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The Contribution of Improved Farming Technologies on Household Food Security

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ABSTRACT

Food security is a major global concern since food is the most basic human need and access to food is a fundamental human right. The right to food is contained in the universal declaration of human rights that was adopted in 1948 by the general assembly and reaffirmed by the World Food Summit and the Food and Agricultural Organization of the UN in 1996. To show their solidarity over poverty and hunger issues, nations under the umbrella of the United Nation (UN) targets to halve by the year 2015 the proportion of people who are hungry. Tackling food insecurity problem on a global level poses critical dynamic challenges. Every country has its own individual dimensions adding to the overall food crisis in farming areas. Due to unprecedented subsidies given to farmers in terms of seeds and fertilizers, they are easily enticed to use larger portion of their land for cultivation of food. Consequently, farmers have to either spend more on buying food or reduce their food consumption, which subject their families to malnourishment and starvation. In other words, low level of investment practiced by poor small scale farmers do not attract economies of scales but makes them remain in constant debts and this incapacitates households' ability to afford adequate food. Farmers being trapped in a debt cycle provide them no option but to keep cultivating this crop irrespective of the long-term, veiled hazardous consequences and questionable economic gains. The power of technological solutions to solve poverty problems currently witnessed in Kenya is installed by the myriad of institutional and supply policies. Moreover, with a better policy environment, investment in rural infrastructure and transport network can bring down input costs considerably by reducing one of the major supply constraints to adoption. Considerable adaptive research, stronger and decentralized research-extension farmer linkage is required to increase the speed with which farmers apply the viable technologies. The best judges of agricultural technology are the end users-the farmers and involving them in technology use is critical to the success of research investment programs for increased sustainable production to alleviate the persistent food insecurity in Kenya.

Introduction

According to the World Bank (1996) Ensuring food security is one of the greatest challenges facing the world farmers. The challenge is most critical in low-income, food-deficit countries of Sub-Saharan Africa where an estimated 70% of the population comprises of resource-poor farmers living on small family gardens where soils have over the years become impoverished, in environments that are prone to drought, soil erosion and epidemics of pests and diseases. Addressing these constraints to crop productivity is a monumental challenge that warrants, among other things, technological interventions requiring use of new intensive production technologies to increase yields and reduce losses including adoption of genetically modified crops (world Bank, 1996) National and regional institutions in Africa in collaboration with their international partners are responding to these challenges and establishing innovative approaches to addressing Africa's agricultural malaise.

The major challenges facing Kenya today are poverty and unemployment. About 50% of the rural population and 30% of the urban population live below the poverty line. With 80% of the population being rural the poverty problem is overwhelming (Waithaka, M.M, 1996) the country has been unable to generate adequate employment and wage employment has been declining over the recent past. While in the 1970s the growth rate of employment was about 4% per annum, in the current decade, the growth rate has been about 1.9% per annum, which is below the population growth rate estimated at about 3%. The country has also witnessed declining growth in income per capita. While in the 1960s per capita income grew at 2.6% p.a. this declined to 0.4% in 1980s. Between 1990 and 95 the decline was even more dramatic at negative 0.3% (Kenya, 1997). The poverty line is defined here as the value of consumption of food and non-food items below which individuals cannot afford the recommended energy intake plus a minimum allowance for non-food consumption. The poverty line has been estimated at about US$ 200 and 300 for rural and urban areas respectively (GoK, 1998). This translates to less than one US$ per day.

The past decades have witnessed a dramatic change in agriculture with food production (FAO, 2008). Decreasing hunger requires farmers' access to productivity; enhancing inputs, knowledge and skills. However the majority of the hungry are smallholder farmers in developing countries who practice subsistence agriculture on marginal soils, lack access to inputs and product markets. One such innovation is the African Agricultural Technology Foundation. Harwood, R. 1979 posits

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that it is an African led and managed organization, focused on African priorities and interests in technology transfer and agribusiness development. Although agricultural growth in Africa demands attention to various economic, environmental and policy challenges, it is recognized that new technology is an indispensable part of the solution. Such technologies can help provide better harvests to improve household nutrition and well-being, reduce households' susceptibility to risks of pests, diseases and climate, provide additional cash income, contribute to a diversifying rural economy, contribute to overall economic growth and address problems of environmental degradation(Harwood, R. 1978.

Until recently, Africa, and indeed much of the rest of the world, depended on public organizations to develop and deliver agricultural technology (World Bank, 1996) in the past few decades the private sector has begun to play an increasingly important role in technology development worldwide, complementing public research efforts. This evolution in research direction, combined with the fact that the private sector is usually more efficient at producing and delivering technologies, helps explain the growing importance of proprietary technology, developed by both the private and public sectors. In most industrialized countries the development and delivery of proprietary technology is facilitated by a number of commercial and legal institutions. Africa's experience in these areas is not yet well established, and private agribusiness and input delivery have relatively less experience. But there are many proprietary technologies developed elsewhere that can make significant contributions to increasing Africa's agricultural productivity and improving rural livelihoods. In many cases, the owners of such technologies are willing to contribute them for agricultural development in Africa. The challenge is to access these proprietary technologies and manage their deployment until they reach smallholder farmers (KARI, 1994)

Donovan, W.G (1995) observes that the agriculture sector dominates the economy and contributes virtually to all the stated national goals including achievement of national and household food security, industrialization by year 2020 as well as provision of employment opportunities. Currently, agriculture accounts for about one-third of the gross domestic product, employs more than two-thirds of the labour force, accounts for almost 70% of the export earnings (excluding refined petroleum), generates the bulk of the country's food requirements and provides significant proportion of raw materials for the agricultural based industrial sector. Overall, the smallholder sub-sector contributes about 75% of the total value of agricultural output, 55% of the marketed agricultural output and provides just over 85% of the total employment in agriculture (Fisher, M. 1995)

The sector's ability to contribute effectively to the national goals hinges on identifying and implementing measures which promote high and sustainable growth rate. Ndubi, J. (1997) asserted that agricultural productivity growth is normally the major source of sustained improvements in rural welfare. Three sources of agricultural growth can be identified in Kenya. One is the expansion of cultivated area. The second is substitution or switching towards higher valued commodities. The third is intensification. Ndiritu, C.G (1994) argues that the first source of agricultural growth is currently extremely limited. The cultivable land available to open up has diminished over the years with rapidly rising population estimated at about 3% per annum to the extent that the land holdings are becoming sub-optimal economic units and there is ever increasing temptation to migrate to the marginal and fragile zone. Moreover, irrigation development which could help in increasing cultivable land has been very slow due to the seemingly high cost associated with it.

Mulagoli, I.J.W (1999) observes that the Commodity substitution will contribute significantly to growth only if the input and output markets function in a way to allow the producers and the private sectors respond appropriately to the market signals. This is expected to occur if the on-going structural adjustment programmes succeed in limiting government intervention to its core functions (of public good nature) and allowing the private sector to take up the production, marketing and distribution role. Most agricultural growth will therefore come from the third source: increased output per unit land area. The realization of this growth potential will hinge on shifting rapidly from resource based to science and knowledge-based agriculture.

World Bank (1996) posits that Technological change has been the major driving force for increasing agricultural productivity and promoting agriculture development in all OECD countries. In the past, the choice of technologies and their adoption was to increase production, productivity and farm incomes. Over many decades, policies for agriculture, trade, research and development, education, training and advice have been strong influences on the choice of technology, the level of agricultural production and farm practices (Saito, A.K 1994) Agriculture is becoming more integrated in the ago-food chain and the global market, while environmental, food safety and quality, and animal welfare regulations are also increasingly impacting on the sector. It is faced with new challenges to meet growing demands for food, to be internationally competitive and to produce agricultural products of high quality.

The purpose of the study

The Paucity of literature on differentiated technology and its implications for increased food production is an acknowledged fact (Fisher, M. 1995). Considering the inter causal relationships that exist in all spheres of farm operations, it is surprising that planners, policy makers, implementers and scholars have either focused on the role of technology in agricultural activities and ensuring food security, without considering both simultaneously. The apparent failure of this approach has prompted scholars such as Kariuki J.N & waithaka M.M (1992) to focus on technological innovations and farming. However, the focus on farmers. They will have an effect on and be affected by changes in these systems (KARI, 1994). Furthermore, these interrelationships are reinforced by agricultural production practices and use of technology. The decisions to purchase and use particular farm equipment, fertilizer, pesticide, storage facilities or going to farm demonstrations, farmers training centres and receive extension services, may already be of better use in the household.

Recent decades have seen a shifting of focus from either subsistence farming to the analysis of the technological use as a determining factor in the adoption and utilization of agricultural technology. However, this literature has largely been general and theoretical, without providing case studies, which reveal the interactive mechanisms that result in the allocation and use of technology (see Githari, J.N, Kanampiu & F.M Murithi, 1996). This has obscured the vital role played in determining the effective adoption and utilization of agricultural technology and its implications for increased food production and improved food security.

Literature review

Today, farmers, advisors and policy makers are faced with complex choices. They are faced with a wide range of technologies that are either available or under development; they must deal with the uncertainties of both the effects these new technologies will have throughout the agri-food chain and the impact that a whole range of policies will have on the sustainability of farming systems. In addition, there is increasing pressure on agricultural research and advisory budgets that must be accommodated (Sands, D. 1986) the focus of the adoption of technologies that have the potential to contribute to sustainable farming systems. Technology adoption, however, is a broad concept. It is affected by the development, dissemination and application at the farm level of existing and new biological, chemical and mechanical techniques, all of which are encompassed in farm capital and other inputs; it is also affected by education, training, advice and information which form the basis of farmers' knowledge. It also includes technologies and practices in the whole agri-food sector that have an impact at the farm level. It should be borne in mind that most of these new technologies originate outside the farm sector (Saito, A.K, 1994)

According to Kimenye, C.M (1997) observes that the concept of a sustainable farming system refers to the capacity of agriculture over time to contribute to overall welfare by providing sufficient food and other goods and services in ways that are economically efficient and profitable, socially responsible, while also improving environmental quality. It is a concept that can have different implications in terms of appropriate technologies whether it is viewed at the farm level, at the agri-food sector level, or in the context of the overall domestic or global economy.

Agriculture has gone through major changes during the late century. It has developed from more or less extensive subsistence farming to intensive agricultural production that is highly dependent on pesticides and chemical fertilizers. It holds the key in maintaining the country's food security, alleviation of poverty, and survival of the existing and future population. The staggering increase in the use of synthetic farm chemicals in the past few decades have not resulted in a similar increase in crop yields, instead it affects substantial environmental damages to the country's water and soil resources. FAO (2008) reported that the application of synthetic fertilizers in the country from 1961 to 2005 had increased by 1000%, but the yields of rice and maize had increased only by 200 and 280%, respectively. Similarly, the use of pesticide had increased by 325% from 1977 to 1987, but rice yield had increased only by 30%. Resource generation and conservation are now considered important goals, given the concern for long-term sustainability. It is therefore important to preserve this local knowledge of farmers before they may be lost forever (FAO, 2008)

Dairy Farming technologies used for animal status monitoring and management continues to grow. Despite widespread availability, adoption of these technologies in the dairy industry has been relatively sparse thus far (Kimenye, C.M. 1997). Perceived economic returns from investing in a new technology are always a factor influencing technology adoption. Additional factors impacting technology adoption include degree of impact on resources used in the production process, level of management needed to implement the technology, risk associated with the technology, institutional constraints, producer goals and motivations, and having an interest in a specific technology (Hassan, R. M eds. 1998). Characteristics of the primary decision maker that influence technology adoption include age, level of formal education, learning style, goals, farm size, business complexity, increased tenancy, perceptions of risk, type of production, ownership of a non-farm business, innovativeness in production, average expenditure on information, and use of the technology by peers and other family members. Research regarding adoption of Precision Dairy Farming technologies is limited.

Jaelzold, R. & G. Osacarsson (1994) observes that dairy farming involves the use of technologies to measure physiological, behavioral, and production indicators on individual animals. The primary goals of precision dairy farming are to maximize individual animal performance, detect diseases early, and minimize the use of medication through preventive health measures. Examples of precision dairy farming technologies include milk yield recording systems, milk component monitors, activity monitors, lying and rumination behavior monitors, milk conductivity indicators, and heat detection monitors. The individual animal information these technologies collect supplements observations of the herd's people and others and improves animal monitoring and decision-making.

Waithaka, M.M (1996) posits that the adoption of precision dairy farming technologies has been slow thus far, likely because of unfamiliarity with available technologies, concerns with benefit relative to cost, apprehension of technology, difficulties learning or implementing the technology, and previous bad experiences with technologies. However, some producers realize the opportunities precision dairy farming may provide for reducing farm labor and allowing more personal time. Technologies may benefit small farms as well as large farms because they allow the small farmer to specialize in an area where time management demands often become limiting. In addition to personal benefits, potential exists for increased efficiency, reduced costs, improved milk quality, reduced environmental impact, and improved animal health and well-being.

The technology within production agriculture has changed very rapidly during the past several years. Many of these changes have brought about a new technology category known as precision agriculture or precision farming. Precision farming (PF) uses "information technologies to tailor soil and crop management to fit the specific conditions found within a field" (GOK, 1998). A report by The National Research Council (1997, p.2) refers to precision agriculture, "…as a management strategy that uses information technologies to bring data from multiple sources to bear on decisions associated with crop production." Precision farming or precision agriculture differs from many previous technologies within agriculture. PF is comprised of numerous component technologies that farmers may adopt as a system. Thus, some farmers may adopt a few components while others may adopt several. PF component technologies include yield monitors, geo-reference grid soil sampling, georeferenced variable rate technology for lime, fertilizer, and pesticide application, global positioning systems (GPS), and detailed field maps created from geographic information systems (GIS), to name just a few (Fisher, M. 1995)

The use of new precision farming technology (PFT) allows growers to micromanage individual grids or management zones in a specific field according to its unique production capabilities. The ability to micro-manage individual grids, zones, or fields is referred to as site-specific farming. Site-specific farming (SSF) is defined as "the time proven idea of crop management: doing the right thing, at the right time, in the right place" (Beynon, J. Akroyds Duncan, A Jones, 1998).

Precision farming technology is designed to provide extensive information and data to assist farmers when making site-specific management decisions. By making more informed and better management decisions, farmers can become more efficient, lower production costs, and, in turn, become more profitable. However, little is currently known about how farmers use PF technologies to make management decisions or identify production problems, or about the relative magnitude of benefits and costs of PF technologies on individual farms. Therefore, research of precision farming technology is needed to assist the agricultural farmers in finding answers to questions surrounding the adoption, uses, and the potential management benefits of precision farming technology (FAO, 2008)

Farming Technologies which can be adopted by farmers

Maize Seed and Fertilizer Technology

Given its importance, the government initiated a maize improvement research program as early as 1955 at Kitale, the centre of high potential maize production area in Kenya (Lynam and Hassan, 1998). Research at Kitale focused on developing late maturity hybrids for the highland areas where typically rainfall is confined to one long season. After 1957, Katumani and Embu research programs were established to cater for semi-arid mid-altitude and moist mid-altitude areas while the Mtwapa program concentrated research on lowland, coastal agricultural zones1. By 1975 ten hybrid maize and three composites had been released and a significant number had adopted this first generation of improved maize material (Gerhard, 1975). Large-scale farmers located in the high-potential areas appeared to be the early adopters of the package and by 1974 almost half of them used the new maize varieties. Small-scale farmers in the relatively marginal areas were the slowest to adopt the technology package with only 16% of the farmers adopting the new varieties by 1984. Although adoption of inorganic fertilizer followed closely on the adoption of improved seed in the large farm sector, it appears the smallholder adoption of fertilizer lagged substantially behind their adoption of improved varieties and remained virtually negligible in marginal areas. Small-scale producers seem to prefer a maize variety that is early maturing, high yielding, does not lodge easily and that yield large quantities of stover for feeding livestock and mulching, attributes that most of the above hybrids meet.

Artificial Insemination

Temperate dairy cattle perform better than the indigenous Zebu cattle in the tropical highlands. As the human population increased in the highlands and land size decreases, it becomes prudent to adopt technologies that would enable efficient utilization of the scarce resources. AI technology involves the identification of the very top genetic potential bulls. These are kept in central stations and semen continually collected, assessed, diluted, packed in straws and preserved in liquid nitrogen at low temperatures. When needed, each straw of semen can be used to artificially inseminate a cow that is on heat. One superior bull once identified can potentially sire thousands of offspring in different herds each year. The genetic superiority of one individual is therefore quickly spread become beneficial to many farmers than would otherwise be possible with natural mating (KARI, 1994)

Improved livestock seed-stock technologies

The economic viability and of a livestock enterprise depends on among other factors the genetic potential of that given germplasm to respond to improved husbandry (good feeding, housing and health care). The germplasm, and particularly its genetic potential in itself and when considered as a resources can impede increases in productivity. For example, in cases where land is limited and labour is constraining, keeping a cow that has low genetic potential for milk production would be uneconomical (Kimenye, C.M 1997) the well being of the keeper of such a cow would not be guaranteed. In such instances, development and wide adoption of germplasm that have higher genetic potential for say milk, meat, egg production has been undertaken in Kenya with the aim of achieving higher productivity and consequently alleviation of poverty among the livestock farmers. Upgrading of indigenous cattle breeds towards the exotic dairy breeds has been done through the use of artificial insemination (AI) technology (Kimenye, C.M 1997)

Improved small scale dairy technology package

Zero grazing is animal management exclusively under confinement. It started to gain relative importance from the late 70s mainly due to the rising land pressure. It is the most intensive milk production system and is implemented by more than 20,000 smallholders all over the country. The system is characterised by keeping high yielding grade cattle like Ayrshire, Friesians and their crosses. This system differs from semi-grazing by the absence of pastures, heavy dependence on cultivated Napier grass and high use of purchased inputs. Milk yields per cow per year, in zero grazing farms average 3,300 kg, 2,340 kg in semi-grazing farms and 1,800 kg in open grazing systems (Egerton University, 1990). The cattle are permanently kept in a cow shed, where they are fed, milked and also sleep. Zero grazing farmers are predominantly market producers with from 1 to 5 cows. Their main interest being milk production, the male calves are sold at an early age. Heifer calves are kept in calf pens from where they are bucket fed with whole milk and some concentrates before they are weaned from 3 to 6 months. After weaning, heifers are kept with the cows. On most farms, cattle are sprayed once a week to control tick-borne diseases and drenching to control internal parasites is done routinely.

The main feed under zero grazing system is Napier grass (Pennisetum purpureum), a perennial fodder grass. It is the most popular fodder crop since under normal rainfall conditions, it is ready for harvest 4 weeks after cutting and on it alone, a cow can produce up to 7 litres of milk per day (Kariuki and Waithaka, 1992). However, Napier grass is prone to frost damage in the high altitude areas, cannot withstand very long dry periods as experienced in the low altitude areas and cannot withstand direct grazing. Napier grass has to be cut from the fields and carried to the cows and is chopped to reduce wastage through spilling and trampling. Other feeds include farm by-products which are in season, e.g., maize stover and vegetables as well as commercial concentrates and mineral supplements

Research-Extension Linkage

Increased investment in agricultural research is advocated for developing countries to facilitate growth if the resulting technologies are viable and adopted. Kenya has done relatively well in investment in research compared with most of the other sub-Saharan countries. Expenditure in public sector agricultural research in many of the countries are found to be less than 0.5% of the agricultural gross domestic product (AGDP), while it is recommended that it should be at least 1% given that in high income countries, it is about 2% (Ndiritu, 1994).

In sub-Saharan Africa, more than 70 percent of the poor live in rural areas. The rural poor are very dependent on their natural resource base, particularly soil and its productive capacity. The main physical asset of poor farmers is land. Its contribution to farmer’s income is far more important than physical capital. Yet, land degradation in the form of soil erosion and nutrient depletion pose a threat to food security and sustainability of agricultural production, particularly in less favored dry-land areas. In Kenya, the magnitude of soil erosion losses to the economy has been estimated as equivalent to US$ 390 million annually or 3.8 percent of gross domestic product (Donovan, W.G 1995). In response government and development partners have devoted substantial resources to improve environmental conditions and increase agricultural productivity.

In particular, the use of modern farm technology—such as soil and water conservation technologies (SWC) and fertilizer—that would enable farmers to increase their productivity while conserving the soil capital has been emphasized as a possible solution (World Bank 2008). However, adoption of modern technology has been limited in most of sub-Saharan Africa. This is particularly the case in Kenya, where small-scale agriculture remains characterized by little use of external inputs, soil erosion, and high nutrient depletion. The government has initiated extension worker programs to promote the adoption of improved technology.

Despite these concerted efforts by government and development partners, the adoption rate of improved farm technology remains disappointingly low. Many questions about the determinants of farm technology adoption remain unclear. Previous research has been devoted on individual and plot characteristics. (Gitari, J.N, Kanampiu & F.M Murithi, 1996) Other recent studies haveexplored the role of social factors on technology adoption (FAO, 2008). A key element missing from the research is lack of empirical analysis on the role of risk in investing in technology and production effects among low-income farmers. Production risk is an important element in agricultural production decisions, particularly in the uptake of farm technology. If poor people are risk averse, they will be reluctant to invest in modern technology because that involves taking risks; thus, they will remain poor in absence of mechanisms to minimize the downside effects (KARI, 1994). For risk-averse individuals, an increase in variance with enormous downside risk may make the individual worse off. Only economically secure farmers who are in possession of sufficient defense against downside risk will undertake profitable capital investments and innovations, while the majority of the poor remains caught in a risk-induced poverty trap (World Bank 1996).

Conclusion

The paper concludes that despite the significant role that technology plays, the uptake of technological production decision is slow which affects food security, empirical literature looking into the role of technology in increasing production on farm investment decisions in low income rain-fed agriculture is scanty. Notable exceptions are the works of Alders, C., B. Haverkort ad L. Van Veldhuizen (2009) With the exception of Lynam, J. and R.M. Hassan (1998), agricultural technology is affected by the development, dissemination and application at the farm level of existing and new biological, chemical and mechanical techniques, all of which are encompassed in farm capital and other inputs and it is also affected by education, training, advice and information which form the basis of farmers' knowledge. It also includes technologies and practices in the whole agri-food sector that have an impact at the farm level which contributes to food security.

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