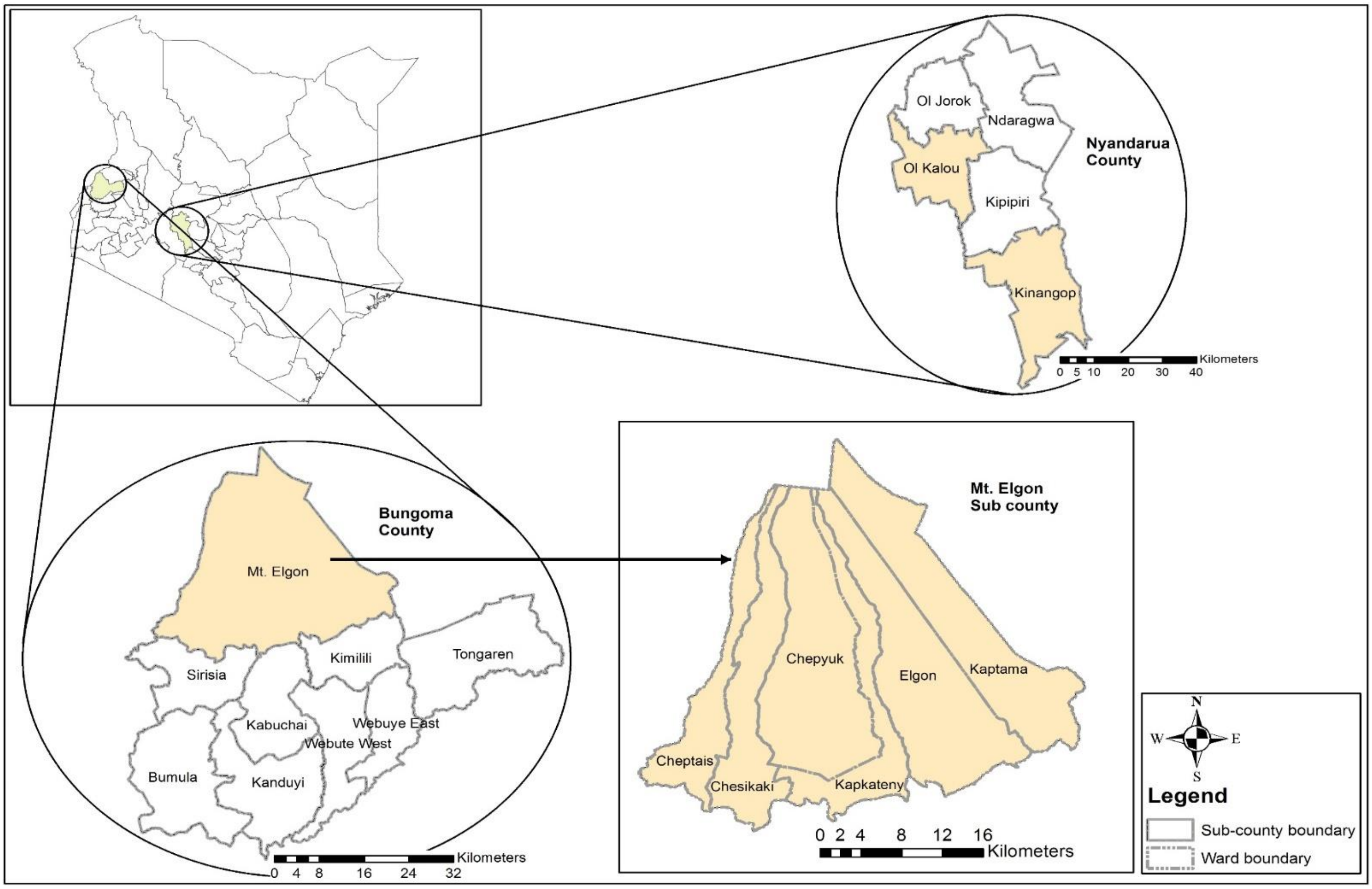

Figure 6: Map of Bungoma and Nyandarua Region

Source: Google maps

Appendix 5: Survey Questionnaire of GIZ Potato Baseline Survey - Kenya

The survey for coordinated by the International Potato Centre

CONSENT STATEMENT

My name is [………………….]. I am from the international potato center, and we are researching potato production in [country]. You've been randomly selected to participate in this research/interview. Your participation is voluntary, and the information we get from you will be treated confidentially. It will be reported together with those of others and your name and contact, or that of your family will not be specifically identified/mentioned in the report. The findings of this study will help our partners and us, including the [country] government, with which we collaborate, better understand the current issues in potato production.

You can choose to answer or not answer any questions and are free to withdraw from further participation in this interview at any time. In case you decline/withdraw, your lack of participation will not have any negative consequence on you, nor will it prevent you from benefitting from the activities that are being undertaken by us, our partners, or the government to improve potato industry. We would, however, really appreciate your participation and completion of the interview, and your honest answers to the issues we shall discuss.

If you have any further questions about this research, you can contact my research supervisor [name] directly on tel. …… [Tel. Of supervisor] …. or Dr. Julius Okello, the survey coordinator, on Tel. […………………………………….……..].

The interview will take about one and a half hours to complete. Do you have any questions right now?

With your permission/consent, I would like to start the interview. May I now proceed to start the interview? Yes………… No………………

Part A: Household and site identification

1. Unique Identifier:		
2. Date of Survey (DD/MM/YYYY):		3. Enumerator Name:
4. Respondent name (include aka):		5. Respondent's phone number:
6. Country Name:		7. District/County Name :
8. Sub-county name		9. Village name
10a). Household GPS Coordinates:	Latitude_______________ (N/S):	Longitude ____________ (E/W):
10b). Altitude (masl):		

11. Did you grow potato during the last one year? 1=Yes 0=No (If No, discontinue interview)

12. Distance to the nearest local market (walking minutes) …………………………………

13. Distance to the nearest farm input store (agrovet) (walking minutes)………………………

14. Distance to the nearest all-weather road (walking minutes) …………………………………

15. Distance to nearest government agricultural office (walking minutes)………………………

16. What is the name of your nearest source of certified seed potato …………………….. -99=N/A

17. Do you know of a community seed multiplier? 1=Yes 0=No

18. If YES, what is the distance to the nearest community? (Walking minutes) ……………

Part B: Household demographics and land ownership

HH member [Start with respondent followed by a spouse. Record all the 3 names]	02: Gender 1=Male 0=Female	03: Age (Years)	04: Relation to the household head (Codes A)	05: Marital status (**Codes B**)	06: Education (Years) (**Codes C**)	07: Years of experience in farming in general	08: Experience in potato farming (yrs)
1.							
2.							
3.							
4.							
5.							
6							
7.							
8.							
9.							
10.							
11.							

Codes A: 1= Household head 2=Spouse 3= Son/daughter 4=Grandchild 5= Sister/brother 6=In-law 7=Other, specify………………

Codes B: 1= Single 2=Married, lives with spouse 3=Married, spouse lives away 4= Divorced /Separated 5=Widowed

Codes C: 0= No formal education at all. [For others record year/grade completed : Primary 1 = 1; Primary 2=2; Secondary: form 1 = 9; form 3 = 11; University/College yr 1= 13; University/College yr 2 = 14, etc]

C: Potato production - plots

1. Please record below information about all the potato plots you had in 1st planting and 2nd planting

[After recording the plots and estimating sizes, inform the respondent that you will need to get an actual measurement of the **main** plot – at the end of the interview]

Season	2. Names of the plots [*Start with **main** plot*]	3. Estimated size (**Codes**)	4. Unit of plot size (**Codes**)	3. Actual plot size (**main** plot only)	4. Unit of plot size (**Codes**)
1st planting	Plot 1………….………				
	Plot 2 ……………..				
	Plot 3………………				
	Plot 4 ………………				
2nd planting	Plot 1……………				
	Plot 2……………..				
	Plot 3………..……				
	Plot 4 ………………				

Codes: 1= Acres 2=Hectares 3=Meter squared 4=Other (specify……………………)

2. For the **MAIN** plot above, please indicate if the potato was grown in the same plot during the seasons listed below and complete the rest of the information. [*Enumerator: Please use 1=if potato grown, 0=Not grown*]

Season (From C.1 above)	2015			2014		
	1. Did you plant potato in this plot in 2015? 1=Yes 0=No	2. If No, what crop did you plant? (Codes A)	3. Why did you choose this crop? (Codes B)	4. Did you plant potato in this plot in 2015? 1=Yes 0=No	5. If No, what crop did you plant (Codes A)	6. Why did you choose this crop? (Codes B)
1st planting						
2nd planting						

Codes A: 1=Maize 2=Beans 3=Tomatoes 4=other vegetable 5=sugarcane 6=cassava 7=Millet 8= Cabbages, 9= Oats, 10=Wheat 11= Onions, 12=Barley 13= Peas, 14= No crop/fallow 15=Others (Specify) ……………………….

Codes B: 1=Improves soil fertility 2=Breaks disease/pest cycle 3=Timing market 4=Breaks seed dormancy 5=minimise erosion 6= weather coping mechanism 7=Other reasons --------------------

Season (From C.1 above)	2013		
	10. Did you plant potato in this plot this season? 1=Yes 0=No	11. If No, what crop did you plant (Codes)	12. Why did you choose this crop? (Codes)
1st planting			
2nd planting			

Part D: Potato production and utilisation in the last season

[Focus on the **main** plot in the last 2 plantings only]

1. Please complete the table below for potato produced from the **main** plots during the last 2 plantings and its utilisation.

Season	Total harvest		Amount used as a food (Units codes)		Amount saved as seed		Amount used for fodder		The amount given out as gifts		Amount of potato sold				Who's responsible for sale decisions? 1=Male 0=Female 2=Both	Post-harvest losses (Kg)
											Ware		Seed			
	Quantity	Units (Codes F)	Quantity	Units (Codes)	Quantity	Units (Codes)	Quantity	Units (Codes)	Quantity	Units (Codes F)	Quantity	Units (Codes)	Quantity	Units (Codes)		
1st planting																
2nd planting																
Codes F																

1 Bags (specify) 1.1=50Kg (Gakweru – Small bag without extension/flat) 1.2=72 kgs 1.3= 90 Kg (Slim tall bags without additional bag extension) 1.4=100 Kg 1.5 = 110Kg (Flat jute/Makongo/ Mukorino) 1.6= 120Kg (Flat/large nylon bags/ Kampala bag) 1.7=150Kg (Kata 3 of large bags/ KATA 2 of small bags) 1.8=150kg (KATA 3 = 1 Full bag+ 1/3 bag) 1.9=180 Kg (KATA 2 of huge bags/ DOUBLE Bags of small bags)	2. Buckets (specify) 2.1=5 Kg 2.2=10 Kg 2.3=15kg (Small bucket) 2.4=18kg (large bucket) 2.5=20 Kg	3. Tones	4. Kilograms	5. Other (specify)

2. Please indicate in the table below the outlets you used for the sale of your potato

Outlet	Used this outlet? 1=Yes 0=No	Volume sold	Units (Use Codes in D 1)	Price received (KShs/UGX) per unit	Total revenue (KShs/UGX)
1st planting					
Farmgate					
Local market					
Local broker (off-farm)					
Distant market					
Farmer group					
Institutions (Schools, hospitals, Children's homes) etc.					
Supermarkets					
Commission agent (E.g.					

OLX)					
Restaurants					
Others (Specify) ………					
2nd planting					
Farmgate					
Local market					
Local broker (off-farm)					
Distant market					
Farmer group					
Institutions (Schools, hospitals, Children's homes) etc.					
Supermarkets					
Commission agent (E.g. OLX)					
Restaurants					
Others (Specify) ………					

3. If you sold some seed potato, please complete the table below:

Outlet	Used this outlet? 1=Yes 0=No	Volume sold	Units (Use codes in D 1)	Price received (KShs/UGX)	Total revenue (KShs/UGX)
1st planting					
Farm gate (family/ neighbour)					
Local market					
Farmer group					
Institutions					
Supermarkets					
Restaurants					
Others (Specify)………					
2nd planting					
Farm gate (family/ neighbour)					

Local market					
Farmer group					
Institutions					
Supermarkets					
Restaurants					
Others (Specify)………					

Part E: Value addition and marketing costs

5. Value addition and marketing costs of potato [*Focus on* ***main*** *plot*]

Value addition and sale	1. Done? 1=Yes 0=No	2. Labour cost (Shs)	3. Material cost (Shs)	4. Total cost (Shs)
1. Washing				
2. Sorting/grading				
3. Packing in garden				
4. Weighing				
5. Packing in store				
6. Storage costs				
8. Transportation from the garden to home storage				
9. Transportation from garden/home to the market				
10. Sales taxes/duty/ levies				
11. Time taken before getting buyers [Convert into Shs – use local farm wage rate]				
12. Finding buyers /communication				
13. Others (specify)……………				

Part F: Potato crop management

1. Please indicate the names of <u>all potato</u> varieties you have planted in the last 5 years.

1. Name of variety (Codes: Use codes in D 4 below)	2. Year first planted	3. Source of seed for this variety during first planting **(Codes A)**	4. Planted variety in 2016? 1=Yes 0=No	5. If Yes, Reason for choosing to grow variety **(Use Codes B)**	6. If No, Reason for choosing not to grow variety **Use Codes c)**	7. Would you consider growing this variety in future (1=Yes 0=No)

Codes D4:	Code A	Codes B	Codes c
1=Shangi 2=Sherehekea 3=Kenya mpya 4=Tigoni 5=Asante 6=Purple gold 7= Dutch Robjyn " Golf" 8= Nyayo 9= Victoria (AT) 10=Nakpot5 (Wanale) 11=Rwangume (Kabale) 12=Rudolf 13=Markies 14=Destiny 15=Jelly 16=Alka (Civillian) 17=Kenya-Karibu 18=Caruso 19=Connect 20=Desiree	1.ADC Molo 2. KALRO Tigoni 3. Kisima Farm 4. One Acre Fund 5. Agrochemical company 6. Farmer association 7. Other farmers 8. Agricultural office 9. NGO (Specify)……… 10=NARO 12=UNSPA 10.. Other (specify)	1. Tuber yield 2. Drought tolerance 3. Late blight tolerance 4. Bacterial wilt tolerance 5. Virus tolerance 6. Pest tolerance 7. Early maturity 8. Uniformity in maturity 9. Tuber size/shape right 10. Input requirement 11. Marketability (demand) 12. Tuber colour 13. Output (Tuber) Price 14. Seed price fair 15. Stores longer 16. Cooking time (boiling time)	1. Low Tuber yield 2. Not drought tolerance 3. Not tolerant to late blight 4. Not tolerant to Bacterial Wilt 5. Not tolerant to Virus 6. Non-tolerant to Pest tolerance 7. Not early maturity 8. Not uniform in maturity 9. Tuber size/shape not right 10. Require more inputs 11. Non Marketable (non-demand) 12. Bad Tuber colour 13. Low output (Tuber) 14. Unfair Seed price 15. Doesn't keep in Store longer 16. Takes longer cooking time (boiling time) 17. Doesn't taste good 18. Has Little nutritional value

21= Others (Specify)…………		17. Tastes good 18. Nutritional value 19. Colour 20. Others (Specify)…………………….	19. Has bad Color 20. Others (Specify)………………………….

2. For the last two plantings (1st & 2nd plantings above) what was your source for the seed you planted?

   1a) p1.____________________________________

   1b) p2.____________________________________

   1= Certified seed

   2=Farm saved seed

   3= Bought from neighbour

   4= Bought from market

   5= Community seed multiplier

   6= Others (specify) ………………………..

3. If seed was selected from farm-saved seed, how did you select your seed**?**

1= Select the healthiest plants or tubers from the potato plot (positive selection)

2=Select small non-marketable tubers

3=Select plants and tubers randomly (i.e., just picks what s/he can see lay hands-on)

4=I buy seed from neighbours/market

5=I buy certified seeds (Community seed multipliers)

6= I buy clean seed

7= Other (specify).........................

4. How many plantings do you consider as appropriate for replacement of the seed stock you have been growing on your potato plot? 1=1-2 2=3-4 3=5-6 4=More than 6, 5= Never (can't remember/don't know)

5. Please complete the table below for the potato production practices you used in the **main plots** in the last one year.

Agricultural practices	1. Did you use this practice? 1=Yes 0=No	2. If yes, during which planting did you apply it? 1=1st planting 2=2nd planting 3=both	3. How many times did you apply?	4. Where did you learn about it first time? (Codes A)	5. What is the main reason for applying this practice? Codes B	6. If you did not use the practice, why? (Codes C)

		99=N/A				
Use of organic manure						
Safe handling of pesticides						
Positive selection						
Use of certified seed						
Fallowing						
Rogueing						
Thinning						
Use of natural enemies to control pests						
Pest scouting						
Crop rotation						

Codes A: Agricultural extension office 2= Farmer group 3= Research Institute (NARO/KALRO) 4=NGO (specify……………) 5= Radio programme 6=TV programme 7=Mobile phone text 8=Other ……
Codes B: 1=To increased yield 2=To ensure that there is harvest 3= Get more food 5=Sell more 6= easily available 7=Cheap 8=Saves cost of fertiliser 9=environmentally friendly 10=Improves soil fertility 11=reduce exposure to pesticide 12=to produce own seed 13=maintain quality 14=break pest/disease circle 15=improve soil structure 16=reduce competition 17=obtain max plant population 18=Other…………..
Codes C: 1=Forgotten how to apply it 2=Difficult to do 3=Expensive/costly 4=Requires too much labour 5=limited knowledge 6=Other ……………………. 99=N/A

5. I would now like to understand a little more about how you conduct some of the practices above

5.1 Land preparation

a) What steps of land preparation did you undertake before planting potato in the **main** plot?

Fallow land					
Used land					

Codes A: 1=Clearing the rubble/bushes 2=Primary tillage 3=Harrowing 4= spraying with herbicides 5=rotorvating 6=Other (specify……………….)

b) What implements do you use to prepare your land for potato production?

1=Hand hoe 2=Ox-plough 3=Tractor (disc plough) 4= Tractor (Mould-board plough) 5=Riger 6=rotavator 7=fertiliser spreader 8= Other ………………………

c) Do you use any chemicals for land preparation (before planting) 1=Yes 0=No

d) If yes, which chemicals do you use? ....

1=Widal 2=touch down 3=roundup 4=gramaxone 5=wipeout 6=mapout 7=clampdown 8=greenfire 9=calach

e) Do you do soil nutrient testing? 1=Yes 0=No

5.2 Planting

a) How do you know that seed potato is ready for planting? [*Circle all that apply*]

1=When it turns green 2=When it starts sprouting 3=When the sprouts have leaves 4=Not sure 5=Other………………

b) How do you plant potato?

1=Dig ridge and place seed on ridge 2=make furrows and plant on furrows 3=Dig holes and plant in the hole 4=plant on raised beds 5=Other…..

c) When do you typically plant your potato?

1=Just before the rains; 2= 1-7 days after rains start; 3=2nd week after rains start; 4=More than 2 weeks from onset of rains; 5=Does not depend on rains (uses irrigation)

d) What seed spacing do you use during planting? ……………………………………………

1=75x30cms; 2=65x20cms; 3=20x20cm (seed multiplication) 4=others (specify) …………………………

5.4 Weeding/ridging

a) How many times do you weed your potato plot in a typical planting? …………………………………..

b) How do you decide on the number of times to weed your potato plot? [*Circle all that apply*]

1=I follow routine/calendar (i.e., weed after a specific number of days) 2=when the weeds emerge 3=when weeds start covering plants 4=When I have the time 5=When I get labour (hired) to work on the field 6= During the flowering stage 7=Other………………………….

c) Do you do earthing up/ridging in your potato plot? 1=Yes 0=No

d) If Yes, during which stage of the plant?

1=Any stage 2=before emergence 3=immediately after emergence 4=2 week after emergence 5=just before flowering 6=during flowering 7=after flowering 7=other…………………. 99=N/A

e) If No, explain why you don't do earthing up/ridging?

1=It makes no difference in yield 2=It costs more (needs more labour) 3=Takes more time 4=I did it during planting 5=Other ………………………. 99=N/A

5.5 Crop protection

5.5.1 Pest control

a) What are the **most common** potato pests that you have to control in your farm (circle all that apply) ………………………………….

1=Aphids 2=potato tuber moth 3=red spider mite 4=white flies 5=Nematodes 6=Leaf miners 7=Millipedes 8=Rodents 9=others (Specify)…………….

b) if more than one, which one is the **MAJOR** pest (i.e. most common and destructive) ……………………………

c) How do you identify this **MAJOR** pest?

1) visual inspection 2=feeding habit 3=type of damage 4=expert/extension advice 5=Other……………………

d) What **main** method do you use to control this **MAJOR** pest?

1=Chemical (insecticides) 2=natural enemies 3=handpicking and killing 4=using ash/natural repellant 5=Resting the field (fallowing) 6=Crop rotation 7=do nothing 8=field hygiene 9= use of pest tolerant varieties 10=uproot and burn infected plants 11=clean seed 12=Other ………………………

e) How do you determine what time to use the methods mentioned above of control?

1=Based on calendar spray regime 2=Pest scouting 3=When I see it in neighbour’s field 4=use of extension advice 9=Other …………………………….

5.5.2 Disease control

a) What are the **most common** potato diseases that you have to control in your farm (circle all that apply)………………………………….

1=early blight 20late blight 3=bacteria wilt 4=soft rot 5=fusarium wilt 6=powdery mildew 7=potato virus diseases 8=Rhizoctonia 9=black leg 10=other…………………..

b) If more than one, which one is the **MAJOR** disease (i.e. most common and destructive) ……………………………

c) How do you identify this **MAJOR** disease?

1) Visual inspection 2=symptoms 3=expert/extension advice 4=Other……………………

d) What **main** method do you use to control this **MAJOR** disease?

1=Chemical (insecticides) 2=natural enemies 3=handpicking and killing 4=using ash/natural repellant 5=Resting the field (fallowing) 6=Crop rotation 7=do nothing 8=field hygiene 9= use of pest tolerant varieties 10=uproot and burn infected plants 11=clean seed 12=others (Specify) ………………………

e) How do you determine the time to use the method mentioned above of control?

1=Based on calendar spray regime 2=Disease scouting 3=When I see disease in neighbour's field 4=When the weather changes 5=Others (Specify) …………………………….

5.6 Harvesting

a) How do you determine that potato is ready for harvesting?

1=based on weeks after planting 2=When leaves turn brown and fall 3=Spot checking tuber size 4=spot checking tuber skin 5=time from flower fall 6=others (specify) ………………………….

b) Do you sometimes harvest your potato even when you believe that they are not ready for harvesting? 1=Yes 0=No

c) If Yes, why? (Circle all that apply)

1=To sell and meet pressing cash need 2=To get an early market 3=To reduce loss from disease/pest 4=To meet family food needs 5=harvesting to make room for another crop 6=getting appropriate seed size 7=Other …………………………. 99=N/A

e) Do you cure the potato (cutting off the shoots and waiting for about 2 weeks (i.e., dehaulming)) before harvesting?

1=Yes 0=No

6. Please complete the table below with changes in weather (rainfall, temperature, frost,) compared to 10 years ago?

1=Yes 0=No

Weather change	1. Have you observed a change 1=Yes 0=No	2. How has it changed? Codes A	3. How has it affected potato production? Codes B	4. How are you coping with the change? (Circle all that apply) Codes C
1. Temperature				

2. Rainfall				
3. Frost				
4. Others (Specify)…………….				

Codes A: 1=has increased 2=has decreased 3=Erratic/unpredictable 4=others (Specify) …………….. 99=N/A

Codes B: 1=Production increased 2=Production decreased 3=No effect 99=N/A

Codes C: 1=Planting drought tolerant varieties; 7=Adjusted spacing; 13=Using agroforestry; 2=Using irrigation; 8=Keeping the field free of weeds; 14=Using early maturing variety; 3=Early planting; 9=Moving to lowlands (valleys); 4=Using pest/disease tolerant varieties; 16=None

5=Planting in deeper ridges; 11. Using minimum tillage (i.e., planting on unploughed field); 10=Water harvesting (irrigation); 6=Mulching; 12. Moving to forest lands (own or public – Shamba System, Tongya)

Part G: Input usage in potato production

a) a) Labour inputs in the MAIN plot

1. Please complete the table below for the family labour hours used in potato production in the MAIN plot

[Collect data only for family members 15 years or older]

Activity	Men		Women	
	1st planting	2nd planting	1st planting	2nd planting
1. Cutting and clearing the rubble/bushes				
2. 1st and 2nd Ploughing				
3. Harrowing/ Rotavating				

4. Planting				
5. Fertiliser application (1st and 2nd)				
6. Weeding (1st and 2nd)				
7. Irrigation				
8. Pesticide application				
9. Harvesting				
10. Sorting/bagging				
11. Others (Specify)				

b) Cost of hired labour used in the MAIN plot during the last two seasons

1. Please complete the table below with the **total costs** you incurred in producing potato for each of the following activities in the **main** plot

Activity	**1st planting (Ksh/UGX)**	**2nd planting Ksh/UGX**
1. Cutting and clearing the rubble/bushes		
2. 1st and 2nd Ploughing		
3. Harrowing/ Rotavating		
4. Planting		
5. Fertiliser application (1st and 2nd)		
6. Weeding (1st and 2nd)		
7. Irrigation		
8. Pesticide application		
9. Harvesting		
10. Sorting/bagging		
11. Others (Specify)		

2. Who is **normally** responsible for decisions on hiring labour in general? 1=Man 2=Woman 3=Both 4=Other, specify……

c) Cost of non-labour and non-pesticide inputs used in the MAIN plot in the last one year

1. Please complete the table below with inputs used for potato production

Season	Seed				Fertiliser applied during planting				Fertiliser applied for Topdressing				Foliar feed				Farm manure		
	s1. Quantity	2. units: (Use Codes B1 below)	**3**. Price/unit if purchased	**4.** What is the **Main source:** 1=Own	**5.** 1=DAP; 2= NPK (17:17); 3=	**6**. Quantity	**7**. Unit: 1=Kg 2=grams 3=50kg bag	**8**. price/unit	**9**. 1=CAN 2= Urea; 3=Foliar (NPK);	**10**. Quantity	**11**. unit: 1=Kg 2=grams 3=50kg bag	**12**. price/unit	**13.** Foliar feed type 1=NPK	**14.** quantity	**15.** Unit codes 1=milliliters 2= 0.5Liters 3=1 liter 4=5litres;	**16.** price/unit	**17.** Quantity	cart 3=pickups 4=tractor trailer; 5=9 tonne lorry; 6=100kg bag	**19**. price/unit
1st planting																			
2nd planting																			

Codes B1

1 Bags (specify)

1.1=50Kg

1.2= 90 Kg

1.3=100 Kg

1.4 = 110Kg (Flat jute/Makongo)

1.5= 120Kg (Mukorino, Kampala bag)

1.6=150Kg

1.7=150kg (KATA 3 = 1 Full bag+ 1/3 bag)

1.8=180 Kg (KATA 2)

1.9=Others (Specify)……

2. Buckets (specify)

2.1=5 Kg

2.2=10 Kg

2.3=15kg

2.4=18kg

2.5=20 Kg

2.6=Others (Specify)……

Machinery	1.Used?	2. If Yes, from where?	3. During which planting was it used?	4. How many times did you use it?	5. What was it used for? **Codes B**		6. Were you satisfied with its use	7. If NO, why not? (Codes C)	8. Cost of machinery (Kshs/UGX) in the **main** plot		9. Who makes decision on its usage
	1=Yes 0=No	Codes A	1=1st planting 2=2nd planting 3=Both 99=N/A		1st planting	2nd planting	1=Yes 0=No 99=N/A		1st planting	2nd planting	1=Man 2=Woman 3=Both
Spray pump											
Water pump											
Ox-plough											
Ox cart											
Tractor											
Pickup (Canter)											
Mechanical harvester											
Hoes											
Potato harvester											
Fertiliser spreader											
rotavator											
Potato planter											
Field maintainer											
Chisel plough											
Others (Specify)….											

2. Please indicate in the table below the kinds of machinery you used in the last 1 year in potato production in the **main** plot

Codes A: 1=Own 2=rented from neighbour/other farmer 3=Rented from farmer group 4=Rented from government 5=Rented from businessman 6= borrowed 7=Other ………………………

Codes B: 1=Land preparation 2=weeding/hilling 3=harvesting 4=Spraying 5=transportation 6=Irrigation 7=Fertiliser application 8=Field maintenance 9=planting 10=Other ………………..

Codes C: 1=Too expensive 2=Not easy to get 3=had to wait for a long time to get 4=High loss of tubers 5=difficult to use 6=compacts the field 7=Other …………….. 99=N/A

4. I would now like to ask you about your need and use of credit for potato production during the last 2 plantings. Please complete the table below if you needed credit for growing potato.

1. Why credit was needed? **(Codes A)**	**2.** How much money was needed (Ksh/UGX)	3. From where was the credit sought? 1=Bank 2=Sacco, 3=Self-help group 4=Chama/Merry-go-round, 5=money lenders, 6=Friends and family, 7=VSLAs 8=Other…..	4. Did you get it? 1=Yes 0=No 99=N/A	5=If YES, how was it received? 1= as a group 2=Individual 3=N/A	6. If you **did not get** credit, explain why **(Codes B)**
1st planting					
2nd planting					

Codes A	Codes B
1=Buy seeds	1=Had no collateral
2=Buy fertiliser/manure	2=Could not afford the interest rate
3=Buy pesticides	3=Could not get a guarantor
4=Buy farm equipment	4=Could not find lenders in this area for this purpose
5=buy/hire oxen for farm operations	5= Lenders could not provide the amount needed
6=Invest in irrigation	6=processing too slow
7=Buy/lease potato field	7=poor customer service/care
8= labour	8=Disqualified due to age
9=credit not needed	9=Considered a risky borrower
10= Other …………………………..	10Other, specify…………………………….

Please complete the table below for your extension service needs in potato production, i.e. information/knowledge that you do not have access to, and you believe that if received will enable you to improve your potato production to the desired level in order of the most important first

1 Type of extension advice	2. Did you get this advice? 1=Yes 0=No 99=N/A	3.If Yes, did you apply advice? 1=Yes 0=No 99=N/A	4. When was the advice applied? 1=1st planting 2=second planting 3=both	5. Did the advice help? 1=Yes 0=No 99=N/A	6. If you **did not get** the advice needed, explain why/ **(Codes)**

			4=others 99=N/A		
Clearing rubble/bushes					
Ploughing					
Harrowing					
Timely/early planting					
Plant spacing					
Fertiliser application					
Weeding					
Earthing up (mounding)					
Use of organic manure					
Pesticide application					
Safe handling of pesticides					
Positive selection					
Use of quality seed					
Crop rotation					
Fallowing					
Rogueing					
Thinning					
Mulching					
Use of natural enemies to control pests					
Pest scouting					
Sorting/grading					
Transportation of tuber					
Packaging/bagging					
Soil erosion management/ soil conservation					
Others (specify)					

Codes: 1=Not available 2=Too expensive 3=Agricultural office too far 4=Don't know where to get 5=Other ……………………………….

Part I: Membership to groups and Socio economic networks in potato

1. Are you a member of a group or organisation that deals with potato production?

1=Yes 0=No

2. What is the name of the group? ____

99=N/A

3. What is the size (i.e., membership) of the group? ____ 99=N/A

4. What are the functions of the group? (Circle all that apply)

1= Produce marketing 5=Savings and credit

2= Input access 6=Group training and facilitation

3= Seed production 7=Agricultural mechanization

4=Farmer research group 8=Other (specify)………………

5. Has this group ever received any training on potato production?

1=Yes 0=No 99=N/A

6. If YES, who gave the training?

1=Government extension officer 2=Project officer 3=NGO extension officer 4= Research organisation 5=Other……………….

7. If the group receive the training, did you participate in any of the training?

1=Yes 0=No 99=N/A

8. What training did you participate in? [*Circle all that apply*]

1= Potato marketing 5=How to access credit

2= Pest and disease control 6=Potato storage techniques

3= Use of quality seed 7= Positive/negative selection

4= Pesticide safe use 8= Other (specify)………………

9. If you are NOT a member of any farmer group/organisation, why not? 1=not available; 2=don't want to be a member; 3=Time wasting; 4=Corruption in the group; 5=Expelled; 6=lack of membership; 7=other, please specify……………………… 99=N/A

Part J: Potato storage practices

1. Do you store some of your potatoes after harvest? 1=Yes 0=No

2. If No, why don't you store? [*Circle all that apply*]

1=Not enough to store 2=Have to sell immediately to get money to use 3=Have no storage facility 4=Avoid loss by pests and diseases; 5=High demand; 6=immature tuber 7=fear of thieves, 8=Other…………..99=N/A

3. If Yes, why do you store potato? [*Circle all that apply*]

1=To get better price 2=Due to lack of buyers 3=For food 4=For seed 5=Other (specify……………………………………..)

4. If you store to get better price, how long do you need to store for this to happen? Months…………………….99=N/A

5. What is the average price margin (difference) between the stored potato and that sold at harvest? -------------------------

6. Where do you normally store your ware potato?

6.1 If On-Farm home

a) Where do you store the potato?

1=In the field 2=In a store inside residential house 3=In a store/granary outside residential house 4=In the living room 5=Other (specify)……………

b) Why do you store the potatoes at home?

1=Fear of theft 2=Not enough to store 3=too much loss 4=store too far away 5=high cost 6=hard to sell 7=nowhere to store 8=Other ………………. 99=N/A

6.2 If off-farm

a) Why do you store ware potato off-farm?

1=People begging for food 2= Avoid too much loss 3= I have no store at home 4=Get premium price 5=Other ………………. 99=N/A

b) Where do you store them?

1=At the group store 2=In a private (ambient) store outside home 3=In a store at the market 4= Other……. **99=N/A**

6.3. How far is it in walking minutes to the storage unit from your home/farm ……………………………… 99=N/A

6.4 How much does it cost you to transport the potato to this store outside home Ksh/UGX ……………………. per unit (specify………….) 99=N/A

7. SEED potato storage

7.1. Do you store seed potato? 1=Yes 0=No

7.2. If yes, what type of storage facility do you use to store seed?

1= Diffused Light Store 4= I store my seed potato in the field 99=N/A

2=Cold storage (ambient) 5= In a separate storage unit from residential house

3=In my residential house 6= Other (specify)…………….

7.3. Where is the storage facility located? 1=on farm 2=off farm 99=N/A

7.4 Who owns the facility?

1=Farmer group 2=Private business firm/company 3=Individual business person 4=Other …

99=N/A

7.5 Do you have to pay to use the store? 1=Yes 0=No

7.6 If Yes, how much do you pay? Kshs/UGX…../unit….. (specify unit …………………..)

7.7 How long (months) do you normally store your seed potato in this facility in a season…….

Part K: Financial Livestock and Physical Asset Endowments

1. Financial assets: Other sources of income in the last one year

Sources	**1.** Earned from source? 1=Yes 0=No	**2.** Total income earned (Shs)	**3.** Who controls the income? **1=** Man **0=**Woman **2=**Both
1. Milk			
2. Eggs			
3. Manure/compost			
4. Other livestock product (specify...........)			
5. Rented out land			
6. Other crops (besides potato)			
7. Potato income from other plots apart from the **Main** Plot			
8. Crop residues			
9. Casual farm employment income			
10. Permanent employment income			
11. Income from businesses (formal and informal)			
12. Remittances			

13. Social security			
14. Other farm income (specify)________________			

2. Livestock ownership and sales [over the last 1 year]

Livestock [select from **Code A**]	Ownership and sales in the last 1 year		Who decides on sales? (Codes B)
	Value of current stock (Shs)	Value of sales (Shs)	

Code A:1=Bulls 2=Cows 3=Heifers 4=Calves 5=Oxen 6= Goats 7=Sheep 8=Donkeys 9=Pigs 10=Chicken 11=Ducks 12=Turkey 13=Rabbit 14= Bees 15=Fish 16=Others (Specify…)

Codes B: 1=Man 0=Woman 2=Both 3=Others (Specify) ………………

Part L: Ranking income sources

Above, we have covered many sources from which you earned income in the last 1 year. Please indicate the Major most important sources of income and rank the first 3. [1=most important, 2= Important and 3=Least important]

	Source	Important 1=Yes 0=No	Rank
1.	Potato		
2.	Other crop(s)		
3.	Dairy/milk sales		
4.	Poultry sales		
5.	Off-farm casual labor		
6.	Non-farm income (Specify…………)		
7.	Other (specify …………)		

3. Please complete the table below for farm equipment you own

Asset name	Number currently owned	Current value (Kshs)	Who decides it use? Codes A
1. Ox-plough			
2. Ox-cart			
3. Chemical Sprayer/pump			
4. Wheelbarrow			
5. Bicycle			
6. Tractor			
7. Mechanical planters			
8. Radio/radio cassette			
9. Mobile phone			
10. Television (TV)			
11. Water pump			
12. Generator			
13. Sprinklers			
14. Fertiliser spreader			
15. Rotavator			
16. Chaff cutter			
17. Brush cutters			
18. Slashers			
19. Sickles			
20. Shovels			
21. Motorbikes (Boda Boda)			
22. Others (Specify)……...................			

Codes A: 1=Male 0= Female 2= Both

Thank you very much for your time and kind responses!!!!