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Full Length Research Paper

Assessment of innovative market access options for banana value chain in Uganda

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Smallholder banana farmers depend almost entirely on fresh banana for their livelihoods in Uganda. Similarly, other banana value chain (BVC) actors specialize in the trade of the fresh fruit for income and employment. Therefore, improving the efficiency of market access options in Uganda's banana sub-sector is one way that banana value chain actors can benefit through the sale of their banana products. In order to achieve this, the actors need to be innovative; departing from dependence on the same product and traditional markets/approaches that limit available benefits. This paper is aimed at identifying innovative market access options among the banana value chain actors in Uganda as a basis for projecting the potential. Cross-sectional research design incorporating 240 value chain actors was employed for the study. The major innovative market access options assessed during the study were collective marketing, contract farming, mobile phone platforms, value addition options and supermarkets. The study discovered that innovative market access options such as farmer associations/collective marketing groups, use of mobile phone tools and value addition among banana actors were vital in improving market access but were underutilized. As such, there is need to develop a specific banana value chain development strategic framework in order to tap up innovations among the value chain actors and promote their diffusion across key banana growing districts in Uganda.

Key words: Market access options, banana, value chain, innovation, Uganda.

INTRODUCTION

Bananas are a major staple food in Uganda constituting 70% of the family food basket (Bujoreanu, 2013). They are grown by approximately 75% of the country's farmers on 40% of the total arable land (PAEPARD, 2012). Additionally, Uganda is currently one of the world leaders in banana production, accounting for approximately 10% of total global production (FAOSTAT, 2006). The country produced 4,300,000 tons in 2008, 4,522,000 tons in 2009, 4,694,000 tons in 2010 and 4,895,000 tons in 2011 (UBOS, 2012).These statistics reveal that with such a vast amount of bananas produced, rural village markets in Uganda are highly unlikely to be meaningful avenues for market access since the majority of people in these localities are most likely to be banana producers (especially in major banana producing areas).

At present, the smallholder farmers in Uganda almost

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entirely depend on fresh banana produce for their livelihoods (Ssali, 2008). The practice has led to a negative impact on their wellbeing since the benefits derived from fresh banana are low (Sanyang, 2012). The situation necessitates the adoption of innovative market access options among banana producers and other value chain actors.

Market access options are alternative avenues through which a value chain actor(s) can supply and sell their product(s) to another value chain actor(s). Therefore innovative market access options are strategies involving change from the norm adopted by a value chain actor(s) to resolve a perceived constraint in the value chain especially when there is stiff competition in the traditional market channels. Innovative market access can therefore be achieved in three ways; (a) by identifying new market avenues (departing/improving the traditional markets or approaches e.g. fresh banana market, individual market access approach, farm gate and roadside selling) (b) by identifying and adopting an activity that the value chain needs in order to operate efficiently (it may be absent or in existence but underprovided) or (c) by creating a new or improving an existing product (reducing dependence on 'traditional' product e.g. fresh bananas). Adoption of innovative market access options facilitates efficiency in a value chain thereby improving the trade system and benefits along the value chain.

The banana value chain in Uganda has over a long time retained its traditional approach thus making it complex in nature; it has repetitive activities which could be handled by one or a few chain actors' e.g series of banana traders. However, in recent times due to increasing globalization through international trade, innovativeness has been embraced in order to reach the international consumers who want to retain their food culture. In the same way there has been an increase in banana funding (e.g. by Department for International Development, Forum for Agricultural Research in Africa and Uganda Government), changes in demographics (urbanization), transport and communication systems (modernization) as well as consumers' preferences which have necessitated the adoption of a theory of change in Uganda's banana sub-sector. As noted by Bouris et al. (2011) farmers' access to markets is majorly influenced by their product's ability to meet the consumers' criteria. The high competition in agricultural markets is primarily due to the oversupply of certain products as a result making it increasingly vital for value chain actors to engage in innovative marketing practices in order to link their products with the market place. Therefore, this study is aimed at assessing innovative market access options and actors as a basis for showing the increased need for change in the banana sub-sector for increased benefits among the value chain actors.

The research questions that guided this paper were; 'Who are the key drivers/actors in banana value chain in Uganda?' 'What roles do the actors play in the value chain development?' 'What innovative marketing options exist in Uganda for banana products and services?' and 'Factoring in innovativeness, what is the ideal banana value chain in Uganda?'.

THEORETICAL APPROACH

This study adopted diffusion of innovation theory in order to identify the innovative market access options and actors in the banana value chain. Innovation refers to an idea, practice or project that is perceived as new by an individual or other unit(s) of adoption (Sahin and Thompson, 2006). From literature, innovations have the following qualities: relative change, compatibility, complexity, trialability and observability (Rogers, 1995). Relative change is the degree to which an innovation is perceived as better than the idea it supersedes. Innovative market access options are considered to be more beneficial compared to traditional approaches. Compatibility is the degree to which an innovation is perceived to be consistent with the existing values, past experiences and needs of potential adopters while complexity is the level of simplicity or difficulty involved in the adoption of a given innovation. The endorsement of innovative market access options among banana value chain actors is pegged on the improvement of the existing products and markets which are considered easy to adopt. Trialability is the degree to which an innovation may be experimented with on a limited basis while observability is the degree to which the results of an innovation are visible to others; the easier it is for individuals to see the results of an innovation the more likely it is that it will be adopted. Considering that innovative market access options have been adopted by some actors this translates to ease of implementation due to observability.

Innovativeness is closely linked to or rather is an ingredient of entrepreneurship and is affected by attitude and perception. Amorós and Bosma (2013) observe that fear of failure and availability of (good) job alternatives in an economy further contributes negatively to entrepreneurship of individuals. That is why creation of awareness and promotion of entrepreneurship should be on top of policy agendas in economies in Uganda and specifically for bvc development. As was evident from the Global Entrepreneurship Monitor (GEM) report, Uganda ranks highly in entrepreneurial intentions at 60.7% compared to other countries in Sub Saharan Africa such as South Africa at 12.8%, Nigeria at 46.8% and Zambia at 44.5%, Latin America and Caribbean (average 32.5%), Middle East and North Africa (average 38.2%), Asia Pacific and South Asia (average 20.9%), Europe-EU28 (average 13.5%), Europe-Non-EU28 (average 13.7%) and North America (average 12.9%). This shows high willingness of the Ugandan people to be entrepreneurs. However, the report further shows low new business initiation and ownership at 20% in Uganda although above Africa's average of 15.5%; an indicator of low implementation and perhaps low level of enablers in realizing individual intentions. Therefore, there is need to identify innovativeness in order to set strategic enablers in agricultural value chains as well as build on the existing structures and systems to create a new system of agriculture transformation that addresses existing barriers and unaffordable policies to support high level entrepreneurial spirit among actors.

METHODOLOGY

Study area

This paper draws information from a study carried out in Mbale district located in Eastern Uganda, and Kabale and Mbarara districts in South Western region. The areas were selected based on their differences in banana production and market characteristics. Mbarara district is characterized by high banana production whereas Kabale and Mbale are characterized by medium and low production levels respectively. Mbale and Kabale districts share a border with Kenya and Rwanda respectively and thus experience cross border effects, different market arrangements from the rest of Uganda.

Research design

The paper used a cross-sectional research design, employing both quantitative and qualitative research methods (mixed methods) as championed by McCormick and Schmitz (2001 in collecting data from the main banana value chain actors. In order to increase the reliability and precision of data, a triangulation method (interviews, focus group discussion and literature review) was adopted as endorsed by Creswell (2009) and Grajek and Kretschmer (2009). Semi structured questionnaires, key informant interviews and focus group discussions were used as tools for data collection.

Sampling design

The paper employed a multi stage sampling technique where in the first stage three districts (Kabale, Mbale and Mbarara) were purposively selected since they had varying characteristics in terms of production, marketing and value chain development so as to ensure representativeness of the sample for Uganda. In the second stage, two sub-counties and two parishes from each sub-county, that is, four parishes per district were purposively selected while in the third stage a total of 240 actors whereby twenty value chain actors were selected per parish using simple random sampling technique.

Data analysis

To determine innovative market access options and actors in the banana value chain, data was analysed through descriptive techniques; means, percentages and frequencies using Microsoft Excel, STATA and Statistical Packages for Social Sciences (SPSS). In addition, ranking of opportunities was done as per key informants views.

RESULTS AND DISCUSSION

Major banana value chain actors and roles played in Uganda

The major banana value chain actors identified during the study included farmers/producers, loaders, transporters, traders (micro-traders, bulk traders and retailers), crafts makers, processors facilitators (state and non-state actors) and consumers (Table 1). The major role each plays is an indicator of their importance in the current BVC and its development.

Banana producers are the main players in the BVC, who are mainly smallholder farmers with farm size ranging between 0.5 to 4 acres. The producers rarely use external inputs such as inorganic fertilizers, tissue culture seedlings and chemicals (at less than 1%) whereas approximately 18% use farm yard manure. Their main sources of seedling (sucker) are from older plantations or neighbours. The producer market approach is through sale of a few bunches of banana to bicycle traders at a go, at the farm gate and or village centres.

Micro traders whose main mode of transport is bicycles move from one farm to the other in search of banana to purchase, either through random checks or referral. They are preferred by banana producers since they ease the transport burden to village markets. These traders mainly fill in the collective function for nonexistent or non functional farmers' marketing groups.

Market vendors operate on a higher scale than bicycle traders. Their major market points are village markets where they buy from farmers and bicycle traders then move the bananas to bigger market points where bulk traders collect them. They mainly have an established relationship with bulk traders which ease their functionality.

Loaders and transporters in the BVC have an important role in moving banana to urban markets. However, they also supply banana to institutions such as schools and hotels. Loaders have the role of carrying and packing banana in green banana leaves, sacks and or in vehicles whereas transporters move bananas on behalf of bulk traders to their preferred market. Transporters act as a key link between rural banana production points to urban consumers.

Retailers are located in village and urban markets, where they sell banana products to small consumers mainly purchase a few fingers or cluster at a time. They also operate in residential neighbourhoods to ease consumer's banana market accessibility.

Some banana bulk traders also function as exporters whose main role is to move banana to international markets mainly to Kenya, Rwanda and United States of America. Exporters are mainly keen on quality in order to meet banana consumer attributes. Banana processors

Table 1. Major banana value chain actors and roles played in Uganda.

Value chain actors	Major role(s)	Characteristics
Producers	Undertake banana production activities; Engage in farm gate and trading points (village level) selling; Human or bicycle transport to markets; Consume a significant portion of their banana produce	Are mainly smallholders (0.5-4acres); Use basic farm implements and traditional techniques in plantation management; Use suckers from own/neighbours farms as a means of plantation maintenance or expansion; Mainly sell produce to micro/bicycle traders
Micro/bicycle traders	Involved in collection of bananas from farms to collection points;Act as a link between farmers and markets	They operate on a very small scale (transport and trade 1-5 banana bunches at a time)
Market vendors	Undertake collection of bananas from bicycle traders; Acts as agents for lorry traders (bulk traders)	Operate on considerable higher scale than micro-traders but less than bulk traders; Have an established relationship with bulk traders
Loaders	Involved in loading of bananas into banana carriers	Are casually engaged by bulk traders
Transporters	Offer transport services to bulk traders	Operate in large scale (large investment)
Bulk (lorry) traders	Undertake bulking of bananas from major rural trading points; Involved in long distance transport of bananas from rural areas to major urban centres	Operate in large scale level (large investments); Act as a link between urban consumers and rural banana sources
Retailers	Buy from large/bulk traders and sell to consumers; Supply bananas to consumers in quantities they want/they can afford	Operate on small scale; Are involved in selling other goods other than bananas; Operate in major markets to next door kiosks in residential areas
Exporters	Involved in large scale production or buy from producers directly; Regional exporters buy bananas from bulk traders or bulk themselves; Distribute banana products to the international markets	Operate in large scale (involve large volumes); Are keen on quality; Have specific long-term relationships (network) with traders in other countries
Processors	Undertake transformation of fresh bananas/banana plant parts; Involved in consumer awareness creation on processed banana products	Operate on a small scale due to consumer unawareness
Value chain facilitators	Provision of advisory services; Value chain development ; Funding of value chain activities	Mostly incorporate banana promotion in their activities along with other theme areas; Undertakes research and development initiatives
Consumers	Provide market for banana products	Ranges from small (individuals and households) to big (restaurants and institutions) consumers

mainly operate on a small scale in transforming banana fruit and banana tree parts to other products in order to boost their market access ability.

Value chain facilitators provide services to BVC actors, that is, provision of advisory services such as extension, finance and research. In the current banana value chain in Uganda, the value chain facilitators are weakly linked to BVC actors thereby constraining the value chain operation. The main banana consumers in Uganda are households, although hotels and institutions (such as schools) are also major consumers.

Innovative market access options and actors in Uganda

Results of the study indicated that although 18% of the farmers were members of farmer groups, only 3% of the banana farmers sold their bananas as a group, that is, the majority (97%) sold their banana produce individually (Table 2). These findings indicate inactivity of the existing farmer groups as indicated during the farmer group discussions despite of the recent high investment in formation of groups under NAADs by Ministry of Agriculture. This could be further attributed to low trust among farmers even when in a group, thus making them unable to sell their banana produce collectively. The findings are an indicator of the opportunity for private sector investment in addressing the actors' constraints along the BVC. The results were similar to the findings of Ngambeki et al. (2010) in the study of banana market distortions in Uganda who found that an estimated of19% of banana farmers sold their banana produce through farmer groups and contracting. The relationship between

Table 2. Farmers' descriptive characteristics for innovation and value addition.

Farmers	Category	Mbale (%)	Kabale (%)	Mbarara (%)	Overall (%)
Banana value chain innovation	Packing in sacks	10	0	0	3
	Chips	2	0	2	2
	Crafts	20	0	0	6
	Marketing innovation	3	0	7	3
	Fertilizer use (manure)	18	0	35	18
Access to value addition information	Have access	40	41	49	44
	Do not have access	60	59	51	56
Banana value addition knowledge	Have knowledge	72	46	70	65
	No knowledge	28	54	30	35
Value addition	Do value addition	37	20	14	23
	Do not	63	80	86	77
Gender proportion in value addition	Male	33	88	83	59
	Female	67	12	17	41
Banana value addition	Ripening	3	0	5	2
	Roasting	5	0	0	2
	Pancakes	3	0	0	1
	Crisps	3	0	0	1
	Juice	3	2	2	2
	Wine/local brew	8	20	9	12
	Drying	5	0	2	2
	Craft	20	0	0	6
Mobile phone ownership	Those who own	63	46	72	60
	Those who do not own	37	54	28	40
Market information channels	Mobile phone	33	15	28	25
	Internet	3	2	0	2
	Market boards	15	5	14	11
	Media	3	0	23	9
	Market visit	33	15	12	19
	Cooperative group	0	0	2	1
	Other bvc actors	25	37	33	31
	Neighbors and relatives	50	41	19	36

group membership and the proportion of farmers who sell through these groups was an indicator of the reverse gains in collective banana marketing.

This study observed that contract farming was increasingly being favoured by exporters and processors as a basis for acquiring quality bananas. Exporters such as Afri Banana Products LTD had established a fresh banana contract with the locals in Mbarara towards its Fresh Vacuum Sealed Matoke (FREVASEMA) export to the United States of America. Banana wine and juice makers had established non-formal contracts with farmers and traders in provision of banana as the need arose. This was discovered to be an avenue for increased returns by the participants, which implied that contract farming was among the pronounced options for market access.

The results of the study also pointed out that mobile phones as a platform of information communication technology presented a viable avenue for bridging the existing gap in acquiring timely market information as evidenced by 25% of the farmers compared to 16% of traders. However, mobile phones are underutilized in market information access where only 25% indicated having used mobile phone tools in accessing market information compared to 60% mobile phone ownership among banana farmers (Table 2). The ownership is quite substantial although farmers do not exploit the information and communication technology (ICT) potential for better market access. However, the study established high potential growth in market access and technology transfer through technology transfer among BVC actors. Guidi (2011) indicated that deficits in rural infrastructure among which is the communication infrastructure hinder agricultural transformation. The underuse of mobile phone gadgets among banana farmers overlooks access to crucial market information which would otherwise be a game changer in the banana market. As noted by USAID (2011) provision of market price information helps actors in agricultural value chains in promoting efficient production and trade. Such information enables producers to; negotiate for better terms with traders, decide whether or not to harvest at a later date, store their produce, choose what markets to sell to and even influence their plans on future crop choices. In a study on the impact of mobile phone coverage Uganda, Muto (2008) affirmed that the provision of market information influences participation in horticultural markets. This is explained by the need for timely sale of horticultural products since they are highly perishable. Therefore, mobile phones present an innovative market access platform which may facilitate efficient trade systems in the banana value chain given that bananas are also significantly perishable hence increased returns to investment.

Results from the study further indicated a limitation of market information as evidenced by banana farmers' dependence on neighbors' and relatives (36%) as their preferred source of market information; a social network platform (Table 2). On the other hand, traders' main source of information was other value chain actors as evidenced by 57% of the respondents. This observation presents a high risk for value chain actors in making informed decisions relating to price determination, what market to sell to and when to sell their banana produce. The parties in a social network platform were characterized by either withholding crucial information or misrepresenting it i.e. information asymmetry, thus constraining market access as well as benefits derivable from banana trade. The findings were similar to those of Ngambeki et al. (2010) who established that the major information source in the banana value chain were the traders and middlemen followed by other farmers. The potential bias of sources increases the likelihood of misinformation especially from traders and middlemen who could provide information geared to favor them.

The study found that brewing was the most common form of value addition among the value chain actors, being practiced by 12% of the farmers. Although the results indicated 44% of the respondents had access to value addition information and approximately 65% indicated they were aware of banana value addition, only 23% were involved in value addition (Table 2). The study revealed that 27% of banana was set aside for value addition by farmers. Banana beer and wine presented a cheaper and nutritious option of alcoholic drinks thus being preferred by rural dwellers and as a result promoting the local economy.

Supermarkets are increasingly being used for value added banana products (wine, juice, crisps, cakes) as an innovative platform for reaching the middle and high income markets. This presents an opportunity for investment in banana value addition for employment creation and income generation through commercialization of existing cottage industries.

Banana traders were found to be innovative by packing banana in sacks as a way of retaining banana quality during transportation, brewing and trading *waragi* and *tonto* as well as cooking and selling banana chips. The study ascertained that 27% of the fresh banana purchased by traders for sale is set aside for value addition that is, ripening, roasting, juicing, crisps making and brewing. He traders main mode of market information access was through other value chain actors (57%) followed by market visit at 27%, mobile phones at 16% and neighbours and relatives at 14% respectively (Table 3).

Product exchange and craftsmanship designs were established as upcoming avenues in the development of the banana value chain. Environmental friendly charcoal makers (especially in urban areas) used banana waste products such as banana peels and stems in making charcoal briquettes. The households and or individuals who supplied banana waste were given charcoal briquettes in exchange thus resolving the waste menace and fuel demand concurrently. The packaged charcoal briquettes have penetrated the supermarket segment as clean energy alternatives for urban dwellers. Craftsmanship designs using banana 'waste' products such as banana stems have also been increasingly developed as an alternative avenue for gaining access to the market thus departing from dependence on fresh banana produce. The fibre from the banana waste is used by craftsmen in designing lamp stands, hats, ornaments, baskets and paper bags which are biodegradable. This innovativeness is increasingly gaining favour in the market and can thus be utilised as a tool for banana value chain development. The results are an indicator of the great potential in banana waste management in Uganda as a source of job and wealth creation.

From the study collective marketing followed by contract farming and value addition were considered as the most preferred market access strategies. On the other hand, craftsmanship designs and product exchange were ranked as the lowest promising market access options. However the last two options were cited as highly innovative and likely to catch up with the rest of market access options due to increasing environmental promotion debates related to climate change across the world. Collective marketing was ranked as the best innovative market access option due to reduced transaction

Table 3. Traders' innovation, value addition and marketing.

Variable	Category	Mbale (%)	Kabale (%)	Mbarara (%)	Overall (%)
Banana value chain innovation	Packing in sacks	20	5	13	11
	Chips	13	5	0	7
	Banana brew trade	7	57	0	27
Value addition participation	Ripening	7	10	13	9
	Roasting	7	0	13	5
	Banana crisps	0	5	0	2
	Banana juice	0	0	25	5
	Banana wine	7	48	0	25
Banana value added	Proportion	26	37	20	27
Information channels	Mobile phone	13	10	38	16
	Internet	0	5	0	2
	Media	7	5	13	7
	Market visit	40	24	13	27
	Other banana value chain actors	60	57	50	57
	Neighbours/relatives	0	24	13	14

Table 4. Differences between traditional and innovative market access options.

Traditional market access options	Innovative market access options
Many actors and small production units	Very few actors and large production units
Lack of standards to adhere to in production	Standards and certification to adhere to in production and processing
No direct information access options on product and processing	Direct market and product information access via information communication technology
Little/no processing and value addition	Advanced processing and value addition
Market based governance structures	Quasi hierarchical governance
Trader driven	Buyer/consumer driven

costs, high returns from better prices and ability to bypass middlemen within the BVC. The study identified contract farming as the second most preferred market access option basically due to assured market by farmers across Mbale, Mbarara and Kabale. The paper recognised innovative market access options such as mobile phones and was associated with timeliness and cost effectiveness by farmers and traders. Value addition was also ranked highly (third) as a promising market access option with benefits associated to extended shelf life, access to high end markets and provision of product varieties to consumers. The study across the three study districts established other innovative market access options such as social networks, supermarkets, product exchange and craftsmanship among other options embraced by BVC actors.

From the study it was clear that a range of banana value chain actors were innovative given various engagements and options explored to meet market demand. However, processors and exporters were considered as the most innovative (as ranked by key informants) considering their market approach of supplying the fresh bananas in distant markets. The ability to extend the shelf life of fresh bananas serves as a basis for scaling up to international trade with other banana demanding markets. Similarly the product exchange and craftsmanship designs market access options were considered highly innovative whose diffusion has been slow. In addition, as noted in the study there is increasing number of innovative actors who are focused on developing consumer tailored banana products meant to meet existing demand and resolve challenges in the BVC. Consequently, the trend will improve the banana trade system though little by little. Critically, the diffusion of innovations like the extension of banana shelf life and processing are constrained by the intellectual property rights.

The findings of the study established major differences between traditional and innovative market access options (Table 4). Key among these was the buyer/consumer

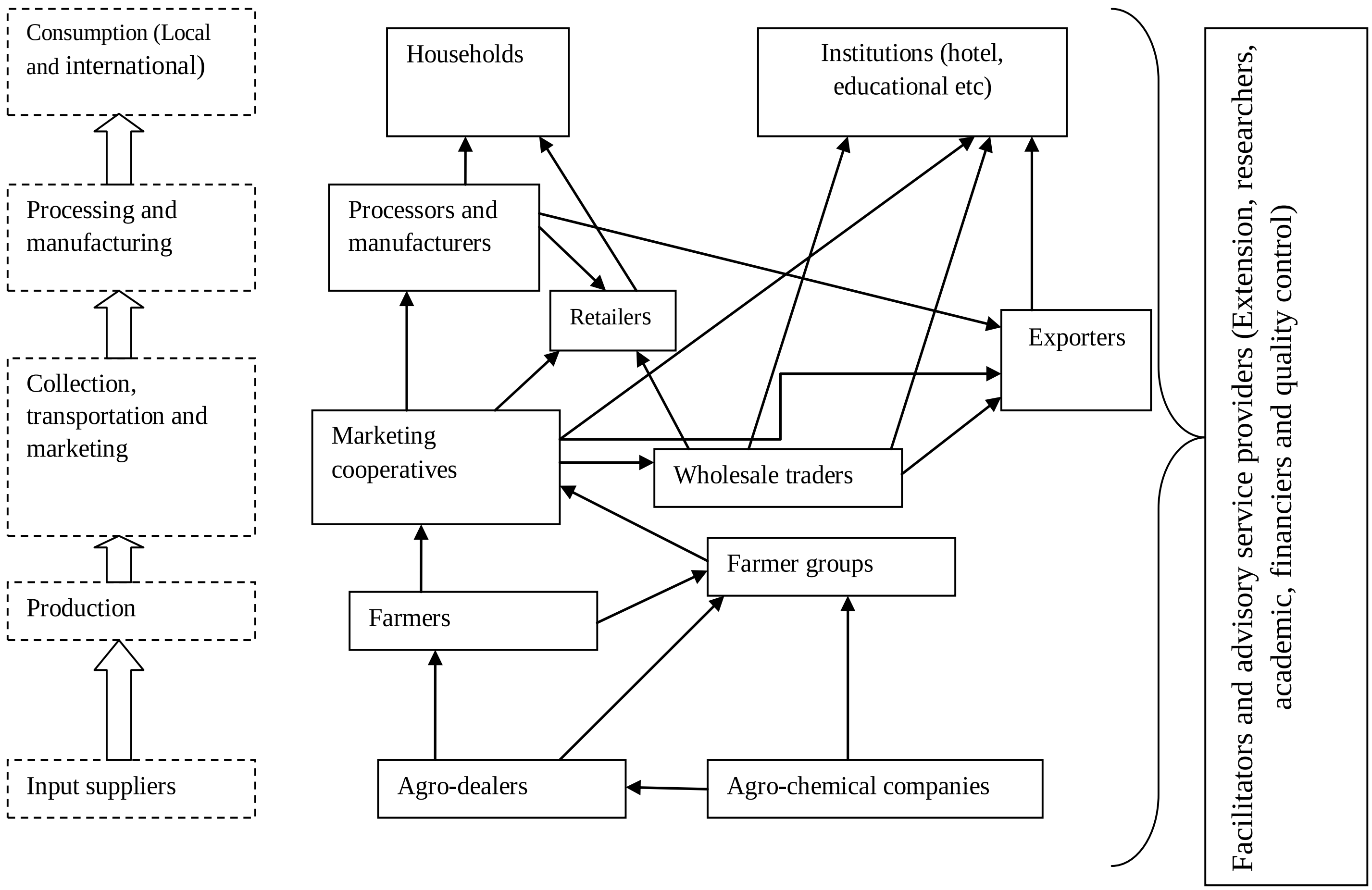

Figure 1. The ideal banana value chain in Uganda.

drive in innovative market access options compared to traditional trade drive. Therefore in today's market structures innovative market access options are superior compared to the traditional market access options as had been ascertained by Keane (2008).

Innovativeness and banana value chain

Through the adoption of innovative market access options (diffusion), the long and complex banana value chain in Uganda could highly be transformed. These options include the bypassing of micro traders and market vendors and transferring those roles to structured farmer organizations. As a result the time taken in distributing banana products to consumers would be notably reduced hence improving the quality of bananas (freshness) offered in the market. Further, the linking of producers to input dealers as well as bridging the gap between financial facilitators to value chain actors would be a potential basis for improving the efficiency in the banana value chain as well as innovativeness. Through these innovations, trade efficiency in the banana value chain would be improved. This study narrowed down to the value chain below as an ideal banana value chain for Uganda (Figure 1).

CONCLUSIONS AND RECOMMENDATIONS

From the study it was evident that the producers, loaders, transporters, traders (micro-traders, bulk traders and retailers), craftsmen, processors, facilitators (state and non-state actors) and consumers were the major actors in the banana value chain in Uganda. The micro-traders were the main link between the producers and the market. Although micro-traders are considered as middlemen by producers, they perform an important function that could be run by producer organizations in an ideal trade system and thereby contribute to BVC efficiency. Input dealers and financial facilitators had a notably weak and in many instance an absent link to banana producers which impacts negatively on the BVC trade efficiency. These actors would have played a major role as production and market enablers respectively. In this case, National Agricultural Advisory Services (NAADS) could play a vital role. There was a noted increase in innovativeness among the banana value chain actors with processors and exporters leading the adoption of innovative market access options through the extension of fresh banana shelf life. Product exchange and craftsmanship were observed as being the most promising avenues in market access. The diffusion of innovations was found to be instrumental in the development of the banana value chain; however, intellectual property rights in the case of processors and exporters were identified as constraint. Financiers and government could play a crucial role in catalysing the diffusion of innovations by availing necessary facilitation to the value chain actors. As a basis of easing market access, the study recommends the need for documentation of innovation efforts in all districts across Uganda and capacity building of the innovative actors in order to raise awareness and in turn promote innovations diffusion which will contribute to the BVC development. The study sought to explore innovation efforts in the banana value chain, however further assessment in innovation and incubation being advocated by funding organizations is required in order to understand their feasibility and contribution to value chain sustainability.

Conflict of Interest

The authors have no conflict of interest whatsoever.

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Root and tuber expansion programme and poverty reduction among farmers in Southwest Nigeria

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This paper evaluates the *ex post* impact of farmers' adoption of Root and Tubers Expansion Program (RTEP) on yield, crop income and poverty in rural Nigeria by means of primary data collected from 161 households in 3 local government areas in South West Nigeria. Using FGT poverty measures and propensity score matching techniques the study found that poverty incidence is higher by about 23% among non beneficiaries than among the beneficiaries of RTEP. Net yield per hectare increased by a range of about 13.00 to 18.52 metric tons while net crop income per hectare increased by a range of about ₦39,705 to ₦42,133 ($198-211) thus, reducing poverty by about 5 to 20%. The factors that positively influenced the probability of adoption of RTEP were: years of education, social capital, farm size and access to improved planting materials while planting of two or three root crops negatively influenced the probability of adoption of RTEP. Therefore, policy options that favor increased education, farmer group membership and access to improved inputs are recommended to encourage RTEP adoption and further reduce poverty among farmers.

Key words: Root and tuber crops, beneficiaries, poverty, adoption, logit.

INTRODUCTION

Poverty reduction and elimination remain key issues of development globally. Poverty has traditionally been higher in rural areas than urban areas despite the bulk of agricultural activities that take place in rural areas. In sub-Saharan Africa (SSA), a greater proportion of the population resides in rural areas and the poverty rate stands at about 50% (Anyawu, 2012). Agriculture remains the mainstay of most economies in the region accounting for a vast majority of the working population. Paradoxically, agriculture has been the locus of poverty in SSA countries, especially in Nigeria which has the highest population of poor people in the region. About 70% of Nigeria's 160 million population is poor and about 60% of the people are engaged in agriculture (NBS, 2012). The welfare of farmers remain generally low due to declining productivity which could be attributed to low technical know-how on crops (that is, agricultural technology) to improve income and food security (Amao and Awoyemi, 2008). Agricultural technology contributes to poverty reduction in terms of enhanced productivity

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and lower per unit cost of production which raise income of adopting farmers (Menale et al., 2011). It follows that the lack of agricultural technology not only results in decreasing capacity to meet the food needs of the people, but also creates critical limiting factors to all-year-round cultivation given that production in SSA countries is largely weather-dependent. Hence, research and adoption of crops having the ability to withstand drought, diseases, improved yield and be cultivated throughout the year is crucial for food security and poverty reduction in the region.

Root and tuber crops rank high as drought resistant crops grown all-year-round hence, have become important staple foods consumed in SSA, accounting for about 20% of calories consumed in the region (Scott et al., 2000). For instance, annual mean per capita consumption of cassava in Africa is about 140 kg (Philips, 1998). In Africa's most populous country, Nigeria, root and tuber crops are the second most important food crops, after cereals and they have the potential to contribute significantly to food security (Kays and Paull, 2004). They are used to alleviate seasonal shortages and fill food gaps caused by natural or man-made disasters (Tanganik et al., 1999). The crops also serve as raw materials in manufactured products for both rural and urban consumption in addition to providing income sources for resource poor farming households (Nwakor et al., 2011). Given the global drive towards poverty reduction and welfare maximization, root and tuber crops have become increasingly important for household and social welfare among rural dwellers.

Government intervention in the development of root and tuber crops as major food crops in Nigeria has been high due to their food security role, drought resistant capability and their potential for commercial processing. Since the 1980s, government efforts have generally focused on development of high yielding varieties that are tolerant to pests and diseases. Various interventions aimed at improving sustainable productivity, farmers' income and the quality of lives of rural households have also been instituted. Cassava has been most favored among the roots and tuber crops for government interventions in Nigeria which include: The Cassava Multiplication Program (CMP) which took off in 1989, the Root and Tuber Expansion Program (RTEP); launched in 2000 and the Presidential Initiative on Cassava (PIC); formed in 2002.

The CMP and the PIC mainly focused on improving production and have helped to boost Nigeria's cassava production, making the country the largest cassava producer in the world (FAO, 2013). In addition, the programs facilitated the building of domestic productive capacity to efficiently, profitably and sustainably satisfy the market demand with the quality and quantity required (PIC, 2003). The RTEP, on the other hand, was tailored to address the welfare of the farmers in addition to increased production.

The root and tuber expansion program (RTEP)

The root and tuber expansion program (RTEP) was formulated to address issues of food production and rural poverty (RTEP, 2010). At the local farmers' level, the program aims to achieve economic growth, improve access of the poor to social services and carry out intervention measures to protect poor and vulnerable groups. At the national level, the program was designed to achieve food security and stimulate demand for cheaper staple food such as cassava, yam, cocoyam, potato etc. (Adeniyi, 2009). Commercialization of roots and tuber production, improving the living conditions, income, food security and nutritional health of poor smallholder households in the program area were the main objectives of RTEP. The overall target group was about 5.2 million small holders with less than 2 to 3 ha of land holding per household in Nigeria (PIM 2001 in Ibrahim and Onuk, 2010). However, due the introduction of the Presidential Initiative on Casava Program, most farmers including the RTEP farmers, took advantage to expand their farm sizes because of the commercialization benefit of the program. Improved technology for storage of fresh cassava cuttings during the dry season and seed yam production through yam mini sett technology to increase production were also provided to the programme beneficiaries. In addition, actions strategies to strengthen downstream activities, check incidences of low prices in producing communities, bridge income disparities, and enhance employment were also incorporated into the programme.

Generally, increase in production of root and tuber crops with little income to the farmers has been observed in Nigeria, due to poor processing and marketing strategies. Ater et al., (2006) observed that the RTEP programme led to increased production and market glut in the 2006 farming season with consequent low prices in the producing communities which ultimately became a dis-incentive to producers. Cassava post-harvest losses continue to be significant, especially when seasonal surpluses are high. Population pressure on the land has also significantly reduced soil fertility in many parts of the country while fertilizers are expensive and frequently unavailable to the farmers (RTEP, 2010). These challenges have implications for the farmers' poverty status and welfare. Given the dismal picture of roots and tuber crops production in Nigeria, adoption of program such as RTEP may be vital to lifting farmers out of the poverty trap.

Many poor farmers are yet to participate in RTEP and they remain outside the program, not benefitting from its several advantages. The farmers' non involvement may be as a result of being unaware of the potential benefits of participating in the project (RTEP, 2010). Expanding the number of beneficiaries will invariably lead to the need for increased funding of the program. There is therefore a need for the assessment of the program to justify such funds. Further, an impact assessment will provide government and policy makers with facts for implementing and/or changing intervention strategies in order to achieve the program goal of reducing farmers' poverty levels. Past studies on RTEP impact assessment (Tijani and Thomas, 2010; Ibrahim and Onuk, 2010; Ater et al., 2006) have only assed the impact of the program on the beneficiaries using descriptive and inferential statistics which do not ensure that the factors isolated to affect RTEP technology adoption and poverty reduction are actually traceable to the program alone and no other source, hence, the evaluation problem arises which produces biased estimates. A more recent study by Obisesan and Omonona (2013) employed the propensity score matching (PSM) to address the evaluation problem and employed the counterfactual outcome framework to show the impact of the outcome defined in the modern policy evaluation literature as the average effect of the treatment on the treated (ATT) which helps to reduce biased estimates. However, the study assessed the impact of RTEP on the food security status of the farmers and not poverty reduction. Therefore, the study seeks to assess the impact of Root and Tuber Expansion Program (RTEP) on farmers' welfare and to find out the factors influencing adoption of the program in Southwest Nigeria.

THE COUNTERFACTUAL FRAMEWORK

Social programmes are appropriately assessed before and after an intervention to ascertain the nature of their outcomes. Impact assessment of the outcomes of a social program on a group of farmers must take into consideration the counterfactual (Angrist et al., 1996; Heckman, 1996; Heckman and Vytlacil, 2007a, 2007b; Rosenbaum and Rubin, 1983; Wooldridge, 2002; Dontsop-Nguezet, 2011). This is because observations are made on farmers who have and have not been exposed to the programme. Observing only exposed farmers will give rise to biases. Some farmers participate in the programme while others do not participate, but not both. Every farmer in the population thus has two *potential* outcomes: With and without adoption of the technology. Individual *i* can either participate or not participate in the programme, but not both, and thus only one of these two potential outcomes can be realized. A counterfactual framework allows us to examine all possible responses for each individual in the sample. For example, let the first potential outcome be $y_{i(0)}$; the outcome that would be realized by farmer *i* if he or she did not participate in the programme. Similarly, let the second potential outcome be $y_{i(1)}$; the outcome that would be realized by farmer *i* if he or she adopts the new technology. The outcome variables $y_{i(0)}$ and $y_{i(1)}$, are further separated into an average components, u_1 and u_0, and an individual-specific component, v_1 and v_0. Thus, we have:

$$y_{0i} = u_0 + v_0 \quad (1)$$

$$y_{1i} = u_1 + v_1 \quad (2)$$

Information about y_i provides us with evidence to establish an *associative relationship* between treatment and response. The difference between y_{1i} and y_{0i} ideally, gives the impact of treatment on each farmer such that we can infer a *causal relationship* based on the counterfactual (Neill and Lee, 2001). However, since a farmer is either treated or not treated, y_{1i} and y_{0i} are mutually exclusive and the counterfactual is therefore unobservable (Heckman and Vytlacil, 2001). The observed outcome y_i is a function of both potential outcomes and treatment status given as:

$$y_i = d_i \cdot y_{1i} + (1 - d_i) y_{0i} = y_{0i} + d_i (y_{1i} - y_{0i}) \quad (3)$$

Where d_i is the binary treatment variable that takes the value 1 with treatment and 0 in its absence.

The binary outcome variable in the absence of treatment, y_{0i} for all individuals equals zero since a new technology cannot be adopted without prior knowledge of it by the farmers. Thus, we can observe $y_{0i} = 0$ for the untreated farmers. On the other hand, y_{1i} remains unobservable for all farmers since we cannot observe the counterfactual corresponding to any technological, institutional or policy change being considered. This is because if the change does occur, one cannot observe what would have happened to the outcomes in the absence of the change. In the same way, if the change does not occur, one cannot observe what would have happened to the outcomes if the change did actually take place. This scenario is depicted in Figure 1.

A most robust evaluation of the impact of a social programme (or research solution) requires randomized experiments (Burtless, 1995). Randomized experiments create a control group of individuals with identical distributions of observable and unobservable characteristics to those in the treatment group (within sampling variation). The randomly determined adoption helps to overcome the selection problem. Hence, Imbens and Angrist (1994) introduced the concept of the compliance type of an individual which describes the level of the treatment that an individual would receive given each value of the instrument. This is captured by the pair of values (*Wi*(0), *Wi*(1)) where *Wi* is an outcome variable. This is a binary instrument with both the treatment and the instrument binary such that responses for potential treatment (*Ti*) takes any of four responses; *Never-taker* if *Wi*(0) =0, *Wi*(1) = 0; *Complier* if *Wi*(0) = 0, *Wi*(1) = 1; *Defier* if *Wi*(0) = 1, *Wi*(1) = 0 and *Always-taker* if *Wi*(0) = *Wi*(1) =1.

In separating the treatment effect of the treated and untreated farmers (W_i) on the outcome (y_i), we have to consider the other variables (x_i) such as socio-demographic (covariates) and the error term ε_i affecting y*i*

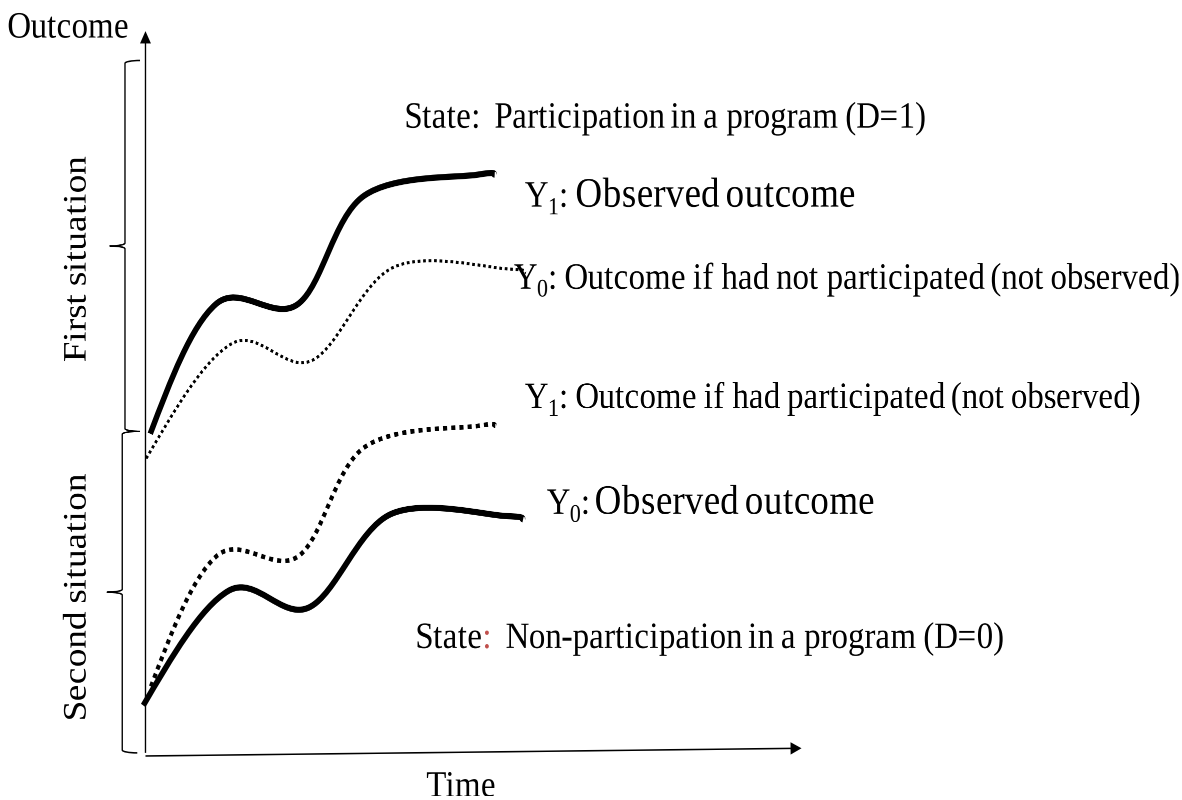

Figure 1. The fundamental evaluation problem: Observed and unobserved outcomes under *mutually exclusive* states.

and W*i*. In cross-section context as is used in this study, if x_i or ε_i differs across *i*, then it is not clear to what extent the differences in y_i across *i* are and if they are due to the differences in W_i across *i*. Hence, controlling for x_i and ε_i that are heterogeneous across *i* is the main task in treatment effect analysis with observational data (Dontsop-Nguezet, 2011) without which the problem biases will arise.

Two types of biases were identified by Rosenbaum (2002): Overt and hidden biases. If the Treatment group (T group) differs from the Control group (C group) in *x*, then the difference in *x*, not in W, can be the real cause for $E(y|W = 1) \neq E(y|W = 0)$; more generally, $E(y|W = 1) \neq E(y|W = 0)$ can be due to differences in both *W* and *x*; whenever the difference in *x* contributes to $E(y|W = 1) \neq E(y|W = 0)$, we incur an *overt bias*. On the other hand, if the T group differs from the C group in ε, then the difference in ε may contribute to $E(y|W = 1) \neq E(y|W = 0)$; in this case, we incur a *hidden (covert) bias*. In practice, however, bias estimates with randomized experiments occur if the implementation of the experiment itself alters the framework within which the programme operates, creating what is known as 'randomisation bias' (Heckman et al., 1998). Randomisation bias occurs with the problems of programme dropouts and comparison group substitution. Programme dropouts are treated farmers who later opt out of the programme, not allowing for identification of treatment on the treated but rather the mean effect of 'intent to treat'. Comparison group substitution occurs when those denied treatment choose to participate in programmes that are effective substitutes for the programme under evaluation (Dontsop-Nguezet, 2011). Non-experimental methods can be used to correct these problems. The choice of the non-experimental method to use in any programme evaluation depends mainly on the characteristics of the programme and the nature and quality of available data. However, in non-experimental techniques, an observable counterfactual is absent, hence; assumptions have to be made to identify the causal effect of a policy or programme on the outcome of interest. These assumptions can be called 'identifying assumptions'. In general, the fewer assumptions you make, and the more plausible they are, the more likely it is that estimated effects will approximate real programme effects (Dontsop-Nguezet, 2011).

MATERIALS AND METHODS

Empirical estimation

The decision to be influenced to participate in RTEP or not can be explained as a discrete variable. Hence, regarding choice of

Table 1. Covariates and their expected signs for Probit model.

Variables	Expected sign
Age	+
Sex	-
Education	+
Number of years spent in root and tuber farming	+
Access to credit	+
Social capital	+
Farm size	+
Two crops planted	+
Three crops planted	-

models, the most important aspect of the decision framework is the dichotomous dependent variable. Classical linear methods are inappropriate for dichotomous choices since they can lead to heteroscedasticity variances. This problem is typically remedied by using maximum likelihood estimation (MLE), although heteroscedasticity in MLE is also a potentially serious problem leading to inconsistent estimators (Greene, 2000). According to Wooldridge (2000), when heteroscedasticity is observed, such models require more general estimation. However, such models are not often used in practice, since logit and probit models with flexible functional forms in the independent variables tend to work well. The probit model was used to determine the factors that influence the probability of adoption of RTEP while both probability models (logit and probit models) were used in the matching algorithm. The description of the variables specified in the probit model for the probability of adoption of RTEP and their expected signs are is given on Table 1.

In real life, groupings of farmers into adopters and non-adopters occur due to self-selection rather than randomized assignment. The farmers make the decision either to adopt the RTEP programme or not based on individualities, which may be related to the outcome of interest (poverty, or crop yield). These individualisms could include managerial skill, motivation, and average land fertility (Menale et al., 2011). The problem of self-selection can produce biased results if not accounted for. The Heckman and instrumental variable methods can be used to deal with the self-selection problem however, they impose distributional and functional form assumptions which could pose further problems in cross sectional data analysis. Hence, this study uses propensity score matching (PSM), a non-experimental statistical matching technique, to make the treated group of RTEP beneficiaries more comparable with the untreated group (non-beneficiaries) under non-random conditions of selection. Each adopter of RTEP (beneficiary) is matched with a non-adopter possessing similar characteristics. This creates the conditions of an experiment in which adopters and non-adopters are randomly assigned, allowing for the identification of a causal link between the choice to participate in RTEP and outcome variable (increase in income and poverty reduction). The PSM is widely used to assess the effect of social programmes since it provides counterfactual situation which reveals what would have occurred if the treated had remained without the intervention/project. The assumption that selection is based on observable variables is a drawback with the use of PSM because unobservable variables that may affect both the outcome variables and choice of technology are not accounted for directly.

PSM method requires that propensity scores, which are the probability of adoption for each observation, be first calculated. Following Menale et al., (2011), each adopter was matched with a non-adopter having similar propensity scores using nearest neighbor matching (NNM) and kernel-based matching (KBM) study after which the mean absolute standardized bias (MASB) balancing test was applied. The MASB was employed to ascertain whether the two groups in the matched sample had no differences in covariates. The MASB balancing test was first applied by Rosenbaum and Rubin (1983) in which a standardized difference of greater than 20% was considered too large and a failed matching process. Comparison of the pseudo-R^2 and p-values of the likelihood ratio test of the joint insignificance of all the regressors obtained from the probit and logit analysis before and after matching the samples also reveal the absence of systematic differences in the distribution of covariates between the two groups (Sianesi, 2004). Hence, the pseudo-R^2 after matching should be lower and the joint significance of covariates should be rejected while the p-values of the likelihood ratio should be insignificant.

Estimation of poverty measures

The Foster–Greer–Thorbecke (1984) indices commonly referred to as FGT, were used to measure poverty. The FGT poverty measure is given as:

$$FGT_\alpha = \frac{1}{N}\sum_{i=1}^{H}(\frac{z-y_i}{z})^\alpha$$

where N is the sample size, z is the poverty line, y is per capita income for the ith person, and α is the poverty aversion parameter. When α= 0, Pα is the headcount index or the proportion of people that is poor; when α = 1, Pα is the poverty gap index, a measure of the depth of poverty and when α = 2, Pα is a measure of severity of poverty and reveals the degree of inequality among the poor. The poverty line used in the study was two-thirds of mean per capita household expenditure (MPCHHE) in the study area.

Data collection

This study was carried out in Oyo State, which is one of the six states in South-West Nigeria. The state has 33 Local Government Areas (LGAs) and a population of 5,591,589 (NPC, 2006). The state capital, Ibadan, is the largest city in West Africa. The climatic condition of Oyo state is tropical and it favours the production of wide varieties of food crops including root and tuber crops such as cassava, yam, cocoyam and sweet-potato. Four (4) Agricultural Development Project (ADP) zones exist in the state as categorized by the Oyo state Agricultural Development Project (OYSADEP): Ibadan/Ibarapa zone, Oyo zone, Ogbomoso zone and Saki zone.

Table 2. Socio-economic characteristics of root and tuber crop farmers (n=161).

Variable	Beneficiaries	Non-beneficiaries	t-statistics
Gender			
Male (%)	80.8	75.0	
Female (%)	19.2	25.0	
Age (mean)	48.67	48.25	-0.26
Household size (mean)	6.88	6.91	0.09
Years of education (mean)	6.12	6.19	0.08
Years of farming experience (mean)	20.99	13.80	-3.87*
Farm size in *ha* (mean)	1.54	1.75	1.39
Output in *tones* (mean)	19.05	12.30	1.98**
Yield in *tones/ha* (mean)	12.72	7.03	-1.95**
Crop income *N/ha* (mean)	39,706.46	27,050.11	2.25**

*Significant at 1%, ** 5%, ***10%.

Hence, the major occupation of the people is farming (OYSADEP, 2010).

The data for the study was collected in 2010 through the use of structured questionnaires while employing a multistage sampling technique. Oyo state was selected at random from a list of six states in the Southwest zone of the country, which participated in the RTEP. The second stage involved the random selected of three out of four ADP zones (Ibadan/Ibarapa, Ogbomoso and Oyo zones). Next, one LGA was selected from each ADP zone (Ibarapa Central LGA from Ibadan/Ibarapa zone, Ogo-Oluwa LGA from Ogbomoso zone and Iseyin LGA from Oyo zone) and lastly, one village from each LGA. Root and tuber crop farmers were found in all villages but RTEP was not adopted by all the farmers, hence; both participating and non-participating farmers were randomly selected in each village. A total of 60 farmers were selected in each village to give a sample size of 180 farmers comprising both RTEP and non RTEP farmers. Only 161 questionnaires (73 beneficiaries and 88 non-beneficiaries) were used for the analyses due to missing data.

RESULTS AND DISCUSSION

Descriptive statistics

The description of the farmers' characteristics is presented on Table 2 and it reveals that both groups of beneficiaries and non-beneficiaries have similar characteristics with only slight differences recorded. Root and tuber crop farming was a male dominated activity in the study area. Generally, male household heads were more than female household heads and there were more female household heads that were outside the RTEP than those participating in the programme. Most farmers were middle aged, still economically active and productive with mean age of about forty eight years. This agrees with Amaza et al., (2007) and makes them more inclined to adopting technology than older farmers, although their rate of adoption may not be as fast as younger farmers (Nwakor et al., 2011). Household size was fairly large with a mean of about seven persons per farming household. This closely follows Balogun and Obi-Egbedi (2012) finding of an average of six persons per household in South west Nigeria. The large household size has implication for the poverty status of the farmer. There was also an appreciable level of literacy among the farmers who had attained about six years of schooling. This is expected to have a positive effect on adoption of the programme.

With respect to the farm characteristics of farmers, RETP farmers had significant years of experience than the non RTEP farmers. Although the farmers did not differ significantly in terms of farm sizes, there were however significant differences in output, yield and crop income. This may be as a result of the cultivation of improved variety by the RTEP beneficiaries. Table 2 shows that mean farm sizes were about 1.54 and 1.75 ha for RTEP and none RETP farmers respectively while yield and mean crop income for both groups were about 12.72 and 7.03 tonnes/ha and ₦39,706.46 and ₦27,050.11, respectively.

Table 3 compares the poverty indices (headcount, depth and severity) of RTEP farmers/beneficiaries and non-beneficiaries in the study area. The poverty indices were computed using the Foster-Greer-Thorbecke (FGT) poverty measure. Two-thirds of mean monthly household expenditure per capital was used as the poverty line. Household expenditure was used instead of the income because it was difficult to capture all the income sources of the farmers. The table shows that poverty incidence is very high in the study area and particularly higher for non-beneficiaries of RTEP than the beneficiaries (by about 23%); hence, RTEP beneficiaries were less poor than the non-beneficiaries. The indices of depth and severity of poverty, which were also higher among non-beneficiaries than the beneficiaries by 8 and 2% respectively, revealing a high degree of income shortfall below the poverty line and a high degree of inequality among the poor.

Table 3. Poverty measures by adopter's status.

Poverty indices	Beneficiaries	Non beneficiaries
Headcount	0.45	0.68
Depth	0.11	0.19
Severity	0.05	0.07
Poverty line using 2/3 of MPCMHHE in ₦	5666.59	5259.84

Source: Author's computation using FGT measures; MPCMHHE, mean per capita monthly household expenditure.

Empirical results

The probit estimates of the adoption propensity equation are shown on Table 4. The pseudo R^2 value of 0.25 correctly predicts 73.90% of RTEP beneficiaries and 76.09% non beneficiaries. Correct predictions were slightly higher for non beneficiaries than beneficiaries. The likelihood ratio test of the hypothesis that the coefficients of all the explanatory variables are zero, has a Chi-square value of 54.90 with 11 d.f., suggesting that the estimated model is highly significant. The results also show that several variables were statistically significant at 1% level in influencing farmers' adoption of RTEP. These include, years of education, social capital, farm size and access to improved planting materials which were positively associated with the probability of adoption of RTEP while planting of two or three crops negatively influenced the probability of adoption of RTEP. Thus a 1% increase in years of education may likely increase the probability of a farmer's adoption of RTEP by 0.03%. This implies a highly inelastic response of 0.22% when evaluated at the mean values of the independent variables.

Education and social capital (which refers to membership of farmer groups) can be proxies for access to information (Menale et al., 2011) which could aid awareness and adoption of the programme. Conversely, a 1% increase in planting two or three different types of root crops is likely to decrease the probability of adoption of RTEP by 0.24 and 0.55%, respectively with inelastic responses of 0.40 and 0.16%, respectively. Farmers who practice the cultivation of a variety of root and tuber crops may not be able to easily adopt modern agricultural technologies disseminated to RTEP farmers due to high level of multiple cropping. This implies that policy options should be directed at encouraging farmers in crops of most efficient production. This will lead to increased productivity and income with the ultimate goal of poverty reduction.

Following from the estimation of propensity scores for RTEP beneficiaries and non- beneficiaries, we assess the quality of the matching process using the common support condition (Appendix 1 for a table on matching). Based on the marching exercise on column 2 Table 4, it was found that among beneficiaries, the predicted propensity score ranges from 0.1300 to 0.9776, with a mean of 0.6176, while among non-beneficiaries, it ranges from 0.0332 to 0.8499, with a mean of 0.3612. Thus, the common support assumption is satisfied in the region of [0.0332, 0.9776], with only a loss of 9 (5.6%) observations from beneficiaries. Figure 1 gives the histogram of the estimated propensity scores for beneficiaries and non-beneficiaries. A visual inspection of density distributions of the estimated propensity scores for the two groups indicates that there exist a substantial overlap in the density distribution of the estimated propensity scores of both beneficiaries and non beneficiaries; thus, satisfying the common support condition. This is shown in the intersection region of the common support graph shown on Figure 2. The bottom half of the graph shows the propensity scores distribution for the non-beneficiaries and the upper half refers to the beneficiaries. The density scores are on the horizontal axis.

A major objective of the propensity score estimation is to balance the distribution of relevant variables between the beneficiaries and non-non-beneficiaries, rather than obtain a precise prediction of selection into treatment. The kernel-based matching (KBM) and the nearest neighbor matching (NNM) were thus used to buttress the probit estimate results used to determine the factors influencing RTEP adoption. The basic approach is to numerically search for "neighbors" of non-beneficiaries that have a propensity score that is very close to the propensity score of the beneficiaries. The balancing test was afterward applied to ascertain whether the differences in the covariates of the two groups in the matched sample have been eliminated, in which case, the matched comparison group can be considered a plausible counterfactual (Ali and Abdulai, 2010). Table 5 shows the results from the covariate balancing tests both before and after matching. The standardized mean difference of about 18% (before matching) decreased to about 4 to 9% after matching. Consequently, the matching process decreased total bias by a range of about 49 to 80%.

The likelihood ratio tests showed that *p*-values before matching were all significant at 1% level indicating that the joint significance of covariates were accepted. However, after matching, the joint significance of

Table 4. Probit estimates of the propensity to participate in RTEP.

Variables	Coefficients (Std. error)	Marginal effects[a] coefficients	Elasticities coefficients
Age	-0.011(0.014)	-0.003	-0.222
Sex	0.189(0.319)	0.056	0.137
Years of education	0.113(0.044)*	0.033	0.219
Years of farming experience	0.023(0.025)	0.007	0.158
Access to credit	-0.093(0.288)	-0.027	0.054
Social capital	1.430(0.351)*	0.428	0.887
Farm size	0.219(0.078)*	0.065	0.738
Household size	0.047(0.055)	0.014	0.317
Accimpvl	0.701(0.238)*	0.206	0.271
Dumy2crp	-0.812(0.263)*	-0.239	-0.395
Dumy3crp	-1.859(0.617)*	-0.547	-0.164
Constant	-2.630(0.731)*		
Summary statistics			
Pseudo R^2	0.25		
Model chi-square	54.90*		
Log likelihood ratio	-83.45		
Non-adopters correctly predicted	76.09		
Adopters correctly predicted	73.90		
Number of observations	161		

Source: Authors' calculations. [a]Marginal effects evaluated at the sample means. [b]Accimpvl- Access to improved planting materials. *Significant at 1% (P < 0.01).

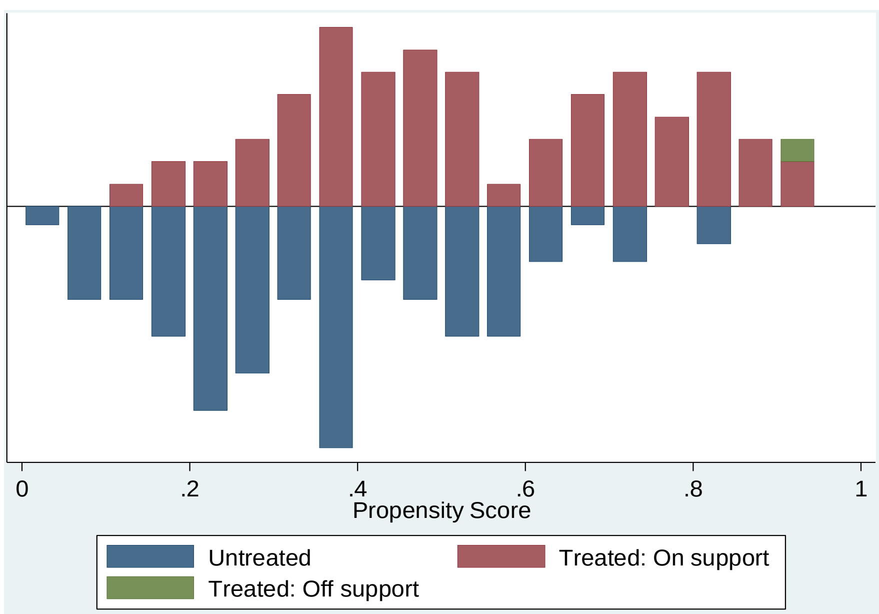

Figure 2. Propensity score distribution and common support for propensity score estimation. Treated: On support indicates the observations in the adoption group which have a suitable comparison. Treated: Off support indicates the observations in the adoption group which do not have a suitable comparison.

covariates was rejected due to their insignificance. Similarly, the pseudo-R^2 reduced from about 25% before matching to a range of about 0.03 to 0.09% after matching. As noted earlier, the outcome of the indicators

Table 5. Matching quality indicators before and after matching.

Matching algorithm	Model type	Pseudo R^2 before matching	Pseudo R^2 after matching	LR X^2 (p – value) before matching	LR X^2 (p - value) after matching	Mean standardized bias before matching	Mean standardized bias after matching	Total % |bias| reduction
NNM[a]	Logit	0.248	0.09	54.29 (p=000)*	7.55 (p=0.893)	18.397	9.439	48.7
	Probit	0.248	0.04	54.29 (p=000)*	8.47 (p=0.671)	18.397	7.816	57.5
NNM[b]	Logit	0.248	0.035	54.29 (p=000)*	6.88 (p=0.809)	18.397	4.259	76.8
	Probit	0.248	0.025	54.29 (p=000)*	4.84 (p=0.938)	18.397	4.906	73.3
KBM[c]	Logit	0.248	0.026	54.29 (p=000)*	4.19 (p=0.964)	18.397	4.909	73.3
	Probit	0.248	0.033	54.29 (p=000)*	5.43 (p=0.909)	18.397	4.235	80.0
KBM[c]	Logit	0.248	0.035	54.29 (p=000)*	6.75 (p=0.819)	18.397	6.519	64.6
	Probit	0.248	0.04	54.29 (p=000)*	7.73 (p=0.737)	18.397	7.286	60.4

[a]NNM = single nearest neighbor matching with replacement and common support. [b]NNM = five nearest neighbors matching with replacement and common support. [c]KBM = kernel based matching with band width 0.03 and common support. [d]KBM = kernel based matching with band width 0.06 and common support. *Significant at 1%.

Table 6. Impact of adoption on all crop income and poverty status and Rosenbaum sensitivity analysis results.

Matching algorithm	Outcome	ATT		Critical level of hidden bias	
		Logit	Probit	Logit	Probit
NNM[a]	Yield per hectare (in ‘000 tones)	15.83 (3.25)*	12.98 (-2.96)*	4.6	4.2
	Net crop income per Hectare (in ‘000	40.734 (3.31)*	40.447(3.02)*	4.5	4.3
	Poverty (headcount ratio)	-0.098 (-0.49)	-0.052 (-0.25)	1.0	1.2
NNM[b]	Yield per hectare (in ‘000 tones)	14.14 (1.91)***	14,073 (3.07)*	3.0	3.0
	Net crop income per Hectare (in ‘000₦)	39.705 (1.96)**	40.447 (3.13)*	3.1	3.1
	Poverty (headcount ratio)	-0.069 (-0.21)	-0.1089 (-0.27)	1.3	1.3
KBM[c]	Yield per hectare (in ‘000 tones)	18.52 (2.02)**	14,545 (2.08)**	3.8	3.6
	Net crop income per Hectare (in ‘000₦)	40.734 (1.85)***	42.133 (2.13)**	4.0	3.9
	Poverty (headcount ratio)	-0.061 (-0.19)	-0.199 (-0.67)	1.3	1.6
KBM[d]	Yield per hectare (in ‘000 tones)	15,991(1.79)***	16,822(1.80)***	3.9	4.4
	Net crop income per Hectare (in ‘000₦)	40.447 (1.83)***	41.010 (1.98)**	4.1	4.3
	Poverty (headcount ratio)	-0.029 (-0.09)	-0.062 (-0.20)	1.5	1.4

[a]NNM = single nearest neighbor matching with replacement and common support. [b]NNM = five nearest neighbors matching with replacement and common support. [c]KBM = kernel based matching with band width 0.03 and common support. [d]KBM = kernel based matching with band width 0.06 and common support. *Significant at 1%. **Significant at 5%. ***Significant at 10%.

show that the proposed specification of the propensity score has a balanced distribution of covariates between the RTEP beneficiaries group and non beneficiaries.

Table 6 reports the estimates of average adoption effects estimated by NNM and KBM. Although the results from the logit and probit models show different quantities in terms of value, the findings are similar in quality and direction. Hence, the results show that adoption of RTEP significantly increases yield, crop income and reduces poverty. Net yield per hectare increased by a range of about 13.00 to 18.52 metric tons while net crop income per hectare increased by a range of about ₦39,705 to 42,133 thus, reducing poverty by about 5-20%. The findings are consistent with past studies on the impact of agricultural technology on household welfare (Mendola, 2007; Dontsop-Nguezet et al., 2010; Menale et al., 2011). The Rosenbaum sensitivity analysis results also shown on Table 6 reveal that the critical level of hidden bias ranged from *T* = 1.0-4.6; where *T* is the critical value at which point we would question our conclusion of a positive effect of adoption of RTEP on yield and crop income and a negative effect on poverty status. It implies that if individuals with the same covariates differ in their odds of adoption by a factor of 50 to 70%, the significance of the adoption effect on the outcome variables may be questionable.

CONCLUSION AND RECOMMENDATIONS

The study has assessed the impact of the Root and Tuber Expansion Program (RTEP) on crop income and poverty reduction in rural Southwest Nigeria. The propensity score matching technique was used to estimate the benefits of participating in RTEP. The technique employed eliminated selection bias on observable differences between beneficiaries and non-beneficiaries of RTEP although some unobservable variables might correlate with adoption in addition to yield, crop income and poverty. The results of the empirical estimation showed that adoption of RTEP significantly increases yield, crop income and reduces poverty of the farming households. Adoption of RTEP increased yield and crop income by a range of about 13.00 to 18.52 metric tons and ₦39,705 to ₦42,133 respectively and reduced poverty by a range of about 5 to 20%. Furthermore, the factors that positively influenced the probability of adoption of RTEP were: years of education, social capital, farm size and access to improved planting materials while planting of two or three root crops negatively influenced the probability of adoption of RTEP. The findings of this paper showed that there is a lot of room for RTEP to achieve its poverty reduction goal among its adopters by going beyond merely increasing farmers' income to significantly reducing poverty among them. Therefore, the study recommends that concerted efforts be made to: improve the education of farmers beyond the basic level, discourage multiple cropping, increase the presence of ADPs in the rural areas and increase enlightenment for membership of farmers groups in order for farmers to escape poverty.

Conflict of Interest

The authors have not declared any conflict of interest.

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APPENDIX

Appendix Table 1. Matching of respondents' of covariates.

Variable	Unmatched/matched	Treated	Control	% Bias	% Reduction in bias	t-values	p-values
Age	Unmatched	19.648	20.721	-6.3	-4.1	-0.40	0.691
	Matched	19.514	18.398	6.6		0.44	0.662
Sex	Unmatched	0.82192	0.75	17.5	44.4	1.10	0.274
	Matched	0.81429	0.77429	9.7		0.58	0.562
Years of education	Unmatched	3.3471	2.0419	37.1	64.8	2.39	0.018
	Matched	3.3191	2.8602	13.0		0.72	0.475
Years of farming experience	Unmatched	6.4585	6.8544	-4.7	-174.1	-0.29	0.770
	Matched	6.1372	5.0522	13.0		1.05	0.297
Access to credit	Unmatched	0.75342	0.625	27.8	73.3	1.75	0.082

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Economic Determinants of the Performance of Public Irrigation Schemes in Kenya

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Thestudy aimed atestablishing the determinants of public irrigation scheme performance in Kenya and give policyrecommendationsusingpanel fixed effect regression model. The results indicated that,the size of land under irrigation had a significant (at 1%) and positive effect on the performance of public irrigation scheme. Similarly, per acre operations and maintenance cost that was collected in the scheme had a significant (at 10%) and positive effect on the performance of public irrigation schemes; however, the amount of donor funding to the scheme had a significant (at 10%) and negative effect on the performance of public irrigation schemes. Consequently,performance can be improved if farmers are treated as clients, shareholders or as co-managers of irrigation scheme rather than just beneficiaries.Therefore, this study recommends the enhancement of policies and institutional changes at the public scheme level, along with increased government investments on irrigationinfrastructure rehabilitation and development.

Keywords: Co-management, donor funding, government investment, public irrigation scheme,panel fixed effect regression model,Kenya.

INTRODUCTION

Ensuring adequate and access to nutritious food for the growing population is a major concern globally.According to Mati (2011) and Valipour (2015), irrigation has a role to reduce poverty in the world through improvement of production, enhancement of employment opportunities and stabilization of income and consumption using access to reliable water, and finally by its role in nutritional status, health, societal equity and environment. Over the years, empirical evidence have shown that irrigation increases yield of most crops by between 100 and 400% and it is expected that, in the next 30 years, 70% of the grain production will be from irrigated land in the world (FAO, 2009). A study by Valipour (2014) indicated that 46% of the cultivated areas in the world are not suitable for rain-fed agriculture because of climate changes and other meteorological conditions. Therefore, this needs to be thought carefully in order not to put too much attention to only commercial enterprises and goals but to also apply the experts' comments to the irrigation systems for any crop to achieve sustainable agricultural

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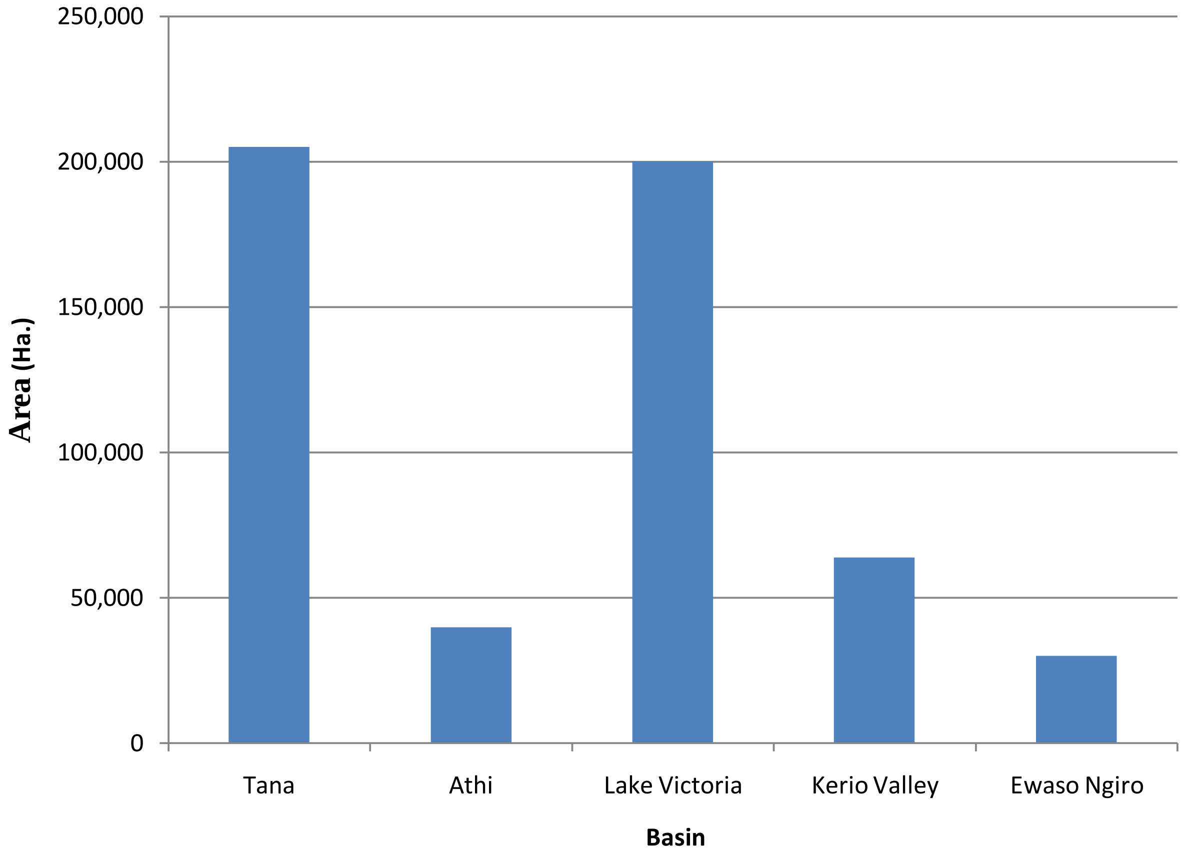

Figure 1. Irrigation potential in the Kenyan river basins.Source: National Irrigation Board (NIB) (2012).

production activities (Valipouret al., 2015; Valipour, 2015). Many studies have identified a positive link between irrigation and other development-related sectors such as population, energy, food, and environment, and the interactions among them require reckoning, as they together will determine future food security and poverty reduction (Ngigi, 2002; Inocencio et al., 2007; Franks et al., 2008; Khan et al., 2009; Mati, 2011; Burney et al., 2013).

Kenya's population has been growing exponentially over the past 10 years reaching 38.6 million in 2009, up from the 28.7 million recorded in 1999.Therefore, the country is facing an uphill task of securing adequate food supply through various strategies of increasing agricultural production capacity to match the population growth.Although agriculture is the backbone of the economy accounting to about 25% of the country's GDP, the scope for increasing production through expansion of arable agricultural land is severely constrained by over-reliance on rain-fedagriculture.

At current levels of population growth, the slower expansion in irrigated areasis resulting in an unprecedented amount of irrigated land decline (Figure 2). This has been exacerbated by increased construction costs, falling real prices for irrigated crops, a growing awareness of environmental and social costs and poor irrigation performance at the farm and project levels (Svendsen et al., 2009; Azad and Ancev, 2010; Valipour, 2014; Valipour et al., 2015). In addition, the environmental efficiencies of irrigated enterprises vary considerably across different agricultural water management regions (Azad and Ancev, 2010; Valipour, 2013). Based on the irrigation potential in Kenya (Figure 1), the development of the irrigation sector is among the long-term initiatives towards the achievement of a 10% annual economic growth envisioned in Vision 2030. Despite heavy initial investments, huge costs relating to land preparation, and the different kinds of machinery, irrigation in Kenya has not realized its full potential. Currently only 114600 ha (20% of total irrigation potential) have been put under irrigation where the development of irrigation potential has been categorized into three types that includes; large private commercial farms (40%), government-managed schemes (18%), and smallholder individual and group schemes (42%) in Kenya (GoK, 2010).

Kenya's main irrigated crops are rice, maize, sugarcane, vegetables, bananas, citrus, coffee, tea, cotton and flowers, some of which require large-scale production for economies of scale to be realized.

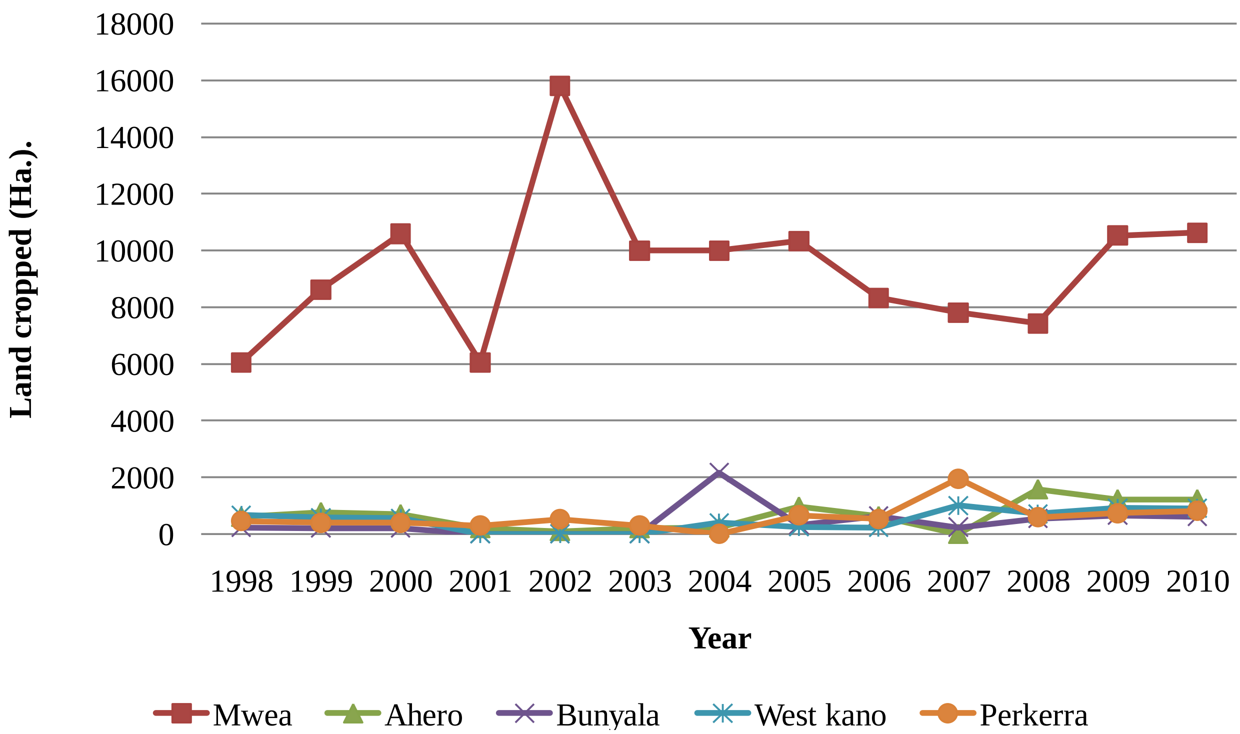

Figure 2. Land cropped status in public irrigation schemes.Source: NIB (2012).

Irrigation infrastructure has been funded in targeted areas in a bid to improve food production and rural economies. Currently, the Kenyan government has been running the operations of the major five public irrigation schemes (Figure 2) in different parts of the country through the National Irrigation Board (NIB). Generally, irrigation activities demands costly continuous operations in terms of supply of water and adequate maintenance of the water distribution and drainage channels.The government, the private sector, and development partners have funded most of the irrigation structures since it is difficult for smallholders themselves to build such structures (PMU-Kenya, 2004). World Bank(2007) indicated that irrigation projects consume many scarce resources through both recurrent and development expenditure and adversely affectdeveloping countries, whose capacity to set up irrigation infrastructure is limited. Ngigi (2002) and Kibe (2007) revealed that, the development of irrigation despite the high costs involved is one of the largest potential for addressing the challenge of the declining agricultural productivity with an up surging population in Kenya. In addition, availability of water also plays a vital role on the performance of an irrigation scheme and indirectly influences the cost of the project. Furthermore Salethet al. (2003);Hussain and Wijerathna (2004); Hussainet al. (2006), and Inocencioet al. (2007) concluded that, those irrigation schemes located in areas with more water available have a tendency of being smaller in size and it reduces poverty both directly and indirectly. Direct impacts are realized through labour and land augmentation effect that ultimately translates to improved performance, employment, income and consumption, while the indirect impact is realized through enhanced local economy and improved welfare at macro level. On the contrary, Fan et al. (2000) and Jin et al. (2002) revealed a negative and/or weak relationship between irrigation and agricultural productivity. This leads to a negative or no impact on food security, household income and poverty reduction at large; hence the direct effect of irrigation could be undermined by other factors, which could have been observed at scheme level. Fan *et al.* (2000), Gomaneeet al. (2003), and Mosley et al. (2004) found out that, higher government expenditure on agriculture, housing and amenities (water, sanitation and social security) had a negative and statistically significant impact on poverty. This is mainly by shifting the distribution of income in a pro-poor direction, since the level of aggregate income was held constant in their regressions.

Recently, emphasis has been on the importance of sustaining and improving the performance of existing irrigation schemes in parallel with area expansion and development of new irrigation (World Bank, 2006). In Kenya, like in many other African countries, irrigation expansion has been hindered by poor performance of the existing public irrigation schemes (Ngigi, 2002; Thairu, 2010). In addition, the performance of public irrigation scheme isway off the mark realizing only 40% of the target production levels and 28% of the expected revenues (Karina and Mwaniki, 2011). Paradoxically, there are successful irrigation undertakings especially among the private commercial large-scale agricultural irrigated farms such as Dalamare, Delmonte, Kakuzi, etc. Given the intensive investment, the already existing public irrigation schemes in the country should be operating efficiently and effectively so as to meet the rising food demands. However, it is not clear what factors play key role in the performance of public irrigation schemes in Kenya. Against this backdrop, this study seeks to establish the factors that influence performance of public irrigation schemes in order to shed some light on the areas requiring policy interventions. Furthermore, it would complement the debate on public irrigation scheme performance, and provide a basis for reformulation of strategies that are geared towards the country's self-sufficiency in food production and food security.

Irrigation performance is the level at which resources such as water, land, and labour can be effectively utilized for the production of maximum output levels. In addition, irrigation performance assessment is the regular observation of irrigation performance parameters with the objective of acquiring important information on the use of resources within an irrigation scheme, and allows irrigation managers to make well informed decisions in terms of resource management (Boset al., 2005; Khan et al., 2009; Mati, 2011; Valipour, 2014). Irrigation performance assessment can be used to satisfy different set objectives on different irrigation schemes but the procedure will vary depending on the system and purpose of assessment. Despite the fact that there is still no one standard way of measuring irrigation performance, most analysts suggest at least two basic domains for the purpose of irrigation or water delivery and agricultural productivity. While the former is associated with the immediate service output and determined most frequently through the performance criteria of adequacy, equity and reliability of water supplied, the latter is considered more outcome-based and can be judged against such parameters as farmers' crop yields, cropping intensities and most recently water productivity. Other studies suggest that such a limited set of indicators should also include measures determining the maintenance status of irrigation infrastructure as well as more user-based socio-economic impact measures (Murray-Rust and Snellen, 1993; Boset al., 2005). Moldenet al. (2010)pointed out that for an increase in irrigation scheme performance, it will require strategies that are based on existing biophysical and socio-economic factors. Frequent evaluation of irrigated areas have become more important in diagnosing and improving the performance of irrigation schemes in order to achieve optimal productivity in the context of increasing food demand, open global markets and competition for limited freshwater resources (Burt et al., 1997;Moldenet al. 1998; Clemmens,2006).Such assessments should analyze the productive and hydrological impacts of internal irrigation processes to assist agents involved in crop production, water management and agricultural policy to improve the performance of irrigated schemes (Perry et al., 2009; Moldenet al., 2010).

The categories of the determinants of irrigation performance has been described by Malano and Burton (2001),Moldenet al. (1998) in Moldenet al. (2010) and it includes those factors such as land, labour, water, cost of scheme operation and maintenance as well as the value of production that analyze the inputs into and outputs from irrigation scheme. They further developed a set of irrigation performance indicators for describing performance at scheme level that includes output per cropped area, output per unit command area, output per unit irrigation supply, output per unit water consumed, achieved production factor, and potential production factor among others. In addition, Ntsonto (2005) concluded that there is need to include financial and environmental indicators since they concentrate on the costs and returns, in monetary value and they include cost recovery ratio; maintenance cost to revenue ratio, total cost of management, operation and maintenance per irrigation scheme and revenue collection performance. While on the other hand, the environmental indicators concentrate on sustainability of irrigation scheme performance, pollution of both land and water as well as the effects of irrigation on the surroundings (Greaves, 2007; Yokwe, 2009).

MATERIALS AND METHODS

Study area and data

The study was conducted in all the five main public irrigations schemes in Kenya (Mwea, Perkerra, West Kano, Bunyala, and Ahero) that are being managed by National Irrigation Board (NIB) and have been in operation since 1998. Panel data for the period 1998 to 2010 that were obtained from Kenya National Bureau of Statistics (KNBS), and National irrigation board (NIB) under Ministry of water and irrigation were used. It was conceptualized that public irrigation scheme performance is influenced both directly and indirectly by the size of the scheme, operations and management (recurrent expenditure), infrastructure and equipments (development expenditure), and the amount of donor funding in form of grants and technical assistanceas well as scheme attributes.

The model

Panel data analysis have been used widely in recent empirical studies that seeks to address various challenges on economic development and policy analysis (Boset al., 2005; Inocencioet al., 2007; Hsiao, 2007; Githuku, 2010; Thairu, 2010; Biwott,2011). This is because it provides a rich environment for the development of estimation techniques and theoretical results. Furthermore, panel data have the strength of accommodating more observations hence increases the degrees of freedom. In addition, it reduces the problem of co-linearity of regressors and modeling flexibility of behavior differences within and between countries and/or groups or institutions (Hsiao, 2007; Biwott, 2011). However, it has a setback of having a cumbersome collection of long-termprimary data particularly on the selected variables. Panel data has fixed effect model (FEM), random effects model (REM), and instrumental variables (IV). Nevertheless, REM and IV were not used in the study because there was no dummy variables and selection biasness in the data that were used hence ruling out the problem of heterogeneity. A standard panel FEM specification is written as;

$$Y_{it} = \beta_1 + \sum_{j=2}^{k} \beta_j X_{jit} + \sum_{p=1}^{s} Y_p Z_{pi} + \delta_t + \varepsilon_{it} \quad (1)$$

Where$Y_{it}$is the dependent variable, the $X_j$are observed explanatory variables, and the $Z_p$are unobserved explanatory variables. The index *i*refers to the unit of observation, *t* refers to the time period, and *j* and *p* are used to differentiate between different observed and unobserved explanatory variables. $\varepsilon_{it}$is a disturbance term assumed to satisfy the usual regression model conditions. A trend term *t* has been introduced to allow for a shift of the intercept over time. The $X_j$variables are the explanatory variables of interest, while the $Z_p$variables are responsible for unobserved heterogeneity and as such constitute a nuisance component of the model. Because the *Zp*variables are unobserved and FEM takes care of that, there is no means of obtaining information about the component$\sum_{p=1}^{s} Y_p Z_{pi}$of the model and it is convenient to rewrite equation 1 as;

$$Y_{it} = \beta_1 + \sum_{j=2}^{k} \beta_j X_{jit} + \alpha_i + \delta_t + \varepsilon_{it} \quad (2)$$

Where $\alpha_i = \sum_{p=1}^{s} Y_p Z_{pi}$ and it represents the joint impact of the Z_{pi}on Y_i. Therefore, it was convenient in this study to refer to the unit of observation as an irrigation scheme, and to the $\alpha_i$as the irrigation scheme-specific unobserved effects. In addition, the model assumes that the disturbance is the sum of three terms: a "scheme fixed effect" that is different for each irrigation scheme but does not vary over time; a "time fixed effect" that is different each year but does not vary across schemes; and a random effect.

This study preferred the agricultural productivity as the best indicator of public irrigation scheme performance. Irrigation scheme performance has been cited to be determined by scheme size, number of plots in the scheme, farmers contribution to investment cost, new constructions costs, mode of O&M for systems, irrigated crops, and regional effects (Bos et al., 2005; Inocencio et al., 2007; Thairu, 2010). It is therefore out of the above reviewed literature that this study will analyze the determinants public irrigation scheme performance in line with the recommendations of Bos etal. (2005) and Thairu(2010). They conclude that, the performance indicator will be based on crop yields or scheme productivity, which will be determined by land size, irrigation scheme operations and management (O&M) collection rate, investment cost, and number of plots in the scheme.

Since panel data were used, the study performed a Durbin-Wu-Hausman (DWH) test in order to determine whether the estimates of the coefficients, taken as a group, are significantly different in the two regressions (fixed or random) and select the one to be adopted using the two methods. In the first case the data was strongly balanced and the results of the DWH test (Prob>chi^2 = 0.0077) suggests that fixed effect exist between the schemes hence the panel Fixed Effect Model (FEM) were adopted since its results were efficient and consistent. Further, the panel fixed effect regression model is highly acclaimed for its simplicityand empirical robustness, and its ability to provide a solution to the problem of bias caused by unobserved heterogeneity, a common problem in the fitting of models with cross sectional data sets. Empirical literature has revealed that panel fixed effect regression model approach is a popular tool and has been used widely by researchers in analyzing the indicators of several irrigation scheme performance. Based on the reviewed literature, this study assumed that five variables affect the performance of public irrigation schemes in Kenya. This includes development and recurrent expenditure, donor funding, rate at which operation and maintenance (O&M) money is collected at scheme level, and the size of the irrigation scheme.

Empirically, taking the above factors into consideration,the panel fixed effect regression model in this study follows the works of Boset al. (2005), Inocencioet al. (2007), Hsiao (2007), and Thairu (2010) where the model assume a lagged form and is specified as:

$$I_{it}^{p} = \beta_1 + \beta_2 R_{it-1} + \beta_3 D_{it-1} + \beta_4 DF_{it-1} + \beta_5 IS_{it-1} + \beta_6 OMR_{it-1} + \varepsilon_{it-1} \quad (3)$$

Where: $I_{it}^{p} =$ Irrigation scheme performance level in yields per area cropped; R_{it-1} = operations and management of the irrigation scheme proxied by recurrent expenditure to the scheme; D_{it-1} = Irrigation equipments and infrastructure proxied by development expenditure; $DF_{it-1} =$ Grants and technical assistance costs proxied by donor funding/investment; IS_{it-1} = Irrigation scheme total land size in operation in acres; OMR_{it-1}= Rate of O&M collection in the scheme in Kenya shillings, and ε_{it-1} = Regression disturbance term

RESULTS AND DISCUSSION

Descriptive statistics

Irrigation productivity is the ratio of output (physical, economical or social) to the size of land cropped in producing the output. It is a measure of the economic or biophysical gain from the use of a unit of irrigated land in crop production and is expressed in productive crop units of kg/acre (Thairu 2010). The results of the trends of public irrigation schemes productivity in Kenya are presented in Figure 3. It showed that the general productivity of public irrigation schemes in Kenya has been fluctuating in various schemes during the period of 1998 to 2010.Most of the public irrigation schemes productivity started to show positive trends in 2003when the strategy for revitalizing agriculture (SRA) 2004-2014,together with the Maputo declaration of increasing the agricultural sector budgetary allocation to 10% was being implemented in the country. Furthermore, Mwea irrigation scheme had benefited during this time from the counterpart funding which saw the Japanese and Kenyan government investing KShs 3 billion.

The introduction of the Economic Stimulus programmes (ESP) in 2008/2009 boosted the productivity of all the public irrigation schemes in Kenya. In addition, the positive productivity trends during this periods was attributed to the stable and growing economy during this period as well as the implementation of the Agriculture Sector Development Strategy (ASDS, 2009-2020) and the first medium term plan for the country blueprint Vision

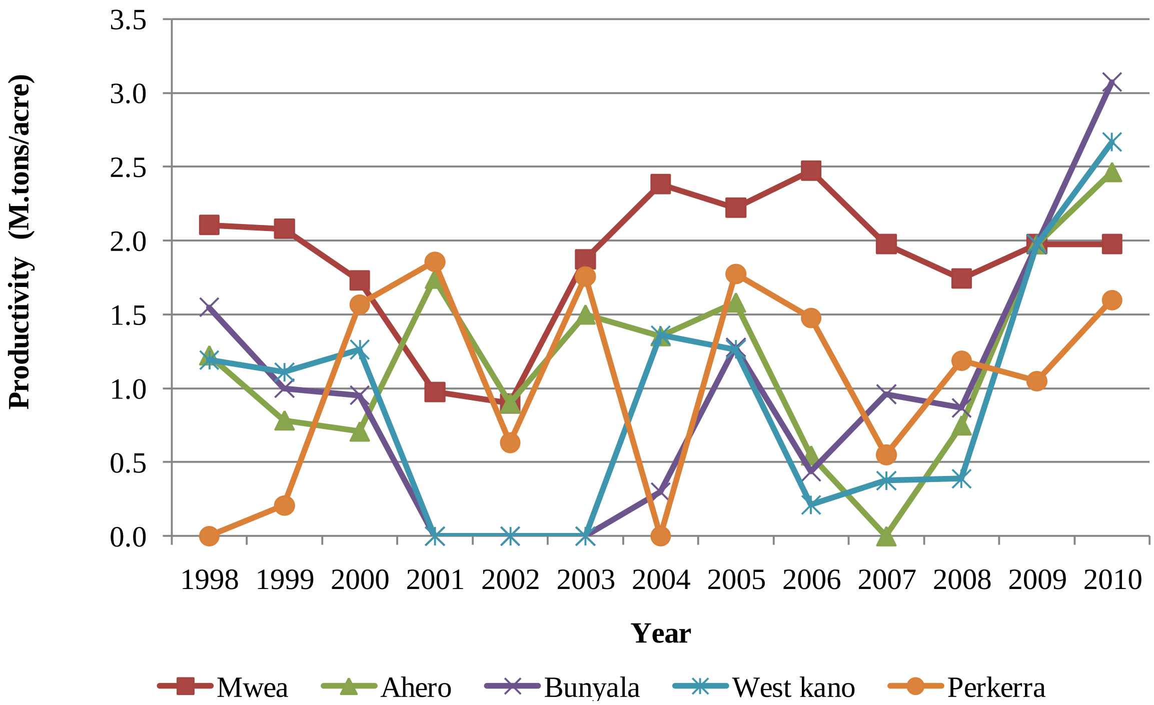

Figure 3. Trends of public irrigation schemes productivity in Kenya.

2030. This was aimed at increasing agricultural productivity, expanding irrigated agriculture, commercializing agriculture, and improving governance in the agriculture sector. This result concurs with the findings of Gulati*et al.* (2005) and Meizen-Dick and Rosegrant (2005), who concluded that poor irrigation scheme productivity is directly related with the decline in irrigation investments and low rates of economic return on the irrigation projects.

Model results

The model results (Table 1) indicates that, the total size of irrigation scheme, amount of donor funding to scheme, and the per acre rate at which O&M were collected were significant at 1, 10 and 10% respectively. This therefore conforms to prior expectations. The result further indicates that,total irrigation scheme size was significant with positive effects on the performance of the irrigation scheme in Kenya. This implies that, increase in the scheme land size, increases the probability of the scheme to perform better in its activities and hence maximum output levels. The findings of this study concur with the findings of Huang et al. (2005); Clemmens (2006), and Kibeet al. (2007)who concluded that as the scale of operation increases, farmers tend to benefit from the economies of scale of operations. In addition, those farmers who own large tracks of land tend in the irrigation schemesto easily access credit facilities in financial institutions, which in turn helps them, meet other farm inputs and hence better performance in their operations. Furthermore, the larger the public irrigation scheme size, the higher the economic returns as confirmed by the finding of Jones (1995) that “big projects just do better than small projects.”

According to Inocencioet al. (2007), irrigation scheme size is a critical determinant of cost and its significant impact on economic returns could be through impact on irrigation cost and economies of scale effect. Larger irrigation schemes are supposed to attract better managers, and managing and implementing agencies like NIB may have more incentive to be cost-efficient given the relatively higher profile and greater public attention. The strong economies of scale in public irrigation schemes suggest the importance of the scarce inputs such as land while, on the other hand, it has been argued that scale of operation appears to be less important in determining the performance of the irrigation scheme than how it is managed (Meinzen-Dick and Rosegrant, 2005). Therefore, theresult of this study indicates that, as far as the scale of public irrigation scheme is concerned, it is definitely the case that “large is good”. However, it requires a caution based on the availability of irrigation water and management. Further, the rate at which farmers are being charged by NIB for the O&M services cost is significant at 10% level with positive effects on performance implying that it increases the probability of achieving more output or yields from public irrigation scheme.Majority ofthe schemes have

Table 1. Summary of the determinants of public irrigation scheme performance.

Variables	Coefficient	Standard error	P-value
Scheme land cropped size	0.4353651	0.1035223	0.000*
Management cost	0.0272844	0.1824122	0.882
Development cost	-0.0082568	0.1881861	0.965
Donor funds	-0.0629516	0.0328501	0.061**
Rate of O&M collection	0.1156603	0.0671855	0.091**
Constant term	-0.525307	1.000779	0.602
Diagnostic statistics			
Corr (u_i, xb)	0.0808		
Sigma_u	0.36588		
Sigma_e	1.54394		
Rho	0.05317		
Number of observations	65		
Number of groups	5		
F(5,55)	5.58		
Prob> chi2	0.0003		

*** ($p<0.01$); ** ($p<0.05$); * ($p<0.10$).

been varying there O&M cost rate depending on the type of crop grown and the region of production. The result further shows that increasing this rate by one unit will lead to an increase in the performance of public irrigation scheme by 11.5% as shown by the coefficient. This implies that O&M cost collection rate have a direct effect on the performance since, when increased, farmers tend to improve on their efficiency in order to maintain and/or increased their profits, which would have otherwise be indirectly affected negatively. This result concurs with the findings of Inocencio et al. (2007) and Moldenet al. (2010) who concluded that, where farmers contribute to irrigation development, irrigation schemes perform better than those without farmers' contribution.

The government as a part of a strategy to encourage a more participatory approach has promoted farmers' contribution to irrigation schemes. This was aimed at achieving a greater sense of ownership among the beneficiaries of irrigation scheme, and results inmore sustainable scheme operations while reducing the financial burden of the NIB.The result in this study confirms theearlier findings, and supports a policy that encourages farmers to contribute to the O&M cost, on the grounds that it serves as an incentive to using the funds more effectively for farmers' needs and priorities.However, poor performance in most of the public irrigation scheme can be attributed to poor irrigation management by NIB, due to lack of accountability and incentive to deliver quality service and water supply. This is confirmed by Gulatiet al. (2005) and Clemmenset al. (2008) who concluded that poor irrigation performance is exacerbated by the absence of link between irrigation quality, revenues generated from irrigation service fees and staff incentives.The existenceof well established and operational WUAs has also been associated with better maintenance of systems and more efficient water deliveries which in turn has led to higher yields and better economic performance of irrigation schemes (Shah et al., 2002; Gulati et al., 2005; Raju and Gulati 2005).

The amount of donor funding to an irrigation scheme has been indicated by the result to be significant at 10% level with negative effects on the performance of public irrigation scheme. This implies that, as the amount of donor finding increases in the scheme the probability of farmers meeting the target of their operations decreases within the irrigation scheme. This could be because farmers tend to relax their effort in terms of effectiveness and efficiency since most of the donor funds are not refundable and they always target specific purpose in a particular scheme which has no effect on their profits.In addition, donor funds comes in form of grants and technical assistant which are always aimed at capital investment and/or irrigation development that takes longer period of time to be in operation. The results concurs with the findings ofSvendsenet al. (2009) and World bank (2008)where they indicated that, donors are providing relatively limited resources to the agriculture sector in developing countries, basedon its comparative advantage, specialization and track records. Furthermore, most of the development partners have recently diverted their attention to smallholder-irrigatedagriculturehence leaving the public irrigation scheme (large) to be run entirely by the government.

Conclusion

The resultof the studybased on the available data on

The authors have not declared any conflict ofinterest.

public irrigation schemes in Kenya used in this paper indicates that most of the public irrigation schemes productivity was boosted by the implementation of the strategy for revitalizing agriculture (SRA) 2004-2014 and the Maputo declaration of increasing the agricultural sector budgetary allocation to 10 percent from 2003. In addition, stable and growing economy as well as the implementation of the Agriculture Sector Development Strategy (ASDS, 2009-2020) and the first medium term plan for Vision 2030 also shows positive contribution to public irrigation productivity in Kenya. The result further indicates that, total irrigation scheme size, amount of donor funding to the scheme, and O&M rate per unit of irrigated land was significant with positive, negative, and positive effects respectively on the performance of the irrigation scheme in Kenya. However, the availability of water supplies is a serious constrain in many of the Kenyan rivers. In addition, while some of these irrigation schemes perform poorly, many perform reasonably well, and therefore could be a positive component of particular links proposed under the ASDS of 2009-2020. Hence, the additional interventions of such links are likely to detract from the performance of specific public irrigation schemes, and therefore require careful scrutiny.

Nonetheless, greater farmer participation in public irrigation O&M in terms of enhancing irrigation performance in Kenya would have positive impact. Therefore, this study recommends for a policy that encourages farmers to contribute to the O&M cost through the formation of a well established and operational WUAs. Moreover, its success would require NIB to treat farmers as clients, shareholders or as co-managers of irrigation scheme rather than just beneficiaries so as to enhance their roles in irrigation scheme O&M fee collection and management. However, while the results of the study provide support for such a policy, the inherent difficulties and challenges in making participatory initiatives should not be underestimated. This is because building capacities and stronger farmers' groups in form of WUAs require a lot of time and resources, which the Government and donors should invest in for public irrigations to be sustainable. Therefore, public investments could focus only on improving and expanding the irrigation infrastructure needed if no special social plan exists, and encourage private operation of the irrigation systems instead of developing and operating additional under-performing irrigation projects. Generally, based on the findings, this study affirms that policy and institutional changes, along with increased government investments in irrigation, and infrastructure, have markedly influenced growth in production and productivity of the irrigation schemes.

Conflict of Interest

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The effect of roll back malaria programme on farmers productivity in BenueState, Nigeria

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The study analyzed the effect of Roll Back Malaria Programme (RBM) on farmer's productivity in Benue State of Nigeria. Roll Back Malaria Programme is a global framework for coordinated action against malaria. A multi-stage random sampling technique was used in selecting 206 respondents from six Local Governments Areas. Data was collected with the aid of well structured questionnaires. The Cobb-Douglas stochastic production frontier was used for data analysis. The study showed thatfarm size, hired labour and quantity of seeds had positive and significant influence on farmer's output in a production pattern that exhibited decreasing return to scale (0.95). The study found technical efficiency of the farmers to vary from 0.14 to 0.95 with a mean of 0.71. Furthermore, farmer's experience (-2.68), use of LLIN (-2.42), access to healthcare (-1.84) and sex of farmer (-2.12) were found to reduce farmer's technical inefficiency. However, increase in sanitation (1.77) increased farmers' technical inefficiency in the study area.The study recommends that productivity of factors could be improved by expanding the farm size at the existing level of hired labour. Also, enlightenment programmes on the benefits of RBM and enlightenment campaigns should be encouraged for better and efficient production.

Key words: Effect, malaria, programme, farmers, productivity, Nigeria.

INTRODUCTION

Malaria is a health problem caused by plasmodium parasites. Malaria attacks an individual an average of four times in a year with an average of 10 to 14 days of incapacitation (Alaba and Alaba, 2002). The frequency of malaria illness and criticality of associated morbidity often portend the disease as a serious economic problem. In many African communities, malaria is a household name with strong resilience and adaptability to different combinations of drugs. In addition to its health impact, malaria is an obstacle to economic development. The goal of the RBM is to halve themalaria burden through interventions that are adapted to local needs. The evolution of new tools (e.g. new Long-Lasting Insecticide-treated mosquito Nets [LLINs], Rapid Diagnostic Tests [RDTs], new drugs) and new strategies (scale-up for impact, expanding from a targeted approach to reach all at-risk people, seeking elimination where possible) is indicative of a partnership that has quickly matured and become responsive to diverse and rapidly changing needs and situations (Lagos State Ministry of Health, 2014). Malaria and agriculture are related. This implies that there may be a bi-directional relationship between

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agriculture and malaria.

On one hand, agricultural environment provides suitable conditions for breeding of disease vectors which cause malaria in human beings. On the other hand malaria is capable of fuelling the nation's poverty situation by inhibiting critical investment plans in agriculture at the households level. Some socio-cultural practices of farmers also indirectly aid breeding of mosquito vectors. Every year the nation loses about N132 billion to malaria in man hours, while the illness drops the nation's annual Gross Domestic Product by 1% (Ogundipe, 2013).

Malaria is still a big healthcare issue in Nigeria and the effect trickles down to agriculture. Rural and semi-modern Nigeria is largely agrarian, thus, the effects of malaria on agriculture, health and development are widespread (Babalola et al.,2009). There are multiple channelsby which malaria impedes development, including effects on fertility, population growth, savings and investment, worker productivity, absenteeism, premature mortality and medical costs (Sachs and Malaney, 2010).

The Roll Back Malaria Programme faces challenges with farmer's socio-economic and socio-cultural behaviours in respect to adoption of the LLIN. Against the background of a deteriorating malaria situation and severe economic hardships particularly in Nigeria, this study is important.

Currently, studies on RBM are limited especially in the Benue state context. The only known study is that ofOgbegbor (2014), who evaluated the managerial and the socioeconomic issues in the realization of RBM in Benue State. In respect of this research gap, this study aims at investigating the effect of RBM on farm household's productivity in Benue state.

MATERIALS AND METHODS

The study area

The study was conducted in Benue state, Nigeria. The State lies between longitude 7°47'E and 10°E and latitude 6°25'N and 8°8'N of the equator (NPC, 2013). Benue state experiences a mean rainfall of 1500mm and a temperature ranging from 24°C to 36°C and is at an elevation of 97m above sea level in the southern guinea savannah agro ecological zone. The major occupation of people in the state is farming, these qualities make the study area suitable for malaria and productivity related research.

Sampling technique and sample size

The population for this study consisted of all farmer households in Benue State. The respondents were selected using multi-stage random sampling technique. The first stage involved the selection of two local governments from each of the three senatorial zones using simple random sampling technique; the second stage involved random selection of one council ward from each selected local government. The final stage involved a simple random selection of 5% of the total households in each council ward. Thus, a total of 206 respondents were selected including both beneficiaries and non-beneficiaries of the Roll Back Malaria Programme.

Method of data analysis

The stochastic production frontier model was used to analyze the productivity of farmers.

Empirical specification

The Stochastic production function used to analyze the productivity of farmers and was specified by the Cobb-Douglas frontier production function and it represented as follows:

$$lnQ = \beta_0 + \beta_1 lnX_{1i} + \beta_2 lnX_{2i} + \beta_{3i} lnX_{3i} + \beta_{4i} lnX_{4i} + \beta_{5i} \ln X_{5i} + V_i - U_i \quad (1)$$

Where Q is total value of output of the farmer in naira; βs are the parameters to be estimated; X_1 is farm size in hectares; X_2 is quantity of seeds in kg; X_3 us fertilizers applied per hectare in kg/ha; X_4 is family labour in man-days; X_5 is hired labour in Naira; V_i is Random error that is assumed to be normally distributed with zero mean and constant variance; U_i= non negative random variable associated with technical inefficiency of production.The inefficiency of production is modelled in terms of factors that are assumed to be independently distributed such that U_i is obtained by truncation (at zero) of the normal distribution with variance δ^2 and mean u where the mean is defined by:

$$U_i = \sigma_0 + \sigma_1 z_{1i} + \sigma_2 z_{2i} + \sigma_3 z_{3i} + \sigma_4 z_{4i} + \sigma_5 z_{5i} + \sigma_6 z_{6i} + \sigma_7 z_{7i} \quad (2)$$

Where;Z_1= Age of respondents (years); Z_2 = Educational attainment (years); Z_3 = Household size; Z_4 = Years of experience in farming (years); Z= Use of LLIN (Use=1, Otherwise =0); Z_6= Sanitation (Clean environment=1, Otherwise=0); Z_7= Access to RBM health care (Very far=4, Far=3, Close=2, Very close=1);Z_8= Sex (Male=1, Female=0).

These variables are assumed to influence technical inefficiency of the farmers. The gamma ($\gamma=\sigma^2_u/(\sigma^2_u+\sigma^2_v)$) which is the ratio of the variance of u (σ^2_u) to the Sigma squared (σ^2) which is the summation of variance of U and V ($\sigma^2=\sigma^2_u+\sigma^2_v$) were also determined. Maximum likelihood estimates of parameters of the stochastic frontier and the inefficiency models were simultaneously estimated using Frontier 4.1 developed by Battese and Coelli (1995).

The technical efficiency of an individual firm is defined in terms of the observed output (Q_i) to the corresponding frontier output (Q_i*) given the available technology.This could be expressed mathematically as:

$$T.E = Q_i/Q_i^* \quad (3)$$

Where:Q_i = Observed output; Q_i^*= Frontier output

Equation 3 can also be expressed as:

$$T.E. = Q_i/Q_i^* = Exp\ (X_i\beta + V_i - U_i)/Exp\ (X\beta + V_i) \quad (4)$$

Where, 0 ≤ TE ≤ 1.

The presence of technical inefficiency effects was tested using the generalized likelihood ratio test (λ), which is defined by:

$$\lambda = -2(L_R - L_U) \quad (5)$$

Where,L_R = Log likelihood of the restricted model (model 1), and L_U = Log likelihood of the unrestricted model (model 2).

It is assumed that λ has a mixed chi-square distribution with degree of freedom equal to the number of parametersexcluded in

Table 1. Maximum likelihood estimates of the stochastic production frontier function of the independent variables.

Variables	Model 1 estimates	+Model 2 estimates
Constant	10.72 (31.06*)	11.78 (33.59*)
Farm size	0.67 (7.90*)	0.85 (10.05*)
Quantity of seeds	0.07 (1.33)	0.10 (2.46**)
Quantity of fertilizer	0.02 (0.68)	-0.02 (-0.74)
Family labour	0.04 (0.99)	-0.02 (-0.55)
Hired labour	0.07 (7.65*)	0.04 (4.22*)
Household size	-	0.05 (1.48)
Sigma squared (σ^2)	0.44	0.37 (5.18*)
Gamma	-	0.39 (2.62*)
Log likelihood function	-205.5	162.9
Likelihood ratio(λ) tabulated		15.51

Source: Field Survey 2015. +,Lead model values in parenthesis represents t-ratio. *, **, *** = t-ratio significant at 1, 5 and 10% levels respectively.

the unrestricted model. The null hypothesis was that model 1 is equal to model 2 (the variance of the inefficiency effects, gamma (γ) = 0).The variables for the research and their measurement are as follows:

1. Age: The number of years of the household head. It was measured in years
2. Sex: The two main categories into which humans are divided on the basis of their reproductive function. It was measured as a dummy, male=1, female=0.
3. Income Level: The total amount of money earned by a household. It was measured in naira.
4. Education: This was measured as the number of years spent in acquiring formal education.
5. Household size: This was measured as the number of persons living in the same house, who share the same income with one household head.
6. Marital status: this was measured as married=1, otherwise=0.
7. Farm size: was measured in hectares.
8. Productivity: a measure of the efficiency of a household.
9. Malaria incidence: The number of cases of malaria a household has in a year.
10. Sanitation: The process of keeping places free from dirt, infection, disease etc by removing waste, trash and garbage. This was measured as Clean environment=1, Otherwise=0.
11. Access to health care: having the timely use of health services to achieve the best health outcomes. This was measured as Very far=4, Far=3, Close=2, Very close=1.

RESULTS AND DISCUSSION

Estimates of the parameters of the stochastic production frontier function

The maximum likelihood estimates (MLE)of the Cobb Douglas stochastic production frontier model and the ordinary least square (OLS) estimates are presented in Table 1. The results revealed the presence of inefficiency amongfarmersinthestudyareabasedonthesignificance of gamma and the likelihood ratio (λ) test. The λ test which has mixed chi-square (χ^2) distribution stood at 85.06 , while the critical value of chi-square at 95% confidence interval and 8 degree of freedom, $\chi^2_{(0.05, 8)} = 15.51$, Thus the null hypothesis of no inefficiency effects (γ = 0) was rejected (Model 1 ≠ Model 2) . This means that the traditional frontier model estimated with ordinary least square (which is estimated without the inefficiency effects) is not the adequate representation of the data, hence Cobb-Douglas Stochastic production frontier model which described the farm's specific inefficiency effects fits this data better.

The value of sigma squared is 0.37 and it was statistically significant at 1% level of probability indicating a good fit and correctness of the distribution. It also implies that the Cobb Douglas stochastic production frontier is the adequate representation of the data. The variance of the ratio (Gamma) which measures the effect of technical efficiency in the variation of observed output is 0.39 and its significant at 1% indicating that 39% of reduction from the maximum output is as a result of inefficiency in management on the part of the farmer which could be overcome by adopting the Roll Back Malaria measures of preventing malaria infection and increasing the productivity of family labour as a result of good health.

The sum of elasticities of the coefficients which is a measure of return to scale of the farmers was less than unity (0.95) indicating a diminishing return to scale. This implies that an increase in the quantity of all inputs employed by farmers in production in the study area will result in less than proportionate increase in the quantity of output produced.

Thus, farmers in the study area can expand their production through additional use of inputs. This is in agreementwiththeworksofTsueetal.(2013)andShehu

Table 2. Maximum likelihood estimates of the stochastic production frontier function of the inefficiency model

Hired labour	**0.07 (7.65*)**	**0.04 (4.22*)**
Constant	-	1.32 (2.94*)
Age	-	0.009 (0.74)
Education	-	-0.002 (-0.10)
Household size	-	0.05 (1.48)
Experience	-	-0.04 (-2.68*)
Use of LLIN	-	-0.006 (-2.42**)
Sanitation	-	0.32 (1.77***)
Access to healthcare	-	-0.02 (-1.84***)
Sex	-	-0.37 (-2.12**)
Sigma squared (σ^2)	0.44	0.37 (5.18*)
Gamma (γ)	-	0.39 (2.62*)
Log Likelihood function	-205.5	162.9
Likelihood ratio (λ) calculated		85.06
Likelihood ratio(λ) tabulated		15.51

Source: Field Survey, 2015.+ lead model Values in Parenthesis represents t-ratio. *, **, *** = t-ratio significant at 1, 5 and 10% levels, respectively.

et al. (2010)that found the return to scale of cat fish and yam farmers in Benue state to be 0.95 and 0.98 respectively, indicating that the farmers had diminishing returns to scale.The estimated elasticities of the independent variables revealed that farm size and hired labour were statistically significant at 1% level while quantity of seeds used was significant at 5% level.

More specifically, the result showed that farm size and hired labour were the most important factors for increasing the quantity of output of farmers in the study area as every 10% increment in the farm size and hired labour used increases the output of farmers by 8.5 and 0.4% respectively. This is however expected as large farm size with correspondent labour will increase the productivity of farmers.

Technical inefficiency analysis

Analysis of technical inefficiency model is Table 2. Factors that were found to exert statistical influence on inefficiency of farmers include farming experience (-0.04), use of LLIN (-0.006), Sanitation as a result of enlightenment (0.32), Access to health care (-0.02) and sex of farmers (-0.37).

However, age, educational attainment and household size were found not to exert statistical significance on the level of farmers' inefficiency. Specifically, the result showed that the more years of experience in farming a farmer has the lesser his technical inefficiency. This is because the more experience a farmer has, the more he is likely to become technically efficient, this result is supported by WolliniandBrummer(2012),that concluded that the most important factor that affects the level of technical efficiency of coffee farmers in Costa Rica was an experience in coffee production. Similarly, the more a farmer and his household make use of the long lasting insecticide treated nets (LLIN) the less likely they will get infected with malaria that is capable of keeping them away from farming activities either directly or indirectly and thus making them more technically efficient on the farm. Also, the positive and significant coefficient of sanitation on technical inefficiency model implies that this factor decreases technical efficiency of farmers in the study area. The negative relation between this variable and technical efficiency may be the case of farmers who think sanitation is enough measure to prevent malaria infection and increasing productivity.

Furthermore, access to health care increased farmer's technical efficiency, this is because when farmers fall sick because of mosquito bites and get rapid access to health care this helps to reduce the number of days they would have been incapacitated with malaria as a result of treatment they would have got from the health centres.

Alternatively, this implies that the more access to health care farmers get, the lesser their level of technical inefficiency. This is expected because when farmers are down with malaria and they get quick and prompt treatment from health care centres, they are more likely to recover on time thereby reducing the number of days they would have been incapacitated by malaria. The result also shows that having more males involved in farming activities, reduces technical inefficiency. This may be as a result of men giving more details to farming instruction than their female counterparts coupled with their ability to withstand the rigorous demands of farming

Table 3. Frequency distribution of the technical efficiency estimates of the farmers.

Range	Frequency	Percentage
≤0.30	15	7.3
0.31-0.60	48	23.3
0.61-0.90	74	35.9
≥0.91	69	33.5
Mean	0.71	
Minimum	0.14	
Maximum	0.95	

Source: Field survey, 2015.

compared to the female folks.

Efficiency estimates of farmers in Benue State

The frequency distribution of the estimated technical efficiency is presented in Table 3. The result revealed thattechnicalefficiencyoffarmersranged between 0.14and0.95withameanof0.71whichis less thanunityindicatingthatthefarmersareproducing below the maximum technical efficiency frontier. This impliesthattechnicalefficiencyoffarmersin Benue could be increased by 29% through efficient use of availableresourcesgiventhecurrentstateof technology. The resultsfurthershowedthatabout69.4%of the farmers had technical efficiency exceeding 60%.

CONCLUSION AND RECOMMENDATION

The study revealed that farm size, quantity of seeds and hired labour had significant effect on the output of farmers. The study further found out that technical efficiency of farmers varied due to the presence of inefficiency effects on the part of management. Specifically, years of schooling, farming experience, use of LLIN, access to health care and male farmers increased the technical efficiency of farmers while increase in sanitation decreased their technical efficiency.

TheresultindicatesthatRBMhashelped improvedtheproductivityofthefarmerseven though the return to scale was 0.95(diminishing returns). The mean technical efficiency of the farmers is 71 percent. This suggests that the technical efficiency could be increasedby29%iftheavailableresourcesare efficiently utilized. The study recommends that productivity of factors could be improved by expanding the farm size at the existing level of hired labour. Also, enlightenment programmes on the benefits of RBM and enlightenment campaigns should be encouraged for better and efficient production.

Conflict of Interest

The authors have not declared any conflict of interest.

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The status of food availability in the face of climate change and variability in Choke Mountain Watersheds, Central Ethiopia

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Food insecurity is an integral part of poverty in Ethiopia owing to agricultural production to be less able to adapt to climate change. The main objective of the study is to evaluate the status of food availability in the face of climate change and variability in Choke Mountain Watersheds, Central Ethiopia. For this purpose structured household questionnaire, Key Informant Interview, Group discussion and field observation were used to generate both qualitative and quantitative data. Both purposive and non-purposive sampling techniques were employed to select each agro ecosystem and sample households. Household Food Balance Model *(*HFBM) was used to analyze the status of food availability. Other quantitative data was analyzed, tabulated and summarized by utilizing Statistical Package for Social Science(SPSS 20).The result of HFBM revealed majority of sample households are food insecured in terms of daily calorie availability per adult equivalent and due to climate variability availability of food is not equal across all Agro Ecology System (AES). Even if the magnitude of productivity problems differ in each Agro Ecology System. Weed infestation, land degradation, dependency on single harvest, lack of farm implements are the cause of reduction of agricultural activities and productivities.

Key words: Food availability, climate change and variability, choke mountain watersheds, household food balance model (HFBM).

INTRODUCTION

Roughly a billion people around the world live their lives in chronic hunger, and humanity's inability to offer them sustained livelihood improvements has been one of its most obdurate shortcomings. Although rapid improvements in agricultural productivity and economic growth over the second half of the twentieth century brought food security to broad swaths of the developing world, other regions did not share in that success and remain no better off today and in some cases worse off than they were decades ago (Burke and Lobell, 2009). Climate change posed the greatest threat to agriculture and food security in the 21st century, particularly in many of the poor, agriculture-based countries of sub-Saharan Africa (SSA) with their low capacity to effectively cope (Maxwell and Smith, 1992; WFP, 2009).

The Fourth Assessment Report of the IPCC has made a critical assessment of the possible impacts of climate change on agriculture, livestock and fishing, particularly

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in the countries of the tropics and sub-tropics (IPCC, 2007). The Food and Agriculture Organization of the United Nations (FAO) also warns about the negative consequences, in particular for smallholder subsistence farmers in what are in any case marginalized regions of Africa. This is largely because of high poverty rates, high vulnerability levels, dependency on fragile environment and low adaptation capacities. Furthermore, the rural populations of Africa for whom agricultural production is the primary source of direct and indirect employment and income are most affected because of agriculture's direct exposure to climate change (IPCC, 2007). From a food security viewpoint, sub-Saharan Africa (SSA) is doubtfully the most vulnerable region to many adversative effects of climate change due to a very high dependence on rain fed agriculture for basic food security and economic growth, and entrenched poverty (IPCC, 2007).

Though it is endowed with varieties of natural resources suitable to produce wide varieties of crops, Ethiopia has been challenged by lack of food security and become one of food aid dependent sub-Saharan African countries (Markos, 1997). At present agriculture dominates the Ethiopian economy, accounting for 47% of GDP and 85% of employment, dominated by small scale farmers who employ largely rain-fed and traditional practices (MARD, 2009). Almost 80% of the population lives in rural areas and depending on crop production and/or keeping livestock as means of livelihood (WB, 2008; USAID, 2010). Climate change has become topical because of its effects on human lives and the future of the world. Interestingly, it affects all the dimensions of food security (FAO, 2003). Ethiopia is the most vulnerable countries and the vulnerability of Ethiopia to climate change impact is a function of several biophysical and socioeconomic factors (Belay, 2011). Therefore, climate change will have a far reaching implication on food security. For example, the increasing year-to-year variability and increases in both droughts and heavy precipitation events lowers agricultural production including frequent drought (1965, 1974, 1983, 1984, 1987, 1990, 1991, 1999, 2000 and 2002) and recent flooding (1997 and 2006) leads to negative effects on food security (Marius, 2009; Markos, 1997).Since 1959, the domestic production of food has never been sufficient to meet the food requirements of the national population. Indeed, since the 1960s, the number of food insecure households has been increasing, whilst per capita food availability has been decreasing(Markos, 1997).The per capita food availability was, on average, 128.08 kg for the period 1961to 1974, and it declined to 119.99 kg in 1975 to 1991. Though average per capita food availability was 125.41kg during 1992 to 2001, still it remained far below the recommended average per capita daily requirement set by the Ethiopian government 2,100 kcal, which is equivalent to about 225kg) of grain per annum (Markos, 1997).

Empirical evidence of food security in Ethiopia indicates the prevalence of a high level of food insecurity, with significant distinctive and spatial characteristics. The specific food security studies conducted by Abebawet al. (2011), Hadleyaet al. (2011), and Hailu (2012) shows that the depth and intensity of food insecurity are high, influenced by poor functioning of marketing systems and other household and socioeconomic factors. Fragile natural resources base, inadequate and variable rain fall in terms of intensity and distribution pattern, improper farming practice, inaccessibility to productive resources, diminishing land holdings and tenure insecurity, poor development of human resources, poor storage technologies that leads to high post-harvest losses, inaccessibility to transport infrastructure, lower productivity of livestock are different human and natural induced factor that made Ethiopia a food insecure country over last few decades (Woldeamlak, 2009; Deveruex, 2010). Due to these reasons, food insecurity is an integral part of poverty in Ethiopia owing to agricultural production is to be less able to adapt to climate change.

Choke mountain have considerable ecological and socioeconomic significance at the local, regional, and national levels. However, land degradation has impaired the capacity of the land to contribute to food security. It has also undermined local access to water supply and woody biomass, negatively impacting social stability. Erratic rain fall, increase in temperature, drought, flood, annual runoff and water availability are also exacerbate deterioration of basic services such as drinking water, sanitation, housing and health facilities which causes food insecurity in poor farm household (Belay, 2011). Both food security and climate change are multidimensional, dynamic and broad concept and climate change have effect on food security: On food availability, accessibility, utilization and stability (FAO, 2008). Even though there are some studies that have been conducted about effects climate change (Tsegaye, 2009; UNDP, 2007; Hamza and Iyela, 2012),there is no study regarding the status of food availability in relation to climate change in Ethiopia in general and Choke Mountain Watershed in particular.Mesay (2001) and Debebe (1995), briefed the necessity to conduct situations food security at household's or individual level. To this end food availability is the main emphasis of the study which can further determine the rest pillars of food security. All the determinants of these pillars like exchange and distribution were not also covered in the study because itismore reliable at regional and national level. Thus, food production was given priority from determinants of food availability in the face of climate change and variability in the study area.

MATERIALS AND METHODS

Description of the study area

The *Choke* Mountains is a large block of highland found in central

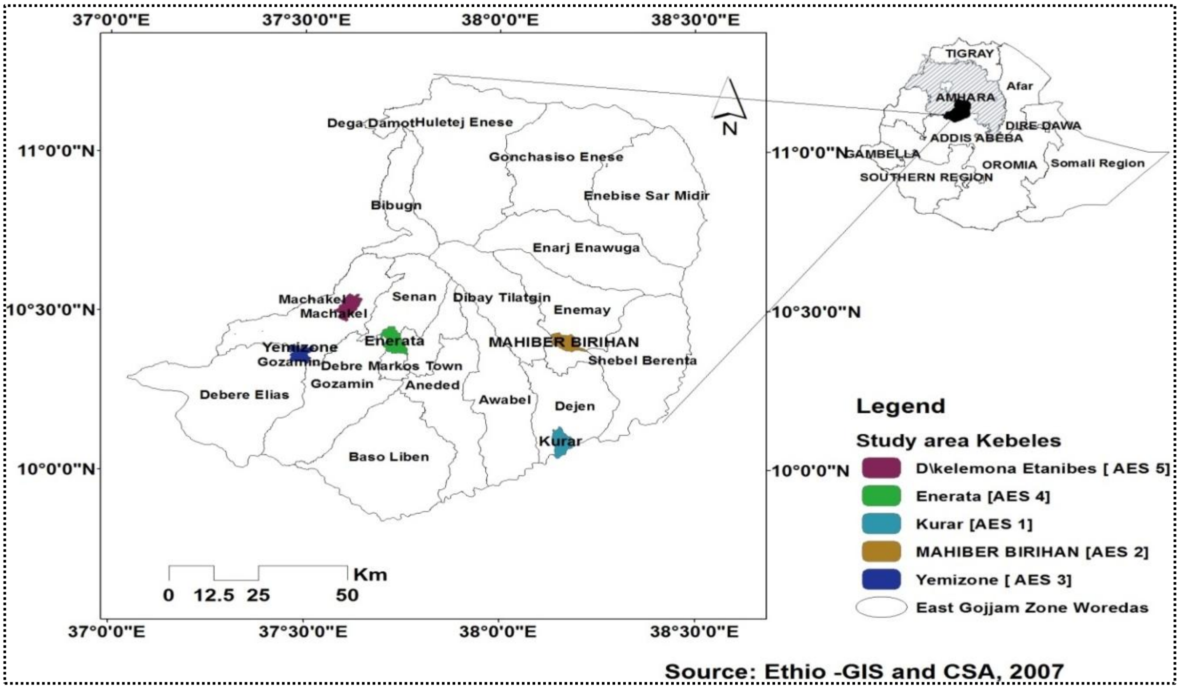

Figure 1. Map of the study area**.**

Gojjam, *Amhara* Regional State, Ethiopia. It is located on plateaus that rises from a block of meadows and valleys and have elevation ranging from approximately 800 to 4200 m above sea level. The central peak is located at 100 42' N and 370 50' E (Figure 1). The mountains were formed by volcanic activity about 30 million years ago in the middle of late tertiary. The prevailing climate can be described as “tropical highland monsoon”. Seasonal precipitation is tightly correlated with the movement of the Inter-tropical Convergence Zone (ITCZ), with most rain falling during the May-October *Kiremt* (rainy season in Ethiopia). The distribution of precipitation within the Choke is far from uniform; average annual precipitation ranges from 600 to 2000 mm year^{-1}, and exhibits strong local variability associated with topographic gradients. Precipitation events are convective in nature, and are characterized by short, sometimes intense erosive bursts with notably large raindrops (Belay, 2011). Type of soil dominate in the watersheds are Leptosols,Cambisols,Vertisols, Nitosols, Alisols, Luvisols, Andosols and Phaozems which support range of agricultural uses. More specifically, sorghum, maize and teff, durum wheat, barley,chickpea, range of pulses and potato grown according to their agro ecological system. The dominant distribution of vegetation types according to their agro-ecosystem are the *Juniperusprocera, Erica arborea, Hageniaabyssinica, Hypericumrevolutum,Oleaeuropae, Oxytenatheraabysnica, Accacia*spp.*, Prunusafricana, Hageniaabyssinica, Erythrinabrucei and Arundinariaalpina and Eucalyptus globulus*.

According to Belay et al. (2013), based on the overlay of three inputs, that is, precipitation and temperature, a soil and terrain analysis, and a map of the distribution of farming systems, the agro ecosystem (AES) of Choke Mountain watersheds is classified in to six. These are as follows.

Lowland and valley fragmented agro ecosystems (AES 1)

This Agro ecosystem includes the lowlandsin the eastern part of the Choke Mountain watersheds and fragmented valleys along the Blue Nile gorge, with an altitude range of 800 to 1400 m. it is characterized by relatively unfavorable agro-ecologic conditions: rugged terrain, lower and more sporadic rainfall than the other AES, and extensive land degradation.

Midland plains with black soil(AES 2)

It is found on the eastern toe of Choke Mountain, extending from the town of *Dejen* to the town of *Mota*. This agro ecosystem represents midland plains with black soil within elevation ranging from 1400 to 2300 m. it is more suitable for agriculture and is potential for input-intensive *teff*, durum wheat and chickpea production, provided appropriate Vertisols management practice is in place.

Midland plains with brown soils (AES 3)

It is found on the western and southern toe of Choke Mountain toe. the elevation varies between 1400 and 2400 m. The annual temperature varies between 16 and 21°C, and the growing period is between 121 and 180 days. It is also a potential area for pulses and oil crops. This system is potentially suitable for input-intensive, mechanized agriculture and irrigation that could contribute to rapid increases in productivity.

Midland sloping lands (AES 4)

This agro ecology system is located at the foot-slope of Choke Mountain with elevation ranging from 2400 to 2800 m. The annual temperature varies between 11 and 15°C and the growing period between120 and 180 days. It is constrained by low natural fertility due to leaching of base ions and high level of soil acidity. Sloping

Table 1. Proportion of sample HHs by*Kebele* and villages.

Agro ecosystem (AES)	Kebele	Village	Population	Sample size (10%)
Lowland and valley fragmented	*Kurar*	*Mekni*	230	23
Mid land plain with black soil	*M/Birhan*	*Dinda kutir.2*	211	21
Mid land plain with brown soil	*Yemezegn*	*Tembol*	170	17
Midland sloping land	*Enerata*	*Digil*	179	18
Hilly and mountainous highland	*D/kelemo*	*Addis Amba*	210	21
Total			1000	100

Source: CSA, 2007.

terrain is more difficult to cultivate than flat land, and is subject to higher rates of water runoff and soil erosion. The main crop types produced are wheat, maize, teff, and a range of pulses. The highly rugged landform, associated land degradation and soil acidity present major constraints for crop production. It has potential for more intensive production system, but soil and water conservation measures are critical.

Hilly and mountainous highlands(AES 5)

These hilly and mountainous highlands are found on the back-slope of Choke Mountain. The major constraints on production in this area are low temperature, soil erosion and deforestation leading to water management problems. Rangeland (grazing or pasture land) degradation is also common due to overstocking. It is not appropriate for high intensity agriculture, but it does have high potential for traditional forestry, including bamboos and potato and barley production with appropriate mountain agricultural land management.

Afro Alpine(AES 6)

The Afro Alpine is the Choke Mountain summit. Elevation ranges from 3800 to 4200 Given the important functions of Afro Alpine as a reservoir for biodiversity and a soil and water retention zone, combined with the area’s relatively low agricultural potential due to low temperatures, the most appropriate use of the area is as a protected bio -reserve (Belay et al., 2013).

Socio economic and demographic characteristics of the study area

East Gojjam zone has considerable ecological and socioeconomic significance at the local, national, and regional levels in its contribution to food security in Ethiopia. This highland zone has the most favourable climate with land resources suitable to grow large variety of crop and livestock species, it stands as the most intensively cultivated and is considered as one of the bread basket areas of the country. The mountain range is densely populated, with an average of 260 to 270 people per km^2. Settlements are fairly common up to 3600m asl. The livelihoods of the farming communities are facing severe constraints related to intensive cultivation, overgrazing and deforestation, soil erosion and soil fertility decline, water scarcity, livestock feed, and fuel wood crisis.While traditional land management, including appropriate agricultural practices as well as good forestry practices have extensively protected the Choke from accelerated erosion in the past, today's land abandonment as well as forest mismanagement has dramatically increased the frequency of intensive soil erosion events. The livelihoods of the communities on the Choke Mountain Range are primarily dependent on biomass-based subsistence economy. Communities depend on biomass for their fundamental needs like food, fuels, construction materials, and raw materials for various traditional crafts, most of which are collected freely from the immediate environment.

Research design

This research has attempted to integrate the use of quantitative and qualitative data. The qualitative approach of this study was comprised by key informant interview, focus group discussions, direct observation, whereas the quantitative approach was employed through household survey. Both primary and secondary data was used in this study. Primary data was collected through household survey, key informant interviews, focus group discussion and direct observation. The study also include secondary data from published and unpublished materials like, reports, books, maps, national and regional manuals and guide lines related to the topic to be studied.

Sampling techniques and procedures

There are six agro-ecosystems in the Choke Mountain Watershed. The researchers used both probability and non-probability (purposive) sampling methods. For the purpose of this study, the researchers select five agro-ecosystems and one *Kebele*[1] purposively by considering their proximity to road. Simple random sampling from probability sampling is used to select five kebeles-one from each agro-ecosystem and sample household, by which households as people living in one village is near homogenous in terms of economic activity, technological development and other socio economic conditions. The selected villages have a total household population of 1000. Because of too many household in the study area, it is difficult to administer questionnaire and conduct interview to all of them. Thus,10% of the total households from those villages were selected. Accordingly, probability proportion to sample size technique (Table 1) was used to distribute questionnaire to the sample households for each sample villages. In addition to this, Key Informant Interview was conducted with 10 individuals (2 from each village) with different background and has deep understanding about the issue (one agricultural expert and one religious leader). Focus group discussion was also conducted with an average of 8 to 10 from different groups with total five focus group discussion in each of the selected agro-ecosystems. Finally, field observation was used to supplement and triangulate information collected insurveyquestionnaire, focus group

[1] Lowest administrative unit which comprises of villages

discussion and data from secondary sources.

Method of data analysis and presentation

Data which were collected from both primary and secondary sources were analyzed, summarized and presented via quantitative and qualitative method of data analysis. Questionnaire which is gathered from respondents is quantitatively analyzed, summarized and presented in table, graph, and percentage. For the purpose of measuring household food security situation, Household Food Balance Model (HFBM) was used.

The net available food for the households was computed using a modified form of a simple equation known as Household Food Balance Model, originally adapted by Degefa (1996) from FAO Regional Food Balance Model and then used by different researchers (Eshetu, 2000; Mesay, 2010; Seyoum, 2012). The quantity of food was calculated and converted into dietary calorie equivalent based on Ethiopian Health and Nutrition Research Institute food composition table. Then the food supply at a household level was calculated by dividing a total number of days per year (365) and adult equivalent value for each sampled households was used to calculate calories available per adult equivalent per day for each household.

According to FDRE FSS (1996), 2100 kilo calories per person per day was used as a measure of minimum calories required per adult equivalent per day (that is, demand) to enable an adult to live a healthy and moderately active life. Then a comparison between the available (supply) and required (that is, demand) grain food was made. Finally, the output of the HFBM, comparison between calories available and calories demanded by a household was made to determine the food security status of a household. A household whose daily per capita caloric available (supply) is less than his/her demand was regarded as food insecure and household who did not experience a calorie deficit during the year under study was regarded as food secure.

$$NGA_i = (GP_i + GB_i + GR_i + GPS_i) - (HL_i + GS_i + MO_i + GG_i + NS_i)$$

Where, NGA_i= Net grain available/year/household; GP_i= Total grain produced/year/household; GP_i= Total grain bought/year/household; GR_i= Total Grain obtained from remittance /year/household; GPS_i= Total grain obtained through previous stock/year/household; HL_i= Post harvest losses/year household; GS_i=Quantity of grain reserved for seed/year/household; MO_i=Amount of marketed output /year/household; GG_i=Grain given to others as a gift within a year/household, and NS_i=grain planned to be left by a household for next season/year/household

In this model, the index i run from 1, 2………….100. Except post harvest losses, all the data needed for HFBM were collected from the primary data from household survey with the period between November 2013 to October 2014. However, the rest post harvest losses data was obtained from secondary data. According to East *GojjamZone*[2] of agricultural office and from previous study made using HFBM an average post-harvest crop loss during the year under investigation was estimated at an average value of 10% of the total production of each crop.

The researchers have also used descriptive statistics to analyze household's perception of food security and utilization of food in face of climate change. After the necessary information and data were collected and generated, the researcher has employed different statistical methods and tools to analyze and present the data collected side by side with qualitative summarization and discussion. The quantitativedata was analyzed by the using (Statistical Package for Social Science) SPSS and Microsoft excel.

[2] Zone is the major administrative division next to region in Ethiopia

The information obtained from key informant interview, focus group discussion and direct observation were analyzed through qualitatively by narrative descriptive.

RESULT AND DISCUSSION

Household's perception about food security in the study area

Farmers who operate land which is inherently more susceptible to food insecurity are thought to have a greater propensity to increase their agricultural production and perceiving the problem provides stimulus to stop the problem. All households in the sample areas were asked about their perception regarding to their food security status. Some 52 and 3% of total sample households replied that they face transitory and chronically food insecure respectively. Other 45% said that, there is no food shortage at all to their family. Specifically among sample kebeles, Kurar (56.5%) and D/Kelemo (52.4%) are more vulnerable to transitory food insecurity. Whereas, Yemezegn (58.8%) andEnerta (50%) are food secured. According to farmers perception from Enerta and D/Kelemo are not affected by chronically food insecurity (Figure 2).

According to households perception, half of the respondents (50%) reported to regularly produce sufficient food from their own crop production and animal production to cover all year round demand. Majority of households who do not produce their own food were found in Kurar and Enerata(Table 2).

In addition to this, number of months of the year that sample households of different AES failed with food shortage were also examined in this study. From the total sample households, about 38.3% of respondents replied that they faced food shortage for about 1 to 2 month/s per annum and 46.8 and 14.9% of household from the total are faced food shortage 2 to 3 and above 3 moths per annumrespectively. Furthermore, Sample households were also asked about food preferences they eat. According to their response, 81.0% of respondents do not eat the food that they preferred. Even though they produce food for the year-round for their consumption, majority of households do not eat the food they prefer and only 19.0% of households eat food they preferred. This can tell us even though the majority eats what they prefer, yet still they are food insecured.

Food security and food availability

The result of the HFBM reveals that from the total sample households, 44% households are food secured who fulfill the minimum recommended daily calorie (2100 Kcal/adul.equ) demanded for their households. While 56%ofthemfailedto supply thisdailyminimum requirements.

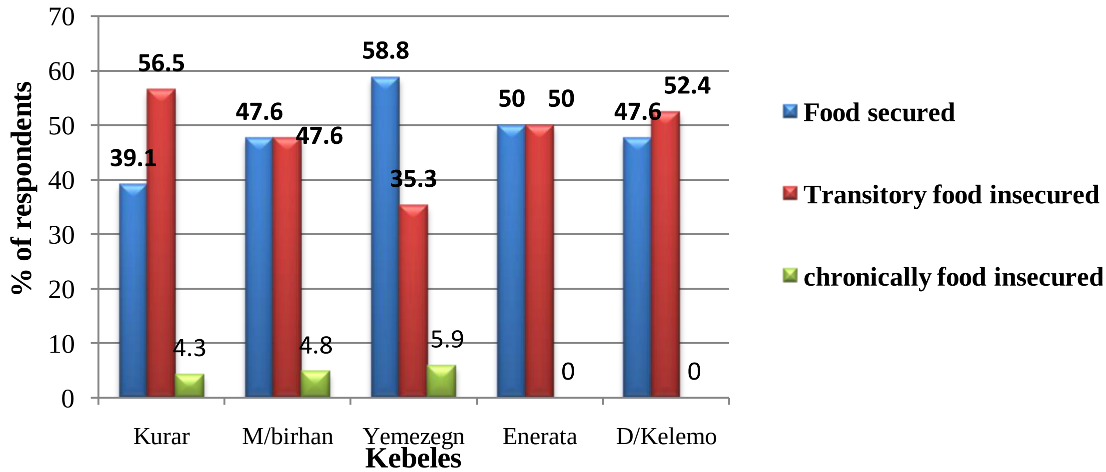

Figure 2. Perception of household about food security status.

Table 2. Farmer's response on whether they produce adequate food to cover all year-round.

Kebele	Alternatives			
	Yes	%	No	%
Kurar	8	34.8	15	65.2
M/ Birhan	10	47.6	11	52.4
Yemezegn	10	58.8	7	41.2
Enerata	7	38.8	11	61.2
D/Kelemo	11	52.4	10	47.6
Total	50	50.0	50	50.0

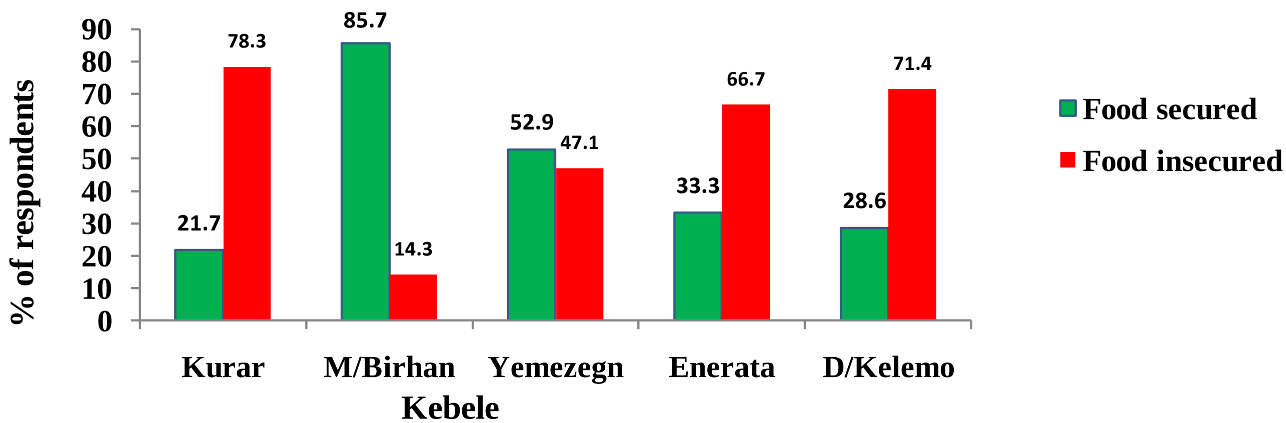

Figure 3. Food security status of sample kebeles.

Majority of food insecured households are from lowland and valley fragmented (Kurar) which constitute 78.3% followed by hilly and mountainous highlands (D/Kelemo-71.4%) andEnerta (66.7%). On the contrary majority of food securedhouseholds arefrommidland plain with black soil (M/Birhan-85.7%) and from mid land plain with brown soil (Yemezegn-52.9%) were food secured (Figure 3). From this figureone can easily view AES midland plain with black and brown soil are the contributing factor behind good agricultural production which in turn perceived to contribute food security in the study area.

Table 3. Household food balance sheet result.

HHFBM Items on kcal/d/ad.equ	Mean FS	Mean FIS	All sample Min	All sample Max	All sample Mean	All sample SD	t-test
Total grain produced	9022.3	2722.2	1037.4	41798.3	5494.3	5637.2	.000***
Total grain purchased	254.3	100.9	.00	3767.1	168.4	508.0	.001***
Food grain as Remittance	8.3	4.5	.00	368.1	6.2	41.2	.133^{ns}
Food grain left from Previous season	932.4	56.8	.00	10327.8	442.0	1649.2	.009**
Subtotal of 1+2+3+4	10217.4	2884.6	1169.00	42803.8	6111.0	6527.6	.000***
Grain for Post harvest	1024.8	296.6	103.74	4179.8	617.0	705.0	.000***
Grain for seed	925.9	361.6	.00	5241.9	609.8	763.0	.000***
Grain for market	2391.4	586.9	.00	26189.1	1380.9	3196.7	.000***
Grain as gift for others	387.1	36	.00	5057.9	190.5	774.7	.016**
Grain to be left for next season	155.2	0.3	.00	2513.8	68.5	343.9	.049**
Sub Total of 5+6+7+8+9	4884.5	1281.5	216.7	34746.5	2866.9	4958.8	.000***
Net available/d/ad.eq	5332.9	1603	241.6	19716.7	3244.1	2709.5	.000***
Food grain Market	2137	478.8	-	26189.1	1208.4	3291.3	.000***

*, **, *** indicated that the coefficient are statically significant at 10, 5 and 1% respectively; FIS = Food insecured household, FS = Food secured household, NS = Not significant.

Household Food Balance Model (HFBM) balance sheet result

The balance sheet of HFBM reveals that the mean per adult equivalent kilo calorie (kcal/daily/adul.equ) of the sampled household is 3244 kcal/daily/adul.equ., which is above the minimum daily requirement set by the national standard of 2100 kcal/daily/adul.equ. But the distribution of this average energy available in each of sampled household is further expose out that it is highly dispersed among the sampled households with a large amount of standard deviation (Std. Dev =2709). These conditions create groups of household that one could achieve in fulfilling the minimum energy requirement in their household while the second groups failed to do so (food insecured). One could also see that the extent of food security situation among the sample households in line of food availability stretches along at a range of 241 to 19716.7 kcal/daily/adul.equ. These minimum (241kcal/daily/ad.equ) and maximum (19716.7kcal/d/ad.equ) is found in Enerata and M/Birhan respectively (Table 3).

The result of the food balance sheet of HFBM in Table 2 also illustrate that food secured households have greater capacity to produce their own production, a better stock that was left from previous production and have greater capacity to take a food reserve for coming season.

Food grain market balance for the household show that food secured household have statistically greater average net energy supply for the market in terms of grain energy than the food insecured groups. Even though mean for the samples household show they are net food sellers for the market and both food secured and insecure groups have a net food grain sellers. Thedata output of the HFBM also reveals that there are household that are supplying their household energy as a net food grain buyers. Furthermore, from the result of the key-informant interview and group discussion confirmed that the current food market price increase trends reward the net food grain sellers, while net food grain buyers are suffered with the price and make their household food security more vulnerable with external price factors for grain market.

Food availability, agricultural production and status of land productivity

Agricultural production and food availability are just one part of the food security. Agriculture in Ethiopia is important for food security in two ways: it produces the food people eat; and (perhaps even more important) it provides the primary source of livelihood for the majority of the working population. The level of agricultural productivity of a household determines the food security status of a household. This is due to the fact that the greater share of household food energy available is derived from household's own agricultural production. In fact small holder farmers in the study area and all over country at large produce for their own consumption and very insignificant part of the household food economy is exchanged. Agriculture in the choke mountain is predominantly crop-livestock mixed systems and also subsistence with very low inputs and outputs. However, mixed farming system in Choke Mountain is highly affected by climate change.

Food production varies spatially and temporally owing to climatic condition. The major agricultural production kebeles' are characterized by relatively stable climatic conditions with dry or at least cold weather condition during harvest time, but food insecure kebeles' from the study area have highly vulnerable climates. Climate change determine the type of crops produced that farmers face problems to make decisions about the type of crops produced in the coming season and the amount of production in different ways.

Types of crop produced are different from one AES to the other due to climatic condition and altitudinal difference. Kurarkebele is suitable for producing Sorghum (*sorghum bicolar*) (M=6.93), Teff (*eragrotisteff*) (M=3.26) and maize (*zea mays*) (M=1.36) (Table 3) where this kebele is characterized by rugged and sloping terrain, low and sporadic rain fall, extensive land degradation and low soil fertility. Although average temperature decrease and annual rain fall increase from 1981-2008, as explained above, production in Kurar is low. This is due to the fact that, production is highly dependent on variability and seasonality of rain fall. On the contrary, mid land plains with black soil zone is productive by Teff (*eragrotisteff*) (M=13.2), Wheat (*Triticum*spp.) (M=6.9) and cheak pea(*Cicerarientinum*) (M=2.83). According to the survey result the topography of this kebele is extensive level plain with high fertility status of soil.

Food security in M/Birhan was achieved since agricultural productivity is high and has a capacity to do more in this zone even if temperature increase (Figure 7) and rain fall decrease (Figure 8). Even though average temperature increase in Yemezegn (Figure 7). This AES have high productivity capacity with irrigation and good chemical fertilizer. This zone is known by the productivity of Wheat (*Triticum*spp.), Teff (*Eragrotisteff*) and Noug (*Guizotiaabyssinica*)with a mean value of 9.91, 6.91 and 2.82 respectively. As compared to other crops Wheat (*Triticum*spp.), Teff and potato with the same mean value (3.83) are main crops for Enerata with moderate sloping terrain and low natural fertility. The last AES (D/Kelemo) like lowland and valley fragmented is highly vulnerable to soil erosion, land degradation and erratic rainfall. Owing to this Potato, Engdo and Barley (*Hordeumvulgare*) are the main crops in the area with no chemical fertilizer and low level of soil fertility. Especially, Engdo is the main stable food crop which substitute previously grown crops –Barley (*Hordeumvulgare*) and wheat (*Triticum*spp.) in D/Kelemo (Table 4).

Moreover, change in size of farm land, slope of farm land and their productivity with fertility status of land determine the type and amount of crops produced in the study area owing to climate change and extreme weather events like drought and flood. More than 75% of the total sample households (77%) revealed that, the productivity of land decrease while the remaining 17 and 6% of them give as land productivity increase and remain the same respectively.

According to the survey result, 61% of total sample respondents especially those from Kurar (93.1%) and D/Kelemo (80%) put that, land productivity decrease due to land degradation (Figure 4). Because these two study areas are highly vulnerable to extreme weather events since the topography is sloppy and is more sensitive for flooding. Land degradation, therefore depressing land productivity per unit area and availability of food from domestic harvest and was a major factor affecting household food security. The result from Focus Group Discussion, Key Informant Interview and Personal also confirmed that the reason for decrement of land productivity is the vulnerability of sloppyareas to soil erosion and absence of well-developed soil and water conservation techniques.

The second and third reasons for decrement of land productivity following land degradation are drought and low and variable rain fall patterns. The fourth reason for decrease of land productivity is insect pest and weeds. The farmers felt that insect pest and weeds negatively affected agricultural production and were most important problem that lowered the productive potential of production and affected household food security. The result from Focus Group Discussion and Key Informant Interview revealed that the reason for increment of land productivity is increasing fertility of soil. Strong extension service and suitable weather condition are also reason for the increment of productivity of land (41.2%) from M/ Birhan.

Size of households' farm land and status of fertility

Regarding changes that occurred to the farmers' size of land holdings, majority of sample households reported about a decrease in size of land holding starting from the time that they produce in their land. Especially in D/Kelemo, Kurar and M/Birhan, majority of respondents reported about decline of land holding, that is, 95.8, 95.7 and 87.2% respectively (Figure 5). Thus, majority of household's land is decreased in the study area under investigation. Some of the households also reveal about increment and no change of farm size.

All respondents were asked about reason for increment, decrement and about no change. The reported reasons for the decline of land holding size includes: Land degradation and increase of grazing land (75%) and loss of land to others by redistribution (50%) from the entire sample households. Land degradation in Choke Mountain is the main constraint to agricultural productivity. Lowland and valley fragmented (Kurar) and hilly and mountainous highlands (D/Kelemo) are the victim kebeles by land degradation that reduce agricultural productivity andin turn affectfoodsecurity. Belay et al. (2013) also shows that land degradation is the main constraint for production in the same area. According to key informant interviewees and focus group

Table 4. Type of crop produced for sampled households in each kebeles

Crops produced /qun/year	Mean (in quintal)				
	Kurar	M/Birhan	Yemezegn	Enerata	D/Kelemo
Teff	3.26	13.21	6.91	3.83	3.00
Wheat	0.13	6.90	9.91	3.83	3.92
Barley	0.00	0.95	0.088	0.083	2.52
Maize	1.36	3.61	12.7	3.50	1.71
Sorgum	6.93	0.00	0.00	0.00	0.095
Engdo	0.00	0.00	0.00	3.27	6.30
Potato	0.00	0.5	6.00	3.83	7.095
Noug	0.087	0.00	2.82	0.125	0.142
Bean	0.065	2.83	0.0147	0.72	0.23
Banana	0.36	0.0005	0.00	0.00	0.00
Cabage	0.00	0.78	0.00	0.16	0.00
Onion	0.00	0.00	0.00	0.055	0.00

1 quintal = 100 kg

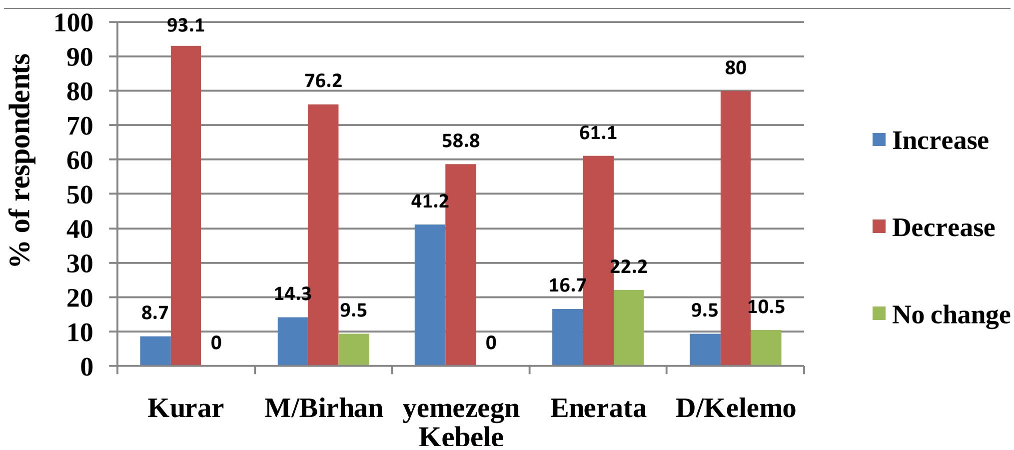

Figure 4. A change in land productivity across kebeles.

discussants from D/kelemo, land degradation before this time occur during June, July and August; where these months are highly rainy and flood occur and leads to soil erosion. However now a day, it continues up to October and December which is a harvest time and reduce crop productivity. This is due to climate variability and extreme weather events like flooding. Population growth has also led to a high level of fragmentation of land in the study area. Hence, acquiring a relatively large tract or tracts of land for farming is a difficult task thereby size of land degraded. When farm land is fragmented to their family, then piece of land will be more vulnerable to other extreme weather events like flooding. The result from Focus Group Discussion, Key Informant Interview and Field observation also strengthen the change happened to land holding size across sampled kebeles, which are very pronetoland degradationinveterateby fragmentation.

On the other hand, those who got additional land mainly benefited from farming mountainous and hill lands (83.3%) and clearing land for farming or deforestation (33.3%). Recent land reallocation by government and a few households from purchasing land as well as from renting land through share cropping arrangements are also means of increasing land size according to focus group discussants. 15% of total sample households reveal, the size of land holding is constant. This may be partly explained by the fact that the size of the holdings is small and already below the optimal. This fact holds true for Enerata, Yemezegn and D/kelemo respectively even if the percentage is very small.

The farmers were also asked to identify the general topography and fertility status of their farm plots. Because, topography and fertility status of farm plot are

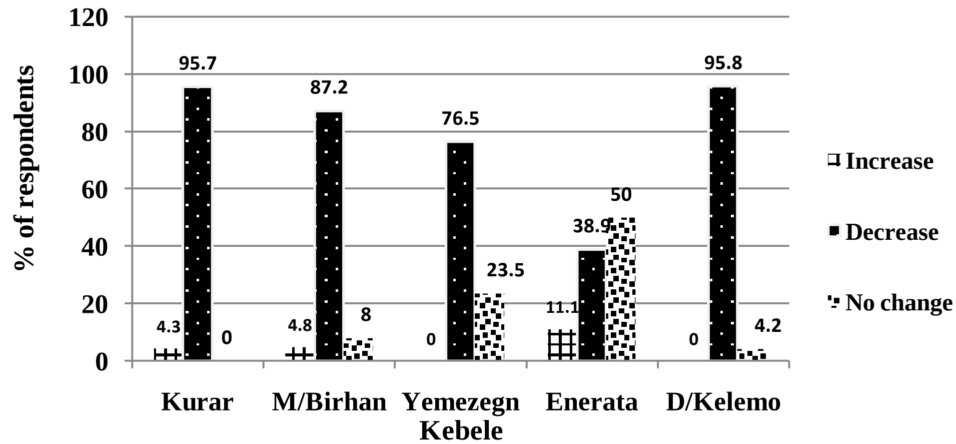

Figure 5.A change that has happened to the size of farmers' land holdings starting from they produce in their land.

Table 5. Topography of cultivated land by a sample household and food security status.

Kebele	Plain		Hilly		Highly sloppy		Mountainous	
	No.	%	No.	%	No.	%	No.	%
Kurar	0	0.0	18	78.3	5	21.7	0	0.0
M/Birhan	20	95.2	1	4.8	0	0.0	0	0.0
Yemezegn	15	88.2	2	11.8	0	0.0	0	0.0
Enerata	3	16.7	8	44.4	5	27.8	2	11.1
D/Kelemo	1	4.8	18	85.7	2	9.5	0	0.0
Total	39	39.0	47	47.0	12	12.0	2	2.0
FS	28	63.6	13	29.5	3	6.8	0	0.0
FIS	11	19.6	34	60.7	9	16.1	2	3.6
X^2	20.65**							

*, **, *** The coefficient are statically significant at 1%, 5 and 1% respectively; FIS = Food insecured household, FS = Food secured household.

determining factor of agricultural productivity and food security status of households. Households from lowland and valley fragmented (Kurar) and hilly and mountainous highland (D/Kelemo) reveal that topography of their cultivated land is hilly and sloppy with mountainous land and not fertile and somewhat fertile with regard to soil fertility status (Table 5). This type of topography and low fertility status of soil is not suitable for agricultural activity and then cause for food in security. Plain level of cultivated land and fertile soil with minimal soil erosion and other degradation problem characterize M/Birhan and YemezegnEnerata is prone to moderate soil erosion and associated degradation.

As the result show, there is a statistical systematic difference between food security status and topography of cultivated land. Food secured households have more of plain land with small proportion of hilly, highly sloppy and mountainous whereas sloppy hilly mountainous slop of land dominate food insecuredkebeles. Eshetu's(2000) work also shows that food has a negative and significant impact on per capita food kilocalorie availability and farmers residing in mid altitude areas are a better position than those residing in high altitude areas regarding per capita food kilocalorie availability.

Food security status of sample household is also determined by fertility status of cultivated land and there is s statistical difference between fertility status of cultivated land and food security status of sample households (*X^2=6.889, P<0.05*).

Analysis of climate change

To see the long term temperature and rainfall change, data were collected from National Meteorological Service Agency for sample kebele. However, the problem in Ethiopia is that, all stations do not have data as required by the study. But the researcher has tried to take data

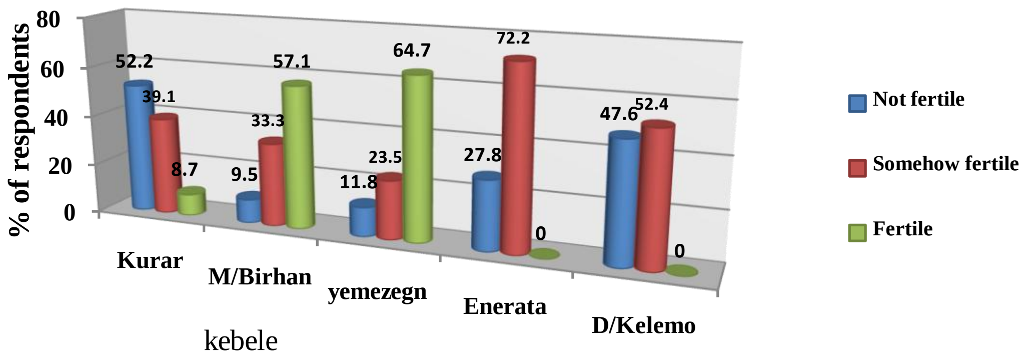

Figure 6. Fertility status of farm land by sample Kebele.

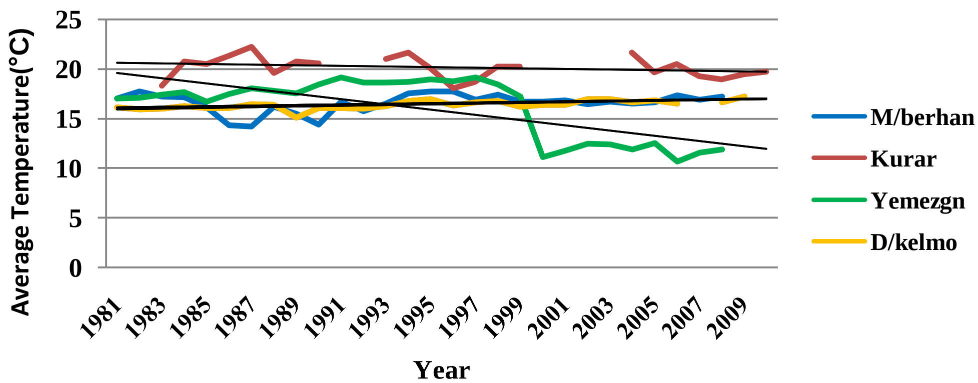

Figure 7. Average temperature trend (1981-2008).

from the nearby distance of the study area. The temperature data of Enerata and D/Kelemo was taken from DebreMarkos whereas both the temperature and rainfall data of M/Birhan was taken from Debre Work.

There is a change in average temperature in all sample kebeles (Figure6). Except Kurar, temperature trend in all kebeles from 1981 to 2008 shows increases. Above all, temperature in Yemezegn shows an increasing trend as compared to other kebeles. However, in Kurar the graph shows decrease in temperature by 0.78°C. This is due to the fact that, Kurar is located in Abay Gorge and the temperature condition of the area could be determined by other factors.

On the other hand, annual rainfall trend shows, there is a variability and in some cases increase from 1981 to 2008 in all areas (except M/Birhan) even if increase by small amount. However, as the study shows, crop productivity decreases especially in lowland and hilly and mountainous areas. This is because; crop productivity does not only depend on amount of rain fall rained but also on seasonality and variability of rain fall.

According to focus group discussants, the cropping and harvesting time was extended due to rain fall variability. For example in the previous time, cropping time for maize was starting from at the end of April and beginning of May and October as a harvesting time. Whereas now a day cropping time is extended up to June and during harvesting time rain failed which damage crop productivity.

Cause of seasonal food shortage

The designing of the main instrument for the inquiry on why farm households were unable to produce adequate food at home was largely based on household survey and focus group discussion. There are different constraints that hinder agricultural productivity and then induce food insecurity. Not all constraints have equal magnitude of influence on each household and in each AES. Hence, in order to identify the impact of the main perceived cause of food shortage, sample households were asked to respond to each constraint according to their severity to identify and prioritize agricultural problems, which had back the production and the growth of productivity.

The household's rated erraticrainfall,dependencyon single harvest, drought and land degradation as most influential of all study area. From the household survey of total sample households, 98% of respondents reveal

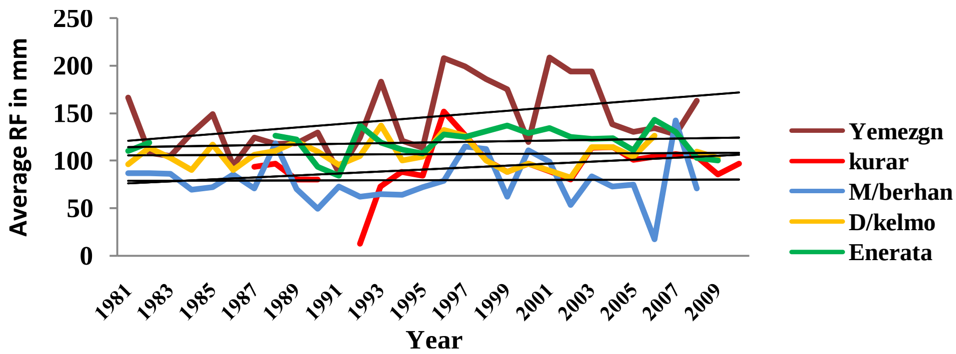

Figure 8. Trends of annual rainfall for sample kebeles (1981-2008).

that erratic rainfall is both severe and more severe leading reducing productivity and then shortage of food. One key informant interviewee from Enerata stated that, 'rain does not come as it formerly used to, rains these days do not fall at the appropriate time; previously started at the end of February and March at all but now it goes up to June; and the weather is now hotter than in the past'. Woldeamlak (2009) also stated that, virtually all food crop agriculture in Ethiopia depends on rainfall that is frequently erratic and unpredictable.

Dependency on only a single harvest affects production in the study area. 44 and 34% of sample households were responding that dependency on single harvest affect food production severely and more severely respectively.

From the entire households 77% of households' response that land degradation is more severe (30%) and sever (47%) impact on food production through hindering agricultural productivity. At a *kebele* level, Kurar and D/Kelemo are highly affected by land degradation which leads to soil erosion and then leaching of soil fertility which is not productive. None of the respondents from these two kebele responded the effect of land degradation as nil rather all of them are included in more severe, severe and moderately. Although land degradation is also a problem for producing food in M/Birhan, Yemezegn and Enerata, the degree of their severity is much differs from Kurar and D/Kelemo (Appendix A).

About 71% of total sample households reflected that, drought is a major cause for food shortage severely and more severely. For more than three decades, Ethiopia has experienced recurrently deadly droughts including those of the 1972/3, 1984% and 2002/03. Drought has a long term effects in reducing the economic base of households, thereby leading to chronic and acute food insecurity. Household's vulnerability to food insecurity increase during protracted drought through progressive depletion of food stocks and capital assets (Markos, 1997).

The farmers felt that insect pests and weeds negatively affected agricultural production and were rated as the most important problem following erratic rain fall, dependency on a single harvest, drought and land degradation. Insect pest and weeds were perceived as a major cause of household food security because they lowered the productive potential of domestic production. 68% of the total sample households explained that pest and weeds infestation as more severely and severely. As compared to the other kebeles', Yemezegn is highly affected by insect pests and weed infestation. As it is shown in Appendix A, sample households from this kebele were 17 and all respondents were failed with severe (n=9) and more sever (8%). According to focus group discussants, this insect pest and weed infestation occur due to climate change particularly drought and they reflect that before this time the temperature was normal but now a day temperature increase from time to time and become cause for insect pest and weed infestation which leads to degradation of productivity.

The opportunity to diversify cash income through employment in off farm or non- farm activities appear very limited in Choke Mountain Agroecosystem. Lack of cash impacts not only farmer's livelihoods, but also directly reflects a lack of capacity to modernize agricultural systems which in turn impact negatively on households food security. The lack of cash among farmers results in the inability to purchase farm inputs and a limited scope to innovate outdated and overused farm implements. Consequently, both labor and land productivity was low. Some of sample households attributed poor productivity and food shortage to the inability to purchase and properly apply modern farm inputs and to unproductive traditional practices.

Access to farm credit could compensate for small farmer's cash deficiencies. However, some of the respondents indicated that no such support was provided by the government or government partners. Agricultural extension services were weak due to low resources and poor commitment by the ministry of agriculture towards strengthening the extension services. Shortageoflabor was also indicated as a constraint affecting agricultural production and food security. Postharvest grain loss due to poor storage structures were indicated as one of the constraint to household food security. Considering the already low production, the poor postharvest handling further affected household food security through diminishing the amount of available food from domestic production.

In addition to household survey, different constraints for household food security were explained households during focus group discussion in each kebele. Health problems were as one important cause of food shortage through constraining agricultural production. Malaria was identified as the main diseases affecting production especially in Kurar through loss of labor for farm operation. The outbreak of an epidemic during critical agricultural operations such as cultivation, weeding and harvesting adversely affected agricultural productivity. Lack of draught animals greatly affects livelihoods presented by group of households during focus group discussion. Farmers with no draught animals cannot prepare their farmlands in a proper manner. They had either to rent out their land to others farmers with adequate draught power or rent draught animals. This is in both circumstances, farmers' loss some of their produce through shares or income, which diversely affects household food security. Other studies such as Tilaye (2004) in Gera Keya woreda in Amhara region also shows the same result for cause of food shortage. Thus, it is possible to conclude that food security will depend not only on climate and socio-economic impacts on food production, but also (and critically so) on economic growth, changes to trade flows, stocks, and food aid policy.

Conclusion

The study revealed that the majority households living in different agro ecological system perceived they are food insecured. The study result also shows that the majority faced food shortage for above 2 months per annum and they do not had food they preferred. The study confirmed that Food security status of sample household is determined by fertility status of cultivated land and there is statistical difference between fertility status of cultivated land and food security status of sample households. The result of Household Food Balance Model (HFBM) also shown that households failed to supply their daily minimum requirement according to national standard which is 2100 Kcal/adul.equ.Additionally, Food Grain Market balance for the household shown that food secured household has statistically greater average net energy supply for the market in terms of grain energy than the food insecured groups. The study result shows that there is a statistical systematic difference between food security status and topography of cultivated land. Food secured households have more of plain land with small proportion of hilly, highly sloppy and mountainous whereas sloppy hilly mountainous slop of land dominate food insecuredkebeles. Additionally, the study confirmed that change in size of farm land, slope of farm land and their productivity with fertility status of land determine the type and amount of crops produced in the study area owing to climate change and extreme weather events like drought and flood. The trends of average temperature and rainfall in sampled agro ecosystem shows that there is clear change which affected cropping and harvesting time as well as amount of crop produced. Climate change determine the type of crops produced that farmers face problems to make decisions about the type of crops produced in the coming season and the amount of production in different ways. The study result shows that climate change determined decision of sample households about crops produced. The study also revealed that land degradation, dependency on single harvest, drought, low and variable rain fall pattern (erratic rainfall), lack of access to farm credit, opportunity to diversify cash income and insect pest were responsible for decrement of their farm land productivity which in turn leads household food insecurity.

Conflict of Interest

The authors have not declared any conflict of interest.

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Appendix A. Frequency distribution for factors causing seasonal food shortage.

Cause	Number of respondents																			
	Kurar				M/Birhan				Yemezegn				Enerata				D/Kelemo			
	Nil	Moderate	Severe	More severe	Nil	Moderate	Severe	More severe	Nil	Moderate	Severe	More severe	Nil	Moderate	Severe	More severe	Nil	Moderate	Severe	More severe
Drought	0	1	5	17	1	7	5	8	2	1	9	5	2	4	10	2	4	7	6	4
Erratic rain fall	0	0	2	21	0	1	6	13	0	1	1	15	0	0	8	10	0	0	9	12
Shortage of labor	4	13	6	0	12	2	6	0	6	2	9	0	10	8	0	0	3	8	9	1
Lack of farming implement	0	3	11	9	18	2	1	0	17	0	0	0	0	8	5	5	0	6	6	9
Lack of agricultural credit service	0	7	5	11	13	6	1	1	13	2	2	0	7	6	3	1	0	5	7	9
Land degradation	0	2	7	14	2	6	9	4	5	3	8	1	1	1	12	4	0	3	11	7
Dependence on single harvest	0	0	7	16	0	2	8	13	1	3	7	6	0	7	5	6	0	5	7	9
Weed infestation	2	3	11	7	3	6	10	2	0	0	9	8	0	7	10	1	3	8	7	3
Lack of cash income	0	2	15	6	10	4	4	3	7	4	2	4	2	7	4	5	0	9	7	5
Post harvest loss	4	12	6	1	7	5	6	3	14	0	1	2	13	5	0	0	16	5	0	0

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