Journal of Economics and Sustainable Development
ISSN 2222-1700 (Paper) ISSN 2222-2855 (Online)
Vol.7, No.8, 2016
www.iiste.org

Analysis of Quality Control in the Informal Seed Sector: Case of Smallholder Bean Farmers in Bondo Sub-County, Kenya

Wilfred Odhiambo[1*] Margaret Ngigi[1] Job Lagat[1] Hans Peter Binswanger[2]
Jean Claude Rubyogo[3]
1. Department of Agricultural Economics & Business Management, Egerton University, P.O. Box
erton, Kenya
2. Institute for Economic Research on Innovation, Tshwane University of Technology, Tshwane, 44 Kingfisher Crescent, Willow Acres Tshwane 0095, South Africa
3. International Center for Tropical Agriculture/ Pan Africa Bean Research Alliance, P.O. Box 2704 Arusha, Tanzania

This research is financed by African Economic Research Consortium (AERC) under the Collaborative Masters in Agricultural and Applied Economics (CMAAE) Program.

Abstract
Common bean is the most widely grown and consumed grain legume in Kenya. However, its contribution to nutrition and income has not been fully felt by smallholder farmers in western Kenya due to low yields. Good quality seed, if used with complementary practices can increase bean productivity. This study was conducted in Bondo sub-County to determine the methods used by farmers in seed quality control; factors affecting the choice preferences for informal bean seed sources; and the structure and contribution of social networks in seed quality control. Primary data were collected from 100 respondents through scheduled interviews using structured questionnaires. Excel, SPSS, STATA and UCINET computer packages were used to run data. A multinomial logit model was used to analyse the effects of socio-economic characteristics on the choice of seed sources. Descriptive statistics were used to illustrate the seed quality control methods. The nature of social networks was determined using measures of centrality and brokerage positions and visualized through network graphs. The results showed that farmers use pre-planting, post-planting, harvest and post harvest methods in controlling seed quality; and are influenced by socio-economic characteristics while choosing seed sources in the informal sector. It was determined that social networks exist, and farmers rely mainly on fellow farmers to access bean seed. Therefore, the study suggests policy interventions to design integrated bean seed system with aspects of formal and informal sector to enhance supply of quality seed to smallholder farmers. Preference for certain bean varieties should be used for strategic varietal development. Finally, youth groups should be used as springboards for seed related interventions.
Keywords: Common bean, seed, quality control, smallholder farmers, social networks, western Kenya

1. Introduction

Grain legumes play a crucial role in human diet and economy. In many developing countries, grain legumes are relatively cheap and readily available source of nitrogen-rich edible seeds. They are used to develop a wide diversity of high-protein products and thus, constitute the major source of dietary protein in the diets of the poor with numerous nutritional benefits (Rebello, Greenway and Finley, 2014; Bouchenak and Lamri-Senhadji, 2013; Shi *et al*., 2004; Venn, 2004). As major components of various farming systems, legumes provide residual nitrogen through fixation of atmospheric nitrogen and hence, reduce the needs for mineral nitrogen fertilizers (Dong *et al*., 2003). Common bean (*Phaseolus vulgaris* L.) is the most important grain legume for direct human consumption in the world. It is the most widely grown and consumed grain legume in developing countries. Being a major source of dietary protein, minerals and certain vitamins, this crop plays a significant role in human nutrition (Pflieger *et al*., 2014). Bean per capita consumption in East Africa (50–60kg) (Buruchara *et al*., 2011) is perhaps the highest in the world (Legesse *et al*., 2013). In western Kenya, beans are produced by smallholder farmers mainly for subsistence. These farmers also sell part of their bean produce in the local grain market to meet other household needs. Hence, bean production contributes to economic and food security for these households (PABRA, 2014). Several nutritional benefits can be attributed to consumption of common bean (PABRA, 2014). For instance, incidents of diseases like cancer, diabetes or coronary heart disease can be reduced through regular consumption of common bean (Leterme, 2002). This is because common bean is low in fat and is cholesterol free. Once eaten, beans digest slowly causing low sustained increase in blood sugar. This slow digestion of common bean can also deter resurgence of hunger, reduce frequency of food intake and enhance weight-loss programs (Katungi *et al*., 2009). Despite the numerous benefits and high potential demand for beans, low yields have been realized for this crop in western Kenya. The low yields can be attributed to among other reasons: the use of unimproved bean varieties as well as recycled seed accessed through the informal seed system. The seed production in the informal seed system is integrated in farmers' cropping system and local grain market. Both local landrace and improved varieties (if any) are recycled and farmers keep on selecting preferred traits to advance into the subsequent seasons. Farmers also share seed among themselves and offload the surplus into local grain market. The Crops Act (2013) places beans among schedule one crops. The crops listed under the schedule are presumed to have breeding programs requiring compulsory certification. Therefore, production and commercialization of bean seed is a reserve of legally recognized institutions and seed companies or licensed seed dealers. This implies that legally, bean seed should be accessed by farmers only through the formal seed system. The formal seed delivery system entails defined model (Rubyogo J.C., Sperling L., and Buruchara R., 2010) that leads to certified seeds of released crop varieties. They include germplasm development or breeding; variety release; bulking; distribution and marketing. The system is made up of public and private organizations with specialized roles in supplying seed of improved varieties. It guarantees clear distinction between seed and grain; maintenance of varietal identity and purity. The system ensures optimal physical, physiological and health quality of seed. In this system, marketing of certified seed is regulated. Formal seed system involves seed legislation and seed development. Seed legislation entails: regulations on variety release; quality standards on seed classes as well as quality control and seed certification. Seed development has to do with varietal breeding, testing and release; seed production, multiplication, processing and marketing. Notwithstanding the stringent requirement to have bean seed accessed only through the formal seed system, the informal seed system remains the major source of bean seed. The informal system supplies up to 90% of seed requirement by smallholder farmers (Sperling and McGuire, 2010) – which confirms its dominance in bean seed supply, but raises several questions: (1) what informs farmers' selection of seed source; (2) how do the farmers control seed quality both at source and on-farm?; and (3) how successful are the farmers in controlling seed quality?. The study sought to determine the reasons that underlie farmers' preference for bean seed sources; investigate the methods used by the farmers for seed quality control in informal bean seed sources; as well as determine the nature and contribution of social networks in the informal seed sector.

2. Importance of seed in agricultural production

The prominence of seed as the bearer of most essential features for crop production remains an uncontested fact. For many centuries, crop domestication has been enhanced through the use of seed – consequently informing present day agriculture (Louwaars and Gam, 2009). Seed is the most important agricultural input as well as the basic unit for distribution and maintenance of plant population. It carries the genetic potential of the crop plant – thus, dictates the ultimate productivity of other input such as fertilizer, pesticide and irrigation water, which build the environments that enable the plant to perform (Mugonozza, 2009). Successful stand establishment requires high quality, genetically pure seed that produces rapid, uniform seedling emergence (McDonald, 1998). This is true more so for the smallholder farmers in Sub Saharan Africa (SSA), where agriculture is characterized by much risk and uncertainty (WBG, 2008). Notwithstanding the vital roles of other components of agriculture including markets, credit supply and support institutions; the use of appropriate seed presents a major starting point in crop production (McGuire, 2010). The use of good quality seed of improved and adapted varieties would ensure increased crop production and productivity. This is even more important in SSA, in the view of increasingly decreasing available land for crop production, declining soil fertility, ever growing population and effects of climate change – necessitating promotion and use of good quality seed as a means to intensify food production. The potential benefits from the distribution of good quality seed of improved varieties are enormous. The availability of quality seed of wide range of varieties and crops to the farmers is crucial if food security is to be achieved in SSA. Enhanced productivity, higher harvest index, reduced risks from seed-borne diseases and higher incomes are some of the direct benefits potentially accrued to the farmers (FAO, 2010). Besides its role in production, food security and rural development, seed is a major element in deliberations concerning technology development and dissemination, biodiversity, globalization and equity. Thus, sustainable availability of good quality seed is an important development issue (Louwaars, 2007).

2.1. Seed Quality

Seed quality can be defined in terms of its components including seed health, varietal and physical purity, size, vigor and germination. While the first three components (health, purity and size) may be observed and determined; seed vigor is inherent and has direct influence on germination. Thus, seed vigor constitutes all the intrinsic properties which determine the potential level of activity and performance of seed during germination and seedling emergence (Ellis, 1992). The aspects of performance that may show variations include rate of germination, emergence and seedling growth as well as emergence of seedlings under unfavorable conditions. Hence seed vigor influences crop growth and yield levels. For instance, dry beans are mainly grown by smallholder resource-poor farmers, with minimal or even no use of external inputs such as fertilizers; thus, quality seed of improved bean varieties constitute a set of critical inputs (Rubyogo *et al.,* 2009). Whereas seeds form a small proportion of the total costs of production, they bear premium value characteristics and farmer-desired, sought-after attributes assessed during varieties' selection (Witcombe *et al.,* 2006). Notwithstanding, the crop yield may not be as expected if seed quality is not guaranteed (Trutmann and Kayitare). In the recent past, continued development of seed enhancements has attracted much of research efforts on seed quality. Many of these properties are regularly considered by seed analysts. However, due to advances in computer technology, seed quality tests are now standardized and evaluated (McDonald, 1998). The potential of seed quality to influence crop yield forms the basis of seed certification (Ellis, 1992), especially in the formal seed sector; while informing the efforts by farmers to select appropriate seed based on preferred attributes (Rubyogo et al., 2009).

2.3. Seed Certification

Seed certification is a legally sanctioned system for quality control of seed multiplication and production. The purpose of seed certification is to maintain and make available high quality seed and propagating materials of notified plant varieties (AgriInfo, 2011). The Kenya Plant Health Inspectorate Service (KEPHIS) is a regulatory body established under the State Corporations Act. Seed certification was previously undertaken by the National Seed Institute under the then Ministry of Agriculture that later became the National Seed Quality Control Station (AFSTA, 2010). Seed certification consists of a chain of processes including: (1) an administrative check on the origin of propagating material for the purpose of trueness to purity (genetic purity); (2) field inspection at the time of growing a crop for seed production purpose - the data should be obtained on trueness to varietal purity, isolation of seed crop to prevent crops- pollination, mechanical admixtures and diseases dissemination, objectionable weeds and admixtures; (3) supervision on agricultural operations intercultural operations, harvesting, storage, transport and processing etc. for identity and quality of lots; (4) sample inspection for quality and to maintain genetic purity, a lab test of representative samples drawn by the seed certification agency (SCA) for determining germination percentage, moisture content, weed seed content, admixture and purity; (5) bulk inspection for checking homogeneity of the bulk as compared with the sample inspected and (6) control plot testing, samples drawn from the source seed and the final seed produced can be grown in the field along with standard samples of the variety. Seed certification has five phases including: verification of seed source; inspection of seed crop in the field; supervision at post-harvest stages including processing and packing; seed sampling and analysis; grant of certificate, certification tag, tables and sealing (AgriInfo, 2011). Seed certification is perhaps the distinct feature that underlies the definition of a seed system and differentiates the various categories of seed systems (Tenesi, 2010).

2.2. Seed systems

Seed systems entail a set of dynamic interactions between seed supply and demand, resulting in farm level utilization of seed and thus plant genetic resource; and may also be viewed as a general concept that covers the practice of development, multiplication, processing, storage, distribution, and marketing of seed within a defined geographical location (Loch and Boyce, 2003). Maredia *et al* (1999) view seed system as the entire complex of organizations, individuals and institutions associated with the development, multiplication, processing, storage, distribution and marketing of seed in any country. Thus, seed system is the economic and social mechanism by which farmers' demand for seed and other desirable seed traits are met by various sources of supply (FAO, 2010). Whereas seed systems can be categorized broadly as informal (traditional) and formal (nontraditional) systems (Abebe and Lejialem, 2011; Beshir, 2011), other sub-systems exist, especially within the informal sector (Habte, 2011) including community based seed multiplication schemes, albeit a relatively new system in some countries (Rubyogo *et al.,* 2011). Legal institutions such as variety release procedures, intellectual property rights, certification programs, seed standards, contract laws, and law enforcement enhance the operations and ideals of both formal and informal seed systems, although the stringent enforcement is more pronounced in the formal system (Kadigi, 2011). These institutions help in determining the amount, quality, and cost among other standards of seeds passing through the seed system.

2.2.1. Formal seed system

The formal seed system, as defined by FAO (1999) comprises all seed program components, namely; plant breeding, seed bulking, processing and marketing. These are facilitated by extension services, quality control and certification. The formal seed sector serves to diffuse quality seed of improved varieties developed by formal breeding programs. The materials for formal breeding programs are obtained from collections of gene banks. The gene banks contain materials originally collected from farmers' systems, that is, developed and maintained by farmers (Rubyogo et al., 2009). Regulations exist in this system to maintain variety identity and purity as well as to guarantee physical, physiological and sanitary quality, through institutions mandated to enforce such procedures (Maredia, *et al*., 1999). Seed marketing takes place through officially recognized seed outlets, and by way of national agricultural research systems. In formal seed production, seed multiplication occurs through several generations rather than continually recycling the seed of one generation, to avoid building up physical or genetic contamination over time in the same lot of seed (Louwaars *et al*., 1999). The formal system has been relatively successful for well-endowed, high-potential areas, but much less successful in more variable, marginal areas. This can be attributable to the system's inability to produce sufficient seed of preferred varieties, and deliver it to farmers at the right time. Seed production is risky in terms of time, space and financial implications; and returns are determined by multiplication rate (that is, amount of seed yield that can be harvested per unit of seed sown (McGuire, 2005). A study by Baniya *et al* (2003) indicated that, the formal seed system focuses more on the interests of the seed company, and has more access to biotechnology and plant breeding techniques. Notably, this system neglects the indigenous knowledge as well as seed requirements and varietal preferences by smallholder farmers. However, a key pillar of the formal seed system is seed certification, which underpins seed quality assurance.

2.2.2. Informal Seed System

The informal seed sector has been in operation in Kenya particularly for the small scale farmers (Walelign, 2008). The source and quality of most of the planting materials and seed purchased, multiplied and marketed by the informal seed sector may not be known, yet this is the major source of planting material for the smallholder resource-poor farmers (Kadigi, 2009). Informal sources of seed may include but limited to: farm-saved seed, farmer-to-farmer exchange, local markets, non governmental organizations (NGOs) and community based organizations (Rubyogo *et al.,* 2011). Informal or on-farm seed systems vary across countries, regions and crops. The system relies on seed saving practices - keeping parts of the harvest for planting in the next season. The system usually plants local varieties of seed kept from the previous year's harvest, obtained from neighbors and/or the local market (Rubyogo et al., 2009). This is the predominant system for food crops in subsistence agriculture. It is estimated that in developing countries, the informal seed system is responsible for more than 80% of the total area planted with subsistence crops, especially beans (Beshir, 2011; Habte *et al*., 2011). It is very resilient system, which is very active even without the support of public or private institutions (Rubyogo et al., 2010). On farm seed systems are essential for improving food security for developing countries (Beshir, 2011). They will likely continue to be the main source of seed for subsistence crops in the world. This system is not market oriented; seeds are usually produced for consumption while surplus can be bartered with neighbors or sold to local grain dealers (FAO 2004). For small-scale farmers in developing countries, management of seed is of crucial importance and forms an integral part of their crop production systems (CRS, 2013). For many centuries, farmers have developed and maintained their own plant genetic resources, based on local means of seed production, selection and exchange (Sperling, Boettiger and Barker, 2013). Introgressions, mutations and introductions from elsewhere are the common sources of new genetic material in a community. Newly introduced varieties are subject to farmers' experimentation, and when adopted they become part of the local gene pool. In many cases, this integration involves physical mixing of seeds and spontaneous crossing with other materials. The informal seed sector has strong local character, without necessarily being confined to a small geographical area (GTZ, 2000).

2.3. Dimensions of seed systems

Patterns of seed access and use emerge as skilling occurs differently for individual farmers across the dimensions (Jones, 2013) as illustrated in Figure 1. These patterns define both the limits of the modern or formal seed system as well as the characteristics of a range of alternative (informal) systems (Stone, 2004). Decisions about the type of exchange, the type of good and the value of the good being accessed are all conditioned by individual and social context characteristics, with a range of options along each axis (Habte, 2011). Three key elements of economic decision-making are the type of exchange used to access a good, the type of good itself and the value of that good to the individual (Kadigi, 2010). Exchanges might occur across a spectrum that includes formal market structures, informal markets and non-formal exchange arrangements or self-provisioning (Hart, 2006). Informal markets directly relate to formal markets, with non-formal traditional economic exchanges existing outside of this direct comparison. However, the establishment of local seed markets and producers bring these different types of economic arrangements into direct contact with one another, so that all three exist on a continuous spectrum (Jones, 2013).

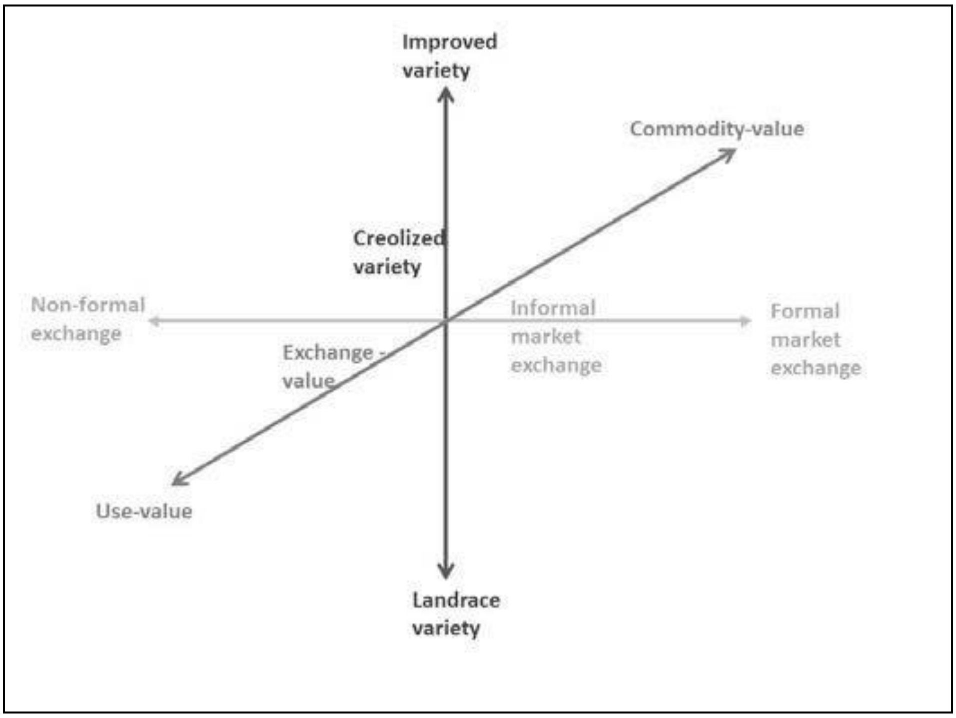

Figure 1: Dimensions of seed access decision making
Source: Adapted from Jones (2013)

3. Social Networks

The fabric of a society is based on networks (Kilduff & Tsai, 2003), with social lives being embedded in interactions among numerous players connected through intertwined relationships (Vidgen, Henneberg & Naude, 2007). The concept of social networks has drawn the attention of social scientists and researchers at large, in the quest to understand the role of interpersonal connections in information and technology exchange (Tatlonghari *et al.,* 2012), especially in describing the pattern of resource sharing among the farmers, premised on social trust. Nicholas *et al*. (2013) in their study on female social networks and learning about new technology in India demonstrate that men and women in the same households have very different social networks and thus different access to information regarding agricultural technologies. They found that the underlying factors that shape network linkages between male farmers are different than those shaping their wives social networks. Viewed as a critical society's asset portfolio, social networks are undoubtedly a form of social capital (Tatlonghari *et al.,* 2012). Relying on social networks for diffusion of information seems desirable in practice because it is an extremely low cost approach in diffusing a new technology (Kyle, 2013). If the allocation achieved by exchange in networks is efficient, then networks could be relied upon as a highly sustainable method of ensuring efficient spread of technologies, particularly in the absence of efficient markets (Beshir, 2012). Handschuch and Wollni (2013) in their case of finger millet in western Kenya conclude that besides formal extension, farmer-to-farmer networks are found to be an effective trigger for the dissemination of finger millet practices. In rural Kenya, many social groups exist and the majority of farmers participate in at least one group (Rabuor, 2010). However, group activities vary widely and can be an influential factor for the diffusion of market information which contributes to a large percentage of transaction cost involved in banana production (Ochieng, 2012).

4. Theory of choice

Farmers' decisions to obtain seed from certain source(s) are embedded in the theoretical framework of economics, often referred to as the science of choice (Parkin, 1997). Thus, economics as a behavioral science is central to understanding how and why individuals make certain choices in the context of information available to them. In essence, it is often assumed that such individuals act rationally, hence they seek the most cost effective means to achieve a specific goal without reflecting on the worthiness of that goal. Many definitions of economics as a science of choice have been documented. Alfred Marshall's definition of economics in the early 1900s as the study of humankind in the ordinary business of life led to the neoclassical definition: the study of choice in the ordinary business of life (McCloskey, 1996). Case and Fair (1992) defined economics as the study of how individuals and societies choose to use the scarce resources that nature and previous generations have provided. Miller (1994) viewed economics as the study of how people make choices to satisfy their wants. Parkin (1997) described it as the study of the choices people make to cope with scarcity. Economics is thus instrumental in studying individuals' decisions on how scarce resources can be optimally allocated in the process of production, exchange and consumption of goods and services. The choice maker's aim is to maximize desirable returns subject to the scarce resources. Rational choice theory constitutes a dominant paradigm in explaining human behavior and actions; underpinned by neoclassical economic theory and utilitarian theory.

4.1. Rational choice theory

Rational choice theory or rational optimization approach has been widely used in social sciences. It uses abstract deductive reasoning by drawing conclusions and predictions from sets of assumptions, and provides critical view of what ought to be. Proponents of the rational choice approach hold that it provides a unified and rigorous framework for understanding human behaviors and actions, an analytical tool for relating aggregate events to micro–worlds of individual decision making, and has a great predictive power not found in other approaches (Friedman and Hechter, 1988; Rule, 1997; Chai, 2001). However, critics point out that the theory enshrines unrealistic assumptions on preferences and fails to incorporate such factors as altruism and cultural diversity. Such limitations have served to confirm the fact that a tractable representation of the complex world would only capture limited features of such complexity. Therefore, details are stripped away to expose only specific aspects of behavior relevant to the question being analyzed. Rational choice theory assumes that individuals are purposive and intentional (Friedman and Hechter, 1988). Individual decisions and actions are shaped by subjective tastes as measured by individual's utility and constrained by resource scarcity, opportunity costs, institutional norms as well as availability, timeliness and quality of information.

4.2. Rational preferences

The postulate of rationality of preferences constitutes a key assumption in the neoclassical economic analysis of behavior. Individuals are assumed to have explicit, complete, reflexive, and transitive rank ordered preferences over the possible outcomes of their actions (Bicchieri, 2004). Preferences would also assume non–satiation, strict convexity, and continuity properties. In other words, individuals would consistently prefer more of something to less and average outcomes to extremes (Rahelizatovo, 2002). Preferences are subjective individual tastes measured by the utility derived from the use of a certain commodity or bundles of commodities. Such preferences may be represented graphically using indifference curve. Such a curve consists of a locus of pair–wise combinations of outcomes that would provide the same level of satisfaction to the decision maker. Each indifference curve represents a different level of utility. The continuity and completeness of a preference ranking would lead to a dense map of indifference curves. The further an indifference curve is from the origin, the higher the utility level. In addition, the convexity of preferences ensures that the indifference curve exhibits the diminishing marginal rate of substitution. In other words, the more an individual has of a good, the less satisfaction he perceives from an additional unit of the same good and the more he is willing to exchange it for a given amount of the other good (Case and Fair, 1992; Varian, 1999; Parkin, 1997).

4.3. Optimization behavior

The fundamental economic problem has been attributed to the limited resources available to satisfy human beings unlimited wants and needs (Parkin, 1997). Resource scarcity drives individuals to make choices to attain desirable goals consistent with their preferences. Differential access to resources affects the individual's ability to attain the alternative end results, making some easy to achieve, and others more difficult or even impossible to reach (Friedman and Hechter, 1988). However, decision makers are assumed to conduct rational calculation and subsequently select the course of action likely to be associated with the highest outcome values constrained by resources available to them. Utility theory offers an understanding of individuals' choice through utility maximization behavior (Varian, 1993; Parkin, 1997). Individuals' preferences are associated with a real–value indexed utility. Consequently, individuals choice is assumed to favor the course of action that provides the highest utility, or maximum satisfaction. Yet, individuals choices often fail to agree with such an ideal proposition. There are other factors that affect decisions. One such factor is opportunity costs, which are incurred when the decision maker forgoes the best alternative available to him. Individuals must consider these implicit costs in their pursuit of maximum benefits and satisfaction (Rahelizatovo, 2002). High opportunity costs can affect the attractiveness of the most preferred action and may prompt the choice of a lower level of utility. Similarly, institutional norms and rules, as well as access to better quality information at the time a choice is made, also influence individual's decision and outcomes. Individuals may also reduce the risk and uncertainty surrounding their choices by acquiring more information. Perception of rewards and costs are shaped by social institution rules (Rahelizatovo, 2002).

5. Methodology

5.1. Study area

The study was conducted in Bondo sub county, situated at latitude 0° 14' 19 N, longitude 34° 16' 10 E and elevation of 1,227 meters above the sea level. It borders Siaya Sub-county; Kisumu County to the East; Homa-Bay County to the South and Uganda to the West (Figure 2).

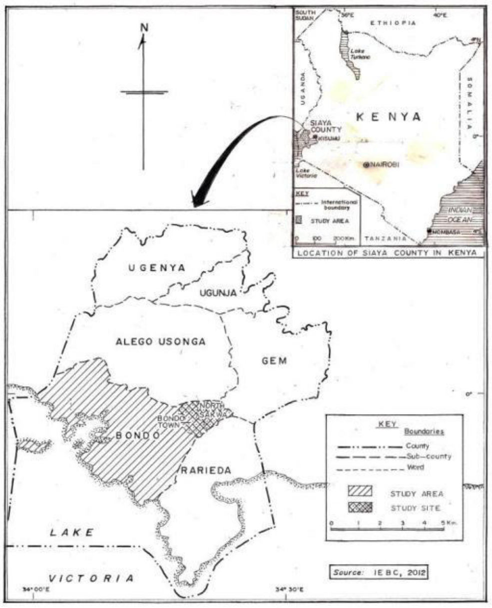

Figure 2: Map of Bondo sub-County, Siaya County, Kenya

5.2. Sampling procedure

Three stage sampling design was used. Bondo Sub-county was purposively selected in Siaya county because it is a major bean growing area. Within Bondo Sub-county, North Sakwa ward was selected purposively due to comparatively larger number of smallholder bean farmers as well as accessability. Likewise, two locations and four sub-locations within North Sakwa ward were selected purposively due to larger number of smallholder bean farmers. The total population was the number of smallholder bean farming households. The numbers sampled were derived as the proportion of population per sub location to the total population (Table 1).

Table 1: Population and sample size, by location and sub-location

Location	Sub location	Total population	Numbers sampled
Bondo township	Ajigo	628	26
	Bar-kowino	740	30
North Sakwa	Abom	477	20
	Bar-chando	575	24

5.3. Sample size determination

A sample of 100 smallholder bean farmers was selected from the four Sub-locations using simple random sampling method. The required sample size was determined using the sampling method by Anderson et al. (2007).

Where n = sample size, p = proportion of the population containing the major interest, q = 1-p, z= 95% confidence level ($\alpha = 0.05$), E = acceptable/allowable error

z = 95% (standard value of 1.96);

p = 0.5;

q = 1-p = 0.5 and

E = 9.8%

Therefore, the sample size was calculated as;

$$n = \frac{(1.96^2)(0.5^2)}{0.098^2} = 100$$

5.4. Data collection and analytical process

Primary data were obtained through scheduled interviews using structured questionnaires. Types of data included general demographics of the respondents such as age, gender, and education level. Data on socioeconomic characteristics, bean seed sources, seed source preferences, bean production, harvesting and storage practices as well as interactions among bean farmers were collected. Data were verified, coded and analyzed using descriptive and inferential statistics, social networks analysis techniques and multinomial regression model with the help of SPSS, EXCEL, STATA and UCINET computer software packages.

Social network analysis (SNA) technique was used to understand the linkages among farmers. Three SNA tools were employed. Information about specific relationships among farmers were gathered and represented in a relational matrix. The relationships were visualized through network maps. Finally, the structure of the networks were assessed through measures of centrality: betweenness centrality, degree centrality, closeness centrality and brokerage positions. Degree centrality refers to the number of direct links an actor has with others, hence it is a measure of activity. Closeness centrality takes indirect relationships into account and calculates the average distance between an actor and the rest of the network. It gives an idea of an actor's accessibility and relative autonomy. Betweenness centrality measures the degree of control that a particular actor can exert over others (Williams and Hummelbrunner, 2011). Brokerage positions were used to define the extent to which an actor or actors can influence the flow of information within a network either as cut points (bottlenecks) or mediators (network hubs). The UCINET software was employed in analyzing the data.

The centrlity measures were defined using the Freeman (1979) and adopted by Lada (2013) as indicated in equation 1 to 5.

(i) The degree centrality:

$$C_D = \Sigma_{i=1}^{g} \frac{[C_D(n) - C_D(i)]}{[(N-1)(N-2)]} \quad \text{..........1}$$

Where,
C_D = the degreed centrality;
n = the number of persons with characteristics of interest; and
N = the total number of respondents
$C_D\ (n)$ = the maximum value in the network

(ii) Betweenness centrality:

$$C_B(i) = \Sigma_{j<k}\, g_{jk}{}^{(i)}/g_{jk} \quad \text{..........2}$$

normalized as:

$$C_B(i) = C_B(i)/[(n-1)(n-2)/2] \quad \text{..........3}$$

Where,
$C_B(i)$ = the betweenness centrality of the individual actor;
g_{jk} = the number of geodesics connecting jk;
$g_{jk}(i)$ = the number of geodesics that actor i is on;
[(n-1)(n-2)/2] = number of pairs of vertices including the vertex itself

(iii) Closeness centrality:

$$C_C(i) = \left[\Sigma_{j=i}^{N} d(i,j)\right]^{-1} \quad \text{..........4}$$

normalized as:

$$C_C(i) = \left(C_C(i)\right)/(N-1) \quad \text{..........5}$$

Where,
$C_C(i)$ = the closeness centrality of individual actor
d = the average shortest path between a vertex and all vertices in the graph

We employed a Multinomial logistic regression model (MLRM) to determine the factors influencing the preferences for seed sources by smallholder farmers. MLRM allows for analysis of different individual characteristics confronted with multiple choices (Maddala, 1983; Green, 1993; Hill et al., 2008). It estimates the probability of an individual i choosing an activity j, seed source in this case, given a set of explanatory variables (socio-economic characteristics).

To construct the choice preference for seed source by smallholder farmers, this study adopted the utility function formulated by Greene (1993), in adjusted form as shown in equation 6;

$$U_{ij} = \beta Z_i + \varepsilon_{ij} \quad \text{..........6}$$

$\boldsymbol{U_{ij}}$ is the satisfaction that the i^{th} farmer derives by choosing j^{th} seed source
$\boldsymbol{Z_i}$ is a vector of individual farmer characteristics

β is the parameter to be estimated and ε_{ij} is the error term.

Given the difficulty in measuring utility directly (Sheffrin et al., 2006), it was assumed that farmers chose seed source from which they derived seed with most satisfactory quality. The general multinomial logistic regression model used was as as specified in equation 7 by Schmidt and Strauss (1975) and used by Kyalo (2009) and Kadigi (2012).

$$Prob\ (Y_i = 1) = \frac{e^{\beta_j x_i}}{\sum_{k=o}^{J} e^{\beta_k x_i}}\ , j = 0,1, \ldots, J \quad \ldots\ldots 7$$

With at least three categories of independent variables, equations were estimated to provide probabilities for *J + 1* choice of seed source for a farmer with X_i socio-economic characteristic.

The β_j *and* β_k are the coefficients which wereestimated using the maximum likelihood method. Equation 8 presents simplified empirical specification of the model.

$$\Pi_{ij} = \beta_o + X_i\beta_k + e_{ik} \quad \ldots\ldots 8$$

Where*;* Π_{ij} is the probability that bean farmer *i* chooses seed source *j,* β_o is the constant term, X_i are the farmers socio-economic characteristics*,* β_k are the model coeficients (parameters) to be estimated and e_{ik} is the error term. To eliminate indeterminancy, the model was normalised by fixing $\beta_o = 0$*.* The probabilities added up to 1 hence, only *J* parameter vectors were required to obtain *J+1* probability. The probailities were therefore specified as indicated in equation 9;

$$Prob\ (Y_i = 1) = \frac{e^{\beta_j x_i}}{\sum_{k=o}^{J} e^{\beta_k x_i}}\ , for\ j = 0,1, \ldots, J, \beta_o = 0 \quad \ldots\ldots 9$$

In the model, seed source preference with at least three options was set as the dependent variable. The options included own-saved-seed, neighbouring farmers, and local grain market. The variable own-saved-seed took the value 1, neighboring farmers took the value 2, and local grains market took the value 3. The STATA and SPSS computer software packages were used to analyze data.

For the three seed source options, the equations were defined as indicated in equation 10, 11 and 12:

$$\begin{aligned} Prob\ (Y = 1) = {} & \beta_1 HHAGE + \beta_2 HHSEX + \beta_3 EDLVL + \beta_4 MRTSTAT + \beta_5 FAMSIZE \\ & + \beta_6 OWNSHLAND + \beta_7 FARMSIZE + \beta_8 HHMAINACTVY \\ & + \beta_9 DISTSEEDSRC + \beta_{10} AREABEANS + e_i \ldots\ldots 10 \end{aligned}$$

$$\begin{aligned} Prob\ (Y = 2) = {} & \beta_1 HHAGE + \beta_2 HHSEX + \beta_3 EDLVL + \beta_4 MRTSTAT + \beta_5 FAMSIZE \\ & + \beta_6 OWNSHLAND + \beta_7 FARMSIZE + \beta_8 HHMAINACTVY \\ & + \beta_9 DISTSEEDSRC + \beta_{10} AREABEANS + e_i \ldots\ldots 11 \end{aligned}$$

$$\begin{aligned} Prob\ (Y = 3) = {} & \beta_1 HHAGE + \beta_2 HHSEX + \beta_3 EDLVL + \beta_4 MRTSTAT + \beta_5 FAMSIZE \\ & + \beta_6 OWNSHLAND + \beta_7 FARMSIZE + \beta_8 HHMAINACTVY \\ & + \beta_9 DISTSEEDSRC + \beta_{10} AREABEANS + e_i \ldots\ldots 12 \end{aligned}$$

5.5. Description of variables

The study was based on the axiom that the choice preference for particular seed source (dependent variable) may be determined by an array of farmer's characteristics as described in Table 2

Table 2: Description of variables used in the Multinomial Logistic Regression Model

Variable code	Variable	Measurement	Type	Expected sign
SEEDSRCE (Y)	Seed source preferred	Own-saved-seed=1, neighboring farmers=2, local seed producer=3, local grain market=4, ertified seed stockists=5	Categorical	+/-
HHAGE	Age of bean farmer	Age in years	Continuous	+/-
HHSEX	Sex of the farmer	Male=1, Female=0	Dummy	+/-
EDLVL	Educational level	Years of schooling	Continuous	+/-
MRTSTAT	Marital status	Single=1, married=2, divorced=3, separated=4	Categorical	+/-
FAMSIZE	Family size	Number of household members	Continuous	+/-
FARMSIZE	Size of farm	Number of hectares	Continuous	+
OWNSHPLAND	Natrure of ownership of land by the farmer	Owned with title deed=1, owned without title deed=2, lease=3	Categorical	+
HHMAINACTVY	Main activity of the farmer	Farming =1, Civil servant =2, Businessman =3 Retired with pension =4, Retired without pension =5	Categorical	+
DISTSEEDSRC	Distance to nearest seed source in Kilometres	Number of Kilometres	Continuous	+
AREABEANS	Area under beans in hectares	Number of hectares	Continuous	+

6. Results and discussions

6.1. Characterization of bean farmers in Bondo sub County

The socio-economic characteristics of the bean farmers are summarized in Table 3. The mean age of the farmers was 52.4 years. A one sample t-test was run to determine whether the mean age was different from the population mean age. There was no statistical difference t (99) = 0.000, p = 1.000 at 0.05 level. The standard deviation (SD) of the age of household head was 14.33. The ages were dispersed with majority (95%) of ages lying between 23.74 and 81.06.

Table 3: Distribution of farmers by socio-economic characteristics, Bondo sub-County, 2015

Variable	Mean	Standard deviation	Minimum	Maximum
Age of household head	52.40	14.33	22.00	83.00
Education level	10.52	2.90	4.00	18.00
Family size	11.24	2.03	8.00	17.00
Distance to nearest seed source	7.42	1.46	3.00	10.00
Size of farm	1.19	0.49	0.20	2.00
Area under beans	0.34	0.28	0.04	1.20
		Percentage of respondents (%)		
Sex of household head				
• Males		57.00		
• Females		43.00		
Main activity of household head				
• Farming		63.00		
• Civil servants		15.00		
• Business		22.00		
Nature of land ownership				
• Owned with title deed		60.00		
• Owned without title deed		40.00		

The mean number of years of schooling was 10.5 years ranging from a minimum of 4 years to a maximum of 18 years. This indicates appreciable levels of literacy and since literacy level in any society is a proxy for ability to embrace change, it is suggestive that the area is a sterile avenue for launching of new agricultural ideas.

The mean household size was 11. This relatively large household size is a reflection of embracement of African culture which upholds extended families (Kadigi, 2012). The number of members in a household has an implication on the disposable income, expenditure levels, and the choice of goods basket. This would then reflect on the type of seed the household would prioritize for planting.

Distance to nearest seed source shows that farmers would have to cover an average of 7.42 km to get bean seed from alternative sources where the seed is not available from own stocks or immediate neighbours (Table 3). Longer distances are associated with higher transaction costs in terms of time and energy losses especially for smallholder bean farmers who require small quantities of seed (Suri 2006; Farrow *et al.*, 2010). This is a plausible explanation for farmers' inclination towards saving their own seed (Sperling, Boettiger and Barker 2013).

The average farm size held was 1.19 ha. The size of land held by a farmer determines the size of land that would be dedicated to bean production given competition among several enterprises on the same land parcel. In this regard, the mean area under beans was 0.34 ha. Due to land scarcity, smallholder farmers sometimes resort to mixed cropping (planting beans alongside other cereals like maize) to increase area under beans.

Forty thee percent of the farmers were females while 57% were males. The increasing interest by men in bean production is attributed to the transformation of beans from traditional subsistence crop where its production was female–dominated (Katungi *et al.* 2009; CIAT, 2004; David, Kirkby and Kasozi, 1999) to market–oriented one. This is consistent with Birachi *et al.* (2011) that in areas where common bean was a market–oriented crop, its production was male–dominated.

Majority of the farmers (60%) owned land with title deeds while 40% had no title deeds. The nature of land ownership is critical because it provides an incentive or otherwise to the owner to invest in long term productive enterprises (Dube and Guveya, 2013; Sylvester, 2013; Jacoby and Minten, 2005).

While 63% of the households practiced farming as their sole occupation, 15% were civil servants and 22% engaged in non-agriculture businesses besides being farmers. The plausible explanation is that the civil servants and business people have strong linkages with rural areas and would be interested in farming to complement their incomes and also reduce expenditures on agricultural products which can be produced within the farm. They also have a greater potential to invest in agriculture due to enhanced access to credit facilities.

6.2. Methods used for quality control in informal bean seed sources

In order to know how quality of beans could be controlled in informal systems, it was necessary to understand the entire production process from seed sourcing, planting to harvesting as well as post-harvest management.

6.2.1. Assessment of seed quality characteristics at sourcing

The ability of the farmers to select good quality bean seed is critical in ensuring higher yields (CRS, 2014). Good quality seed will result in high germination rate, crop population, uniform stand and consequently uniform maturity (Karrfalt, 2013; Powell, 2009). In Rwanda and Congo, farmers carefully considered seed type and quality when sourcing seed for planting (Trutmann *et al.,* (1996). Farmers in Ethiopia took specific phyto-sanitary measures to enhance bean seed quality through sorting out poor-quality materials, including visibly diseased grains (Rubyogo *et al.,* 2009).

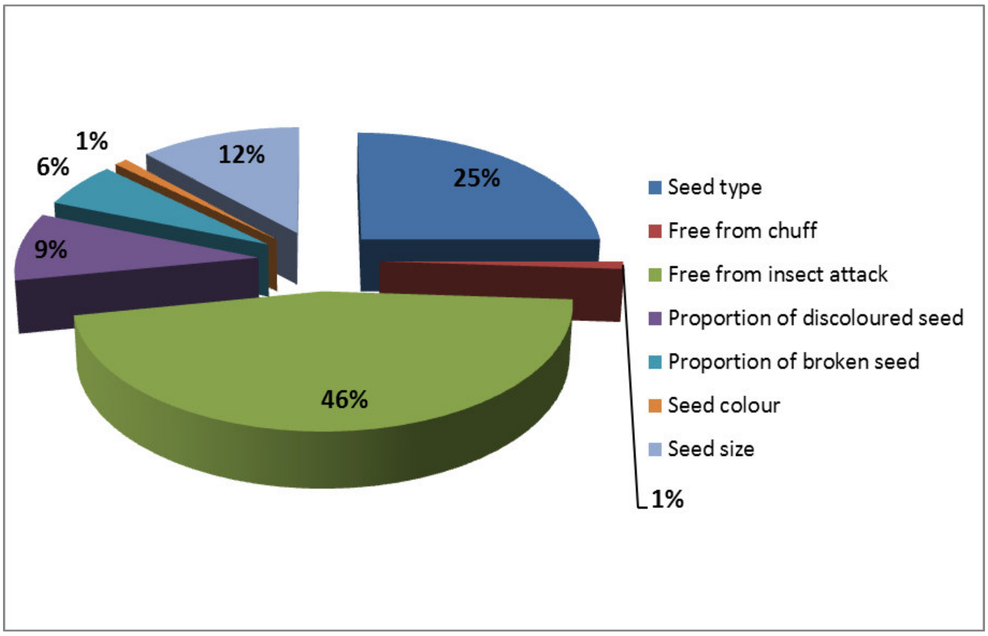

Figure 3: Distribution of farmers by quality characteristics of seed assessed

To ensure quality control in informal sources, 90% of households in Bondo assessed the type of bean they would adopt as seed. The characteristics sought during selection are presented in Figure 3. The most outstanding characteristics thought to portray high quality were beans free from insect attack as indicated by 46% of the households. This is plausible because even formal seed companies ensure the beans are free from insect attack by dressing with insecticides (Sridhar and Kumar, 2013).

Second in importance was the bean type as indicated by 25% of the farmers. Over time, farmers learn certain attributes that make them be associated with some bean types and not the others (Trutmann *et al.,* 1996). Such attributes may include early maturity, shortened cooking period, better taste and non-flatulence after consumption. Such attributes have also informed demand-led breeding which seeks to improve and avail bean varieties that meet specific farmers' and market requirements.

Twelve percent of the farmers assessed the size of seed. Seed size is critical during planting and marketing. Large seeded bean types have higher seed rates while small seeded types have lower seed rates hence, farmers intending to reduce seed costs would prefer small seeded types. On the other hand, bean grain and seed traders would prefer large seeded types because they use lower quantities to fill the measuring containers and thus make higher profits.

Assessing the proportion of discolored seed was important (9%) because seed discoloration may be an indication of disease infection, premature harvesting or improper drying. Premature harvesting may lead to seed with low viability while disease-infected and improperly dried seed are highly likely to rot when planted. Six percent of the farmers considered the proportion of broken seed. Higher proportion of broken seed increase the cost of seed by reducing the value per unit of seed purchased. Presence of chaff and the color of seed were regarded as least important characteristics while sourcing bean seed. However, seed colour is an indicator of varietal purity and uniformity.

6.2.2. Planting and post planting management practices

To eventually generate good seed, both planting and post planting management practices summarized in table 4 are critical.

Table 4: Distribution of farmers by planting and post-planting practices used for bean quality control, Bondo sub-County, 2015

Management practice	Farmers practicing (%)
Seed treatment at planting	
Treating	16
Not treating	84
Cultural practices for controlling pests and diseases	
Weeding	84
Early planting	7
Intercropping	6
Roguing	3

Results demonstrate that 16% treated beans before planting. The credible explanation is that farmers use seed from their own stores or other sources they trust – whose quality and management requirements they know well; and may not require additional treatment at planting (CRS, 2013). Farmers carry out functions of multiplication; seed selection and storage in the informal system as in the formal system, but the functions are integrated in their crop production and marketing practices rather than discrete activities (Sperling, Boettiger and Barker, 2013). The post planting management practices in informal seed production were basically cultural practices such as weeding (84%), early planting (7%), intercropping (6%), and rouging (3%). It is quite apparent that farmers understand the importance of weeding. Controlling weeds enhances quality of bean grain because many weed plants act as hosts for pests and diseases. Thus, if left unchecked the harvest may be infested in the field and consequently, the pests/diseases may be carried into the stores, predisposing the stored beans seed to early deterioration in quality. The other practices were considered less important although in formal seed production, both early planting and rouging are critical aspects (Kadigi, 2012).

6.2.3. Harvesting and post-harvest management practices.

The harvesting and post-harvest management practices are presented in Table **5**. There was a variation in the timing of harvest where 87% harvested beans when the pods were completely dry, 8% when leaves had fallen and 5% when the pods turned yellow. The time of harvesting is a proxy for maturity level of beans and consequently determines the quality of bean grain harvested. This has an impact on the farmers' seed especially where a farmer grows own-saved seed (Nasirumbi, 2009).

Table 5: Distribution of farmers by harvesting and post-harvest management practices used for bean quality control, Bondo sub-County, 2015

Management practice	Farmers practicing (%)
Timing of harvesting	
When pods are completely dry	87
When pods turn yellow	8
When leaves have fallen	5
Method of harvesting	
Uproot whole plant	97
Collect dry pods	2
Cut plant at the collar	1
Use of bean grains fallen while harvesting	
Collect and consume	63
Leave in the field to germinate	22
Mix with other grains and sell	16
Time between harvesting and threshing	
3 days	75
7 days	13
1 day	11
14 days	1
Where threshing is done	
Open yard	79
Farm house	20
In the field	1
Stage at which cleaning is done	
During threshing	90
After threshing	10
Method of cleaning	
Completely remove chuff, broken seed, discolored seed, sort by size	76
Remove chuff only	22
Remove broken seed only	2
Methods of testing bean dryness	
Toss and listen for metallic sound	48
Bite with teeth	34
Press with fingers	18
When storage is done	
After threshing, cleaning and drying	92
After threshing and cleaning	5
After threshing only	3
Length of storage period	
1-5 months	68

More than 5 months	31
Less than 1 month	1
Type of storage structure	
Room within the house	98
Raised platform near house	2
Construction material for storage structure	
Concrete	37
Wood	34
Clay	29
Period of using storage structure	
More than 4 seasons	90
Three seasons	7
Two seasons	2
One season	1
Uses of storage structure	
Store beans and other foodstuffs	98
Store beans only	2
Measures undertaken in storage structure before storing	
Clean the store	85
Reinforce with dung or concrete	15
Treatment of storage structure	
Apply no treatment	61
Apply some treatment	39
Type of storage treatment	
Commercial insecticides	80
Wood ash	15
Smoke	5
Methods for solving storage problems	
Expose and sundry stored beans	58
Apply chemicals	41
Physically kill insects and pests	1

Farmers harvested beans by uprooting the whole plant (97%), cutting the bean plant at the collar (1%) and collecting the dry pods (2%). While the first two methods are less time consuming, the third method is a preferred where there is less uniform pod maturity; requiring piecemeal harvesting (Khaemba and Akiro, 2008). Majority (95%) of the farmers agreed that during harvesting, some bean grains fell to the ground while 5% indicated that they were able to collect all the bean grains. How farmers handle the fallen grains is critical because often the grains get contaminated with soil and pests which may find their way into the store if unchecked (Malinga and Tenesi, 2010). Majority of the farmers collected and consumed (63%) the fallen grains, 22% left them in the field to germinate while 16% mixed them with other bean grains and sold.

The time lapse between harvesting and threshing has an influence on the quality of bean grains. While extraneous factors such as cold weather conditions may increase the time lapse, the process may also be impeded by the fact that for the smallholder farmers, both harvesting and threshing compete for the same labour (Otieno and Nyabuto, 2001). Similarly, after harvesting, sufficient drying is required to enhance opening of pods during threshing; and reduce grain breakage. Farmers threshed their beans three days after harvesting (75%), seven days after harvesting (13%), one day after harvesting (11%) and fourteen days after harvesting (1%). The location where threshing is done is also critical as the grains may be predisposed to mixing with soil and foreign matter; hence quality compromised. Farmers threshed their beans in the open yard (79%), in the farm house (20%) and in the field (1%). A plausible explanation for preferring open yard and farm house over threshing in the field is that, many farmers use the bean residues to feed their livestock (Grisley and Mwesigwa 1991; Birachi *et al.* 2011). However, threshing in the field helps to recycle the nutrients held in the bean residues thus, improving soil fertility (Dong *et al.,* 2003).

Majority of (90%) farmers cleaned the beans at threshing stage while 10% kept the threshed beans for later cleaning. There were differences in the methods for cleaning bean seed/ grains where farmers completely removed the chuff and broken seed, sorted the grains by size and sorted out discolored beans (76%); removed the chuff only (22%) and removed broken beans only (2%). This affirms the importance of absence of chuff as the major quality characteristic assessed by farmers while sourcing bean seed from the informal seed sources (Maredia *et al*., 1999). Farmers stored their beans after threshing, cleaning and drying (92%), after threshing only (3%) and after threshing and cleaning (5%). Storage is not only critical for seed viability and ultimately yields (CRS, 2011), but also promotes food security and resilience (Seyoum and Jonfa 2012). Reduced quality of grain from insect infestation and moisture can have significant implications to both food availability and income. This results from direct loss and poor quality which influence market prices. Cereal prices fluctuate greatly between harvests which can make effective storage profitable (CRS, 2013). It is important to dry beans after threshing and cleaning to ensure requisite moisture content before storing. High moisture results in lower germination rates, plant vigor and yield. Whereas in the formal sector machines are used to ensure requisite moisture content of beans before storage, such equipment are absent in the informal sector (Sperling, Boettiger and Barker, 2013). Farmers tested bean dryness by tossing the grains between hands and listening to unique metallic sound (48%), biting the grains with teeth (34%) and pressing the bean grains between fingers (18%). All these methods have no scientific backing, but they have been learnt, practiced over decades, and passed over from one generation to another (Asfaw, Almekinders, Struik and Blair, 2013; Kadigi, 2012).

The length of storage period is a critical aspect of seed quality management. The longer the storage period, the higher are the risks of losing the stored beans to storage pests (CRS, 2014) and therefore extra costs incurred in maintaining bean seed/ grain quality. Farmers stored their beans for 1-5 months (68%), more than 5 months (31%) and less than one month (1%). Those who stored beans for shorter periods were either risk averse or disposed of their beans to meet immediate household needs including paying school fees for their children. These farmers fetched relatively lower prices when they sold immediately after harvest. Conversely, those who stored beans for longer periods did so for speculative purposes, eventually selling as seed at higher prices due to higher demand during planting period (CRS, 2014).

The type of storage structure, location, and material used to construct the storage structure play an important role in enhancing the shelf-life and viability of the stored grain/ seed at the time of disposal. Farmers stored beans in their houses (98%) or used some raised platforms near their houses (2%). Concrete was largely used by farmers for constructing storage structure (37%), while wood (34%) and clay (29%) were also used. The preference for concrete is attributed to its durability and less susceptibility to breakage by termites and rodents unlike wood and clay, thus reducing the likelihood of infestation and costs associated with bean storage. On the other hand, wood and clay were both readily available and affordable.

The period of usage of storage structure is critical in bean quality. Storage pests get recycled into the store if the same structure is used for a long time, more so if the necessary treatments are not adhered to. Ideally, the farmers would have to change the storage structure nearly every season to break the cycle of storage pests' incidences. However, this is untenable given the financial constraints and the minimal scale of bean production by these farmers. Farmers had used their storage structures for at least four seasons (90%), three seasons (7%), two seasons (2%) and 1 season (1%). Majority of the farmers stored beans together with other grains in the same store (98%) while the others used their stores exclusively for beans (2%). Mixing of grains in the same store compromises the quality of stored beans because the other grains may be hosts for certain pests, thereby increasing susceptibility to infestation (Traore and Kone, 2013).

To reduce incidences of pest infestation, farmers undertook sanitary measures before storing beans including: cleaning the store (85%), reinforcing with dung or concrete (11%) and both cleaning and reinforcing (4%). Additionally, 39% applied some treatment to the store. Farmers who applied treatments to the storage structure used commercial insecticides (80%), wood ash (15%) and smoke (5%). Wood ash and smoke are traditional methods which are considered cheap, convenient and safe (Kyemba *et al.* 2010). However, due to their usage over long periods of time, their effectiveness cannot be guaranteed as many pests tend to develop resistance to them over time (Tuni, 2011). This is a credible explanation for the shift from the use of wood ash and smoke to the use of commercial chemicals. This is also possible because as farmers engage in repeated interactions with the extension service providers there is tendency of transition from traditional practices to conventional modern practices (Kadigi, 2012).

To deal with storage problems, farmers exposed and sundried the stored beans (58%), applied pesticides (41%), or physically killed the insects/pests (1%). Exposing the stored beans in the sun is the most convenient and least costly method of dealing with storage pests (Santra, 2010). The use of pesticides is the most effective but relatively less popular with smallhoder farmers due to cost implications (Kangili, 2009), while physically killing the insects may only be applied to large pests like rodents.

6.3. Nature and contribution of social networks in seed quality control

Social networks describe the pattern of resource sharing among the farmers. The study revealed that farmers obtained their bean seeds from a range of sources or were aware of the sources. These sources include; farmer groups, local seed dealers, certified seed stockists, neighboring farmers, and extension service providers. These resource centers are consequently referred to as the actors/events as visualized in Figure 4.

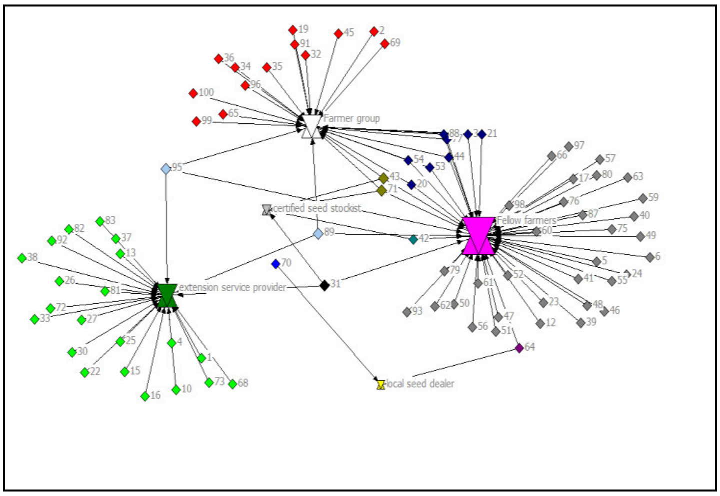

Figure 4: Social affiliation graph

Seed acquisition through social networks is influenced by a confluence of factors. It is a continuous process involving farmers' processing information from a variety of sources including; their own experiences, the experiences of other farmers, and the nature of their ties (strong or weak) with other farmers and network members. Social network analysis (SNA) provides a set of representational techniques for the analysis of the social ties and underscores the importance of the ties in influencing behavior or information and resource transmission among the actors (Williams and Hummelbrunner, 2011).

6.3.1. Strategic position and important actors

As depicted in Table 6, farmers who relied on fellow farmers to get seeds had the highest in degree centrality of 48 links followed by farmer groups, 25 and extension service providers, 24. Multiple direct links accord these farmers numerous seed sources options with a positive implication on seed security. In Tanzania, Kasambala (2007) found that the multiple seed sources initiated and maintained by farmers ensured seed security in the informal sector.

Table 6: Linkages among network segments and individual actors, by measures of centrality

Categories of centrality	**Network segments (seed sources)**					**Individual actors**		
	Fellow Farmers	Farmer group	Local seed dealer	Certified seed stockist	Extension service provider	Farmer 89	Farmer 31	Farmer 64
Betweenness	2690	1161	86	19	1599	562	365	170
Degree	48	25	2	4	24	3	3	2
Closeness	161	211	327	247	213	175	201	243

Within the segments of the network, fellow farmers exhibit the highest (2690) betweenness centrality followed by extension service providers (1599), farmers groups (1161), local seed dealers (86) while the certified stockists had the least (19). The plausible explanation is that farmers' agricultural decisions are highly influenced by fellow farmers (Kasambala, 2007). Extension service providers also have relatively high control over farmers' decisions due to repeated interactions at various forums such as field days, seed fairs, agricultural shows, chiefs' *baraza* and home visits. The control of farmers groups is limited to members of a particular group, which explains the lower betweenness centrality compared to that of extension service providers who can access both members and non–members of a group (Naegasha, 2011).

Closeness centrality takes indirect relationships into account and calculates the average distance between an actor and the rest of the network. It gives an idea of an actor's accessibility and relative autonomy. The shorter the average distance, the more accessible an actor is within the network (Hanneman and Riddle, 2005). Among the network segments, fellow farmers exhibit greatest accessibility with closeness centrality of 161 links. On the other hand, local seed dealers and certified seed stockists have the autonomy and lower accessibility with closeness centrality of 327 and 247 links respectively. This is because farmers are interdependent and interact more frequently and openly, while local seed dealers and certified seed stockists are detached from farmers due to their business orientation. This is consistent with results of a study in Rwanda by Nsanzabera (2009) who found that farmers were more efficient in technology dissemination due to their interdependence.

Figure shows a social affiliation map indicating the key structural features at individual and network levels and how the emergence of subgroups pivots around involvement in the flow of information and other resources. For instance, the network has five interlinked subgroups including fellow farmers, farmer group, extension service providers, certified seed stockists, and local seed dealer. These subgroups and individual actors within subgroups are identified by the color and size of nodes. The larger the node of a subgroup implies more direct ties affiliated to it (Williams and Hummelbrunner, 2011).

Most of the farmers in the county sourced been seed from fellow farmers and from farmer group while least of them sourced from certified seed stockist and local seed dealers in that order respectively (Figure). However, some farmers are pivotal in creating the linkages with other farmers and subgroups. This can be explained using betweenness centrality principle which focuses on the ability of an actor to be an intermediary between any two other actors in the network. Consequently, a network is highly dependent on actors with high betweenness centrality and these actors have a strategic advantage due to their position as intermediaries (Tatlongari *et al.,* 2012). In the social affiliation map, the concept of closeness centrality is used to reveal the ability of a node to quickly connect with all the other actors of the network. The smaller the value of centrality and the shorter the line between nodes implies the quicker a node connects actors within the network. Affiliation to fellow farmers has the least closeness centrality measure of 161 (Table 6) and shorter lines connecting individual actors. This increases the probability of resource sharing between the individual actors and fellow farmers given the shortest geodesic distance in the network (Erdem, Ceyhan, Atasever and Uysal, 2008).

6.3.2. Events overlap

Figure 5 captures members who share a common event. Social network theories argue that affiliation to similar events leads to development of social ties (Matuschke and Qaim, 2009).

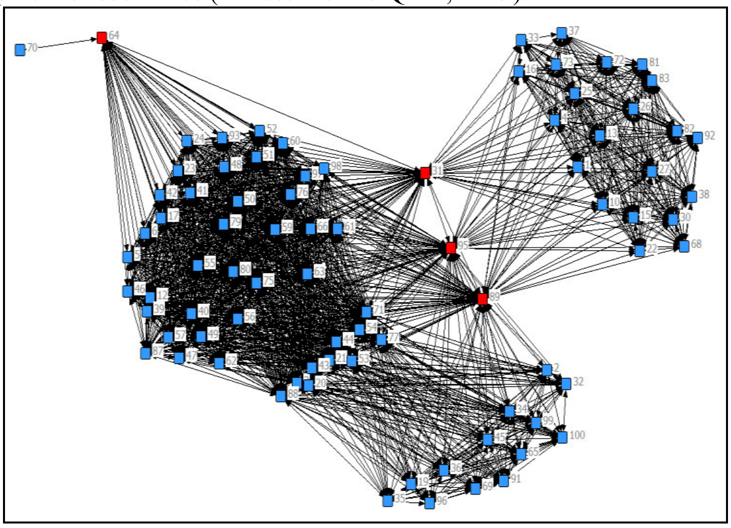

Figure 5: Two-mode actor by event overlap graph

The farmers indicated in red act as a bridge between the farmers and events and therefore act as bridges between the subgroups. The nodes of the other farmers within the network are indicated in blue. In social network analysis, the role of the farmers indicated in red can be explained using the concept of brokerage positions; cut points and mediators. Actors who are cut points control the flow of information from one part to another part of the network, while mediators exert this function either between groups or within groups (Williams and Hummelbrunner, 2011). The actor number 64, 31, 95 and 89 were identified as brokers between the other actors. Through their multiple linkages with other actors, they have the best access to information and can be considered as network hubs. Similarly, they are also cut points, with the ability to control the flow of information between parts of the network.

6.4. Factors influencing farmers' preferences for seed sources

A Multinomial Logistic Regression Model (MLRM) was used to determine the factors influencing smallholder bean farmers' preferences for seed sources in the informal seed sector. The effects of the explanatory variables on seed source preferences are indicated in Table 7.

Table 7: Estimated results of the Multinomial Logistic Regression Model (reference category: certified seed stockists)

Variables	Own saved seed		Neighbouring farmers		Local grains market	
	Log odds	Significance	Log odds	Significance	Log odds	Significance
Intercept	-5.458***	.020	-4.121***	.036	4.322	.345
Age	.059***	.035	.072***	.005	.014	.690
Education level	.133	.290	.167	.324	.076	.126
Family size	.399***	.035	.722***	.003	.632***	.033
Distance to nearest seed source	1.268***	.001	1.353***	.000	-1.254***	.000
Farm size	-.566	.433	.022	.982	-.032	.743
Area under beans	3.867***	.021	1.883	.295	-1.723	.256
Sex of household head	.873	.313	1.132	.232	.789	.312
Marital status (Single=1)	2.802	.229	1.448	.277	1.325	.721
Marital status (Married=2)	5.250	.341	4.174	.067	3.241	.132
Nature of land ownership	-.2.056	.083	-3.108***	.012	-2.223***	.014
Main activity: (Farming =1)	-1.741	.101	-.641	.583	.564	.138
(Civil servant =2)	-3.611***	.022	-3.052***	.005	2.735***	.002
(Business =3)	-1.183	.380	-.095	.949	.854	.439

Note: ***significant at 0.05 levels

The likelihood of a farmer choosing a certain informal seed source from a number of alternative sources available to the farmers relative to the formal sources (certified seed stockists) were examined. As indicated in 错误!未找到引用源。, some predictor variables influence the choice of informal seed sources significantly relative to the formal sources. Of the ten independent variables used in the model, five variables in own saved seed, five in neighbouring farmers and four in local grains market seed sources were statistically significant at 0.05 level. In eight out of ten cases, the signs of the estimated coefficients were consistent with the *a priori* expectations.

There was a positive and significant coefficient of family size (FAMSIZE) in choice of own saved seed relative to certified seed stockists. The logit estimate for a unit increase in family size is 0.399. When the size of household increases by one individual, the log-odds of preferring saving own seed planting relative to obtaining seed from certified stockists increases by 39.9%. The plausible explanation is that the larger the household size, the more likely they will prefer to source bean seed from their saved stock. Such households may be obliged to keep their own seed for planting; to reduce or eliminate expenditures on seed from certified seed stockists owing to limited disposable income. These results corroborate those of Sonamo (2008) and also Gani and Adeoti (2011). Similarly, family size positively influenced the choice of neighbors as seed source relative to certified stockists. In this case, the logit estimate for a unit increase in family size is 0.722. A unit increase in family size triggers a 72.2% increase in the log-odds of preferring neighbors as seed source relative to certified stockists. The plausible explanation is that the larger the size of a household, the more intense and closely knit are the interactions between and among different households of similar social class (smallholder farmers). These interactions increase the chances of exchanging information and other resources including seed with their neighbors relative to obtaining seed from certified stockists. Sourcing of seed from the local grains market relative to certified stockists is positively influenced by family size; with a logit estimate of 0.623. An increase of the family size by one individual triggers an increase in chances of farmers choosing to get their bean seed from the local grains market by 62.3% relative to certified seed stockists. This is possibly attributed to the fact that the larger the size of a household, the higher the amount of beans consumed such that at the time of planting, there is too little or no seed reserve. This prompts the purchase of beans from the local grains market to either replenish the finished stock or supplement the little seed reserved for planting. Also, the farmers will resort to local grains market relative to certified stockists due to the latter's prohibitive costs (Rubyogo *et al.* 2007).

The age of household head (HHAGE) positively influences the use of own saved seed for planting relative to certified stockists with a logit estimate of 0.059. An increase in the age of household head by one year would increase the chances of choosing own saved seed relative to certified stockists by 5.9%. The rationale is that as farmers advance in age, they device effective methods for controlling quality of their own bean seed (Asfaw, Almekinders, Struik and Blair, 2013) and develop trust in their own seed over other sources (CRS, 2014). Moreover, age is also a proxy for experience in bean production and farming in general. Results also indicate that an increase in the age of the farmer by one year increases the chances of the farmer preferring to get seed from a neighbor relative to certified stockists by 7.2%. The intuition here is that the more aged a farmer becomes, the more they build trust in their neighbors – and the more they tend to share information and other resources. This trust is premised on the notion that if information given is incorrect, it will be found out and the rest of the community will know. In many rural settings, sharing resources is the norm rather than exception hence, many farmers try their level best to be faithful with regard to the quality of the resource being shared. For instance, giving poor quality seed to a neighbor would amount to breaching the societal norm. In some cases this is punishable through sanctions. More aged farmers also interact often through neighbourhood visits. These are avenues for sourcing seed and information on new varieties from their neighbouring farmers.

Distance to nearest seed source (DISTSEEDSRC) was significant at 5% for the choice of own saved seed relative to certified stockists. The logit estimate for a unit increase in family size is 0.127. When distance to nearest certified seed stockist increases by one kilometer the log-odds of farmers preferring their own seed relative to certified stockists increases by 12.7%. Smallholder farmers do plant relatively small amounts of seed and covering long distances in search of the small quantities of seed may not be cost effective to the farmers (Rubyogo *et al.,* 2008). Distance also influenced seed sourcing from neighborhood relative to certified stockists with a logit estimate of 1.35. A unit increase in distance to nearest certified stockist increases the log-odds of farmers resorting to source bean seed from the latter relative to the former by more than 100%. This is logical because farmers cannot spend money to buy seed at a distant source when it can be found at the neighbourhood. Smallholder farmers are often cautious about their expenses and would wish to access production resources at the cheapest possible cost. This is also because many farmers live in areas with poor physical infrastructure thus, accessing the seed sale points may be a challenge. However, the logit estimate for the choice of local grain market relative to certified stockists was -1.25. When the distance to local grains market increases by 1 kilometer, the chances of choosing to source seed from it relative to certified stockists decrease by more than 120% – especially where seed stockists are closer to the farmer than the local market. Farmers would prefer sourcing bean seed from the nearest outlet more so if there is variation in quality (CRS, 2011) and if additional costs – in terms of time and physical energy spent in obtaining seed from far off grains market are not justified (Suri 2006; Farrow *et al.* 2010).

Area under beans (AREABEANS) positively and significantly influenced the farmers' preference of own seed for planting relative to certified stockists with logit estimate of 0.867. The results indicate that when area under beans increases by one hectare the log-odds of farmers preferring to save and use their own bean for planting relative to sourcing seed from certified stockists increases by 86.7%.This is because the larger the area dedicated to bean crop, the more the amount of seed required. This translates into higher expenditure on seed. These costs are reduced or even eliminated when farmers keep their own seed from previous harvests (Rubyogo *et al.,* 2007).

The main activity of the household head (HHMAINACTVY=2) has negative influence on the choice of own seed and neighbors' seed for planting relative to certified stockists with logit estimates of -0.611 and -0.052 respectively. Specifically, civil servants show less preference for own saved seed and neighbors' seed relative to certified stockists unlike those who practice farming as their major occupation as well as those who had retired. A unit increase in chances of becoming a civil servant decreased the log-odds of preferring own seed and neighborhood as source of bean seed relative to by 61% and 5.2% respectively. However, the choice of local grains market as a source of bean seed relative to certified stockists is positively influenced by the main activity of the household with log estimate of 0.735. When an individual's chance to be a civil servant increases by one unit, the log-odds of sourcing bean seed from the local grains market relative to certified stockists increases by 73.5%. These civil servants who are part-time farmers have the advantage of accessing the local grains market frequently and at no extra costs. This is because often they commute to work places and can conveniently stop by such markets to purchase beans.

The nature of land ownership (OWNSHPLAND=1) negatively influenced choice of neighbourhood and local grains market as source of bean seed relative to certified stockists. The logit estimates are -0.108 and -0.223 respectively. A unit increase in opportunity to own land with title deed reduces the log-odds of choosing neighbouring farmers and local grains market as sources for bean seed by 10.8% and 22.3% respectively. The possession of land title deed is an incentive to invest in bean production not only for subsistence but also as source of household income. Ownership of land with title deed is a critical element for higher levels of investment on land and intensification of agricultural production through enhanced access to credit as well as increased flexibility for reallocation of production factors to maximize allocative efficiency in land use (Dube and Guveya, 2013).

7. Conclusions

The study revealed that smallholder bean farmers bear varying socio-economic characteristics including age, years of schooling, gender, main occupation and nature of land ownership. Smallholder bean farmers use different methods to control seed quality at pre-planting, planting, post planting, harvesting and post-harvest stage. The most popular methods are cultural practices. Generally, farmers assess quality characteristics and seed which is free from insect attack is considered as being of high quality. However, nearly all farmers experienced storage problems – most common being insects and rodents. There exists a web of social networks which define the relationships that are developed, established and used by smallholder bean farmers and are critical in exchanging information, seed and other resources. The most prominent ties are those between farmers and fellow farmers; which highly influences the farmers' choice of bean seed sources; with consequence on the quality of seed so accessed by farmers. Finally, the observed differences in socio-economic characteristics have implications on the choice of bean seed sources in the informal sector. For instance, as the age of a farmer advances they tend to prefer sourcing bean seed from either their own harvest stock or from neighbours.

8. Recommendations

Given the dominance of the informal seed sector in supplying seed to smallholder farmers, an integrated seed system should be designed, tested across the study area among the farmers and possibly scaled out to other legume crops facing similar seed situation as the common bean. The suggested integrated system would have aspects of both the formal and informal systems. For instance, whereas farmers practice seed quality control, the methods they use may not be efficient enough to prevent post harvest losses. The formal sector can therefore take a lead in providing technical backstopping to enhance farmers' skills in pre and post harvest management of beans.

Farmers preference for certain bean varieties can be used as a strategy by bean breeders, seed systems specialists and agencies engaging in seed aid to target seed development, delivery and interventions based on the preferences. This can indirectly contribute to high rates of acceptability and adoption of such varieties. Consequently, this can prevent any wasteful use of resources on development of varieties which might otherwise be rejected by farmers.

Age plays a critical role in farmers' choice of seed source. Younger farmers can be a prime avenue for introducing new varieties as well as non-varietal technologies in the communities. A viable approach would be to use youth groups as springboards for such initiatives.

The in degree, betweenness and closeness centralities evidenced in this study should be exploited to hasten diffusion of resources (seed, information) and other improved technologies to other farmers. This is based on the premise that farmers trust one another and would easily accept a new technology if a fellow farmers has approved of it. The starting point would be to identify the key person with highest influence in the social network and scale out to the entire community.

Acknowledgements

The authors express their gratitude to African Economic Research Consortium (AERC) for supporting the study both financially and Egerton University for the technical support. We gratefully acknowledge the smallholder farmers in the study area for cooperating during the study and providing the critical data.

References

Almekinders, C. (2000). Increasing the Resilience of Farmers' seed system through linkage with formal sector, technology and Agrarian Development. *Targeted seed aid and seed systems interventions* (pp. 69-73). The Netherlands: Wangenigen University.

Asfaw, A., Almekinders, M., Struik, C. and Blair, W. (2013). Farmers' common bean variety and seed management in the face of drought and climate instability in southern Ethiopia. *Academic Journals*: 1022-1037.

Audu, S., Aremo, O., Lajide, L. and Oko. J. (2014). Functional Properties of Processed Pinto Bean (*Phaseolus vulgaris* L.) grown in Plateau State. *Chemical and Process Engineering Research.* Lagos, Nigeria.

Audu, S., Aremu, O. and Lajide, L. (2013). Influence of traditional processing methods on the nutritional composition of black turtle bean (Phaseolus vulgaris L.) grown in Nigeria. *International Food Research Journal*: 3211 –3220.

Baniya, B. D. (2003). Factors affecting seed systems, experience from Nepal, Nepal Agricultural Research Institute. Pucallpa, Peru.

Birachi et al. (2011). Factors influencing smallholder farmers' bean production and supply to market in Burundi. *African Crop Science Journal:* 335-342.

Bouchenak, M. and Lamri-Senhadji, M. (2013). Nutritional Quality of Legumes and their Role in Cardiometabolic Risk Prevention, a review. *Journal of Medicinal Food*: 185-198.

Buruchara, R. (2011). Development and delivery of bean varieties in Africa: the Pan Africa Bean Research Alliance (PABRA) model. *African Crop Science Journal*: 227-245.

Buruchara, R. (2007). Background information on Common Beans (*Phaseolus vulgaris* L.) in Biotechnology, breeding and seed systems for African crops. *African journal of Biotechnology*: 84-92.

Butts, T. (2008). "Social network analysis: A methodological introduction" *Asian Journal of Social Psychology:* 13-41.

Case, K.E. and Fair, R.C. (1992). *Principles of Microeconomics. 2nd Ed.*Prentice Hall Inc.Eaglewood cliffs, New Jersey.

Carrington, P., Scott, J, and Wasserman, S. (2004). *Models and Methods for Social Network Analysis.* New York: Cambridge University Press.

CRS. (2014). Introduction – Improved Seed Storage Briefs. Nairobi: Catholic Relief Services.

CRS. (2013). Documenting and Socializing Lessons Learned from 7 OFDA Grants on Household Seed Storage.

Workshop held: April 15–19th 2013. Bujumbura, Burundi.

CRS. (2011). From relief to resilience – linking Burundian farmers and researchers in evaluating improved bean varieties. Catholic Relief Services: Bujumbura, Burundi.

Chai, S. (2001). *Choosing an Identity: A general model of preference and Belief Formation.*The University of Michigan press. Michigan, USA.

Claude R., Dickinson M., Mayes S. and Assefa T. (2009) 'Seed- Health Assessment of different Bean Seed Grades and Sources from Ethiopia Using Molecular Tools' *Journal of New Seeds:* 293-310.

DARTS. (2010). Annual Report. Seed Services. DARS: Lilongwe, Malawi.

Doreian, P., Vladimir, B. and Anuska, F. (2005). "Positional analyses of sociometric data." Chapter 5 pages 77-97 in Carrington, Peter J., John Scott, and Stanley Wasserman (eds.) *Models and Methods in Social Network Analysis.* Cambridge: Cambridge University Press.

FAO. (1999). *Seed Policy and programmes for Sub Saharan Africa.*Food and Agriculture Organization of the United Nations. Rome, Italy.

FAO. (2004). Seed Multiplication by resource-limited farmers. *Proceedings of the Latin American workshop, Goiania Brazil, 7-11 April, 2003.*Food and Agriculture Organization of the United Nations. Rome, Italy.

Faust, K. (2007). Very Local Structure in Social Networks." *Sociological Methodology*, 37:209-256.

Faust, K. and Fitshugh, S. (2012). Social Network Analysis: An Introduction. *2012 ICPSR Summer Program in Quantitative Methods of Social Research*. The Odum Institute, University of North Carolina, Chapel Hill, USA.

Friedman, D. and Hechter, M. (1988). The contribution of Rational Choice Theory to Microsociological Research. *Sociology Theory.* 6:201-218.

Hanneman, A. and Riddle, M. (2005). Introduction to social network methods. Riverside, CA: University of California, Riverside.

Jacknon, M.O. (2008). *Social and Economic Networks*. Princeton University press, Princeton – New Jersey, USA.

Jones, K. (2013). The political ecology of market-oriented seed system development and emergent alternatives. *The Journal of Peasant Studies*: 1-26.

Karrfalt, R.P. (2013). The importance of good seed. In: Haase, D.L., Pinto, J.R., Wilkinson, K.M, technical coordinators. National Proceedings: Forest and Conservation Nursery Associations—2012. Fort Collins (CO): USDA Forest Service, Rocky Mountain Research Station. Proceedings RMRS-P-69. 49-52.

Katungi, E., Farrow, A., Chianu, J., Sperling, J. and Beebe, S. (2009). *Common bean in Eastern and Southern Africa: a situation and outlook analysis.* International Center for Tropical Agriculture. Kampala, Uganda.

Katungi, E., Wozemba, D. and Rubyogo, J.C. (2011). A cost benefit analysis of farmer based seed production for common bean in Kenya. *African Crop Science Journal*: 409-415.

Kothari, C. (1990). *Research Methodology, Methods and Techniques.* New Delhi-110002, India: New Age International (P) Ltd., publishers, 4835/24.

Knoke, D. and Yang, S. (2008). *Social network analysis* (Vol. 154). Sage publishers, London.

Legesse, H., Negussie, D., Setegn, G., Geremew, B. and Firew, M. (2013). Multivariate Analysis as a Tool for Indirect Selection of Common Bean Genotypes (Phaseolus vulgaris L) for Soil Acidity Tolerance under field conditions. *Science, Technology and Arts Research Journal*: 7-15.

Leterme, P. (2002). Recommendations by health organizations for pulse consumption. *British Journal of Nutrition*: 239-242.

Louwaars, N. and Gam, M. (1999). *Seed supply system in developing countries.* The Netherlands: CTA.

Maredia, M., Dancun, B., Anwar, N., Maria, W. and Kajia, K. (1999). *Increasing seed system efficiency in Africa; concepts, strategies and issue.International development working paper.* Michigan: MSU.

McGuire, S. (2005). *Re thinking seed system analysis and reform for sorghum in Ethiopia.* The Netherlands: Wangenigen University.

McCloskey, D.N. (1996). *The Economics of Choice. Neoclassical Supply and Demand, Economics and the Historian.*University of California Press.Berkeley, Los Angeles

Miller, R.L. (1994). *Economics Today, the Micro View. 8th Ed.* Harper Collins College Publishers. New York.

Mugonozza, S. (2001). *Seed system in Africa* . International center for agriculture research in the dry areas (ICARDA).

Olaofe, O. Famurewa, V. and Ekuagbere, A. (2010). Chemical and functional properties of kidney bean seed (*Phaseolus vulgaris* L.) flour. *International Journal of Chemical Sciences*: 51 –69.

PABRA. (2014). Innovation partnership: Agricultural research in Africa. *End of 2009–2014 Phase Report and Partnership in Research for Impact*: Case of Common Beans in Ethiopia.

Parkin, M. (1997). *Microeconomics. 3rd Ed. Updated Edition. The Addison-Wesley Series in Economics.* Addison Wesley Longman Inc. New York.

Powell, A. (2009). The importance of quality seed in agriculture. *What is seed quality and how to measure it?.*University of Aberdeen, UK.

Rebello, C. (2014). A review of the nutritional value of legumes and their effects on obesity and its related co-morbidities. *Journal of Food and Nutrition Research*: 392-407.

Robins, G., Pip P., Yuval, K. and Dean, L. (2007). An introduction to exponential random graph models for social networks. *Social Networks*: 173–191.

Rohbarch, D. (2002). *Comparative study of three community seed supply strategies in Tanzania, International Crops Research Institute for the Semi-arid Tropics.* Bulawayo, Zimbabwe: ICRISAT.

Rubyogo J.C., Sperling L., and Buruchara R. (2010). Bean Seed Delivery for Small Farmers in Sub-Saharan Africa: The Power of Partnerships. *Society & Natural Resources: An International Journal*: 285-302.

Rubyogo J.C., Sperling L. and Assefa T. (2007). A new approach for facilitating farmers' access to bean seed. *LEISA Magazine:* 27-29.

Rule, J. (1997). *Theory and Progress in Social Science.* Cambridge University Press.New York.

Secretariat, Bondo District (2005). *Bondo district strategic plan 2005-2010 for implementation of the national population policy for sustainable development.* Nairobi.

Secretariat, Bondo District (2006). *District Environment Action Plan (DEAP)-Bondo district (2006-2011).*Nairobi.

Shi, J. (2004). Saponins from edible legume: chemistry, processing and health benefits. *Journal of medicinal food*: 67-78.

Soniia, D., Roger, K. and Sarah, K. (1999). Assessing the impact of bush bean varieties on poverty Reduction in sub-saharan africa: evidence from Uganda. Paper presented at the workshop "Assessing the Impact of Agricultural Research on Poverty Alleviation", San Jose, Costa Rica, 14-16 September 1999.

Sperling, L. and McGuire, S.J. (2010). Understanding and strengthening informal seed markets. *Experimental Agriculture*46: 119-136.

Sridhar, S. and Kumar, A. (2013). Seed Treatment Techniques. Centre for Indian Knowledge Systems (CIKS) Seed Node of the Revitalising Rainfed Agriculture Network. PM Digital products - Peters Road, Chennai, India.

Stone, G. (2004). Boitechnology and the political ecology of information in India. *Human Organization*: 127-140.

Sylvester, S. (2013). Land tenure reforms and investment in Tanzania. *Masters dissertation, University of Dar es Salaam*, Tanzania.

The crops Act (2013). Assented on 14th January, 2013. *Kenya Gazette Supplement No. 16,* pp. 25-29. Nairobi.

Tsgedingile, M. (2002). *Potential and limitation of smallholder seed production in Ethiopia: the case of Soro district. An MSc thesis presented to Sokoine University of Agriculture.* Morogoro.

Varian, H.R. (1999). *Intermediate Microeconomics: A modern approach. 5th edition.* Norton and Company. New York.

Venn, B. (2004). Cereal Grains, Legumes and Diabetes. *European Journal of Clinical Nutrition:* 1443-1461.

Walelign, G. (2008). *Determinants and role of farmers' seed and seedling multiplication in the SNNP region seed system. A thesis submitted to the Department of Agricultural Economics, School of graduate studies, Himaraya University.* Addis Ababa: Himaraya University.

WBG. (1999). *Sub saharan Africa seed initiative, program description, World Bank Group.* African Region: World Bank Group.

Welfzien, E. and Brocke, K.V. (2001). Seed systems and their potential for innovation; conceptual framework for analysis, Hohenheim University. *Targeted Seed and Seed-system interventions. Strengthening Small-Farmers seed systems in East and Central Africa* (pp. 1-112). Kampala: Hohenheim University.