

Motivations and Mental Models Associated with Smallholder Farmers' Adoption of Improved Agricultural Technology: Evidence from Use of Quality Seed Potato in Kenya

Julius Okello¹ · Yuan Zhou² · Ian Barker² · Elmar Schulte-Geldermann¹

Published online: 5 June 2018

© The Author(s) 2018, corrected publication July 2018

Abstract Potato is a major food staple that makes a significant contribution to food security, having potential to smooth the volatility in food prices resulting from recent episodes of global food price increases. Despite its importance, most potato growers continue to use poor-quality seed, normally obtained from local/community sources. This study uses means-end chain theory to examine the drivers of use of quality seed potato, and the mental models associated with quality seed potato use. It finds that the decision to purchase and use quality seed is driven by deep-seated life goals that farmers pursue, and that profit-making is merely a means to these end/life goals. It further finds that the structure of mental models differs by the gender of the adopter and between adopters and nonadopters. The study concludes that the structure and content of farmers' mental models differ by farmer type. The implications of the study findings for policy are discussed.

The original version of this article was revised: With the author(s)' decision to opt for Open Choice the copyright of the article changed on June 2018 to © The Author(s) 2018.

✉ Julius Okello
jjokello@gmail.com

Yuan Zhou
yuan.zhou@syngenta.com

Ian Barker
Ian.Barker@syngenta.com

Elmar Schulte-Geldermann
E.Schulte-Geldermann@cgiar.org

¹ International Potato Center, SSA Regional Office, Nairobi, Kenya

² Syngenta Foundation for Sustainable Agriculture, B.1.4., 215 Schwarzwaldallee, 4058 Basel, Switzerland



Résumé La pomme de terre est un aliment de base important qui contribue de façon significative à la sécurité alimentaire et qui a le potentiel important de lisser la volatilité des prix des aliments résultant des récentes hausses de prix des denrées alimentaires mondiales. Malgré son importance, la plupart des producteurs de pommes de terre continuent d'utiliser des graines de mauvaise qualité, généralement obtenues auprès de sources locales/communautaires. Cette étude utilise la théorie de la chaîne des moyens et des fins pour examiner les facteurs d'utilisation de la pomme de terre issue de graines de qualité ainsi que les modèles mentaux associés à cette utilisation. L'on constate que la décision d'acheter et d'utiliser des graines de qualité est motivée par des objectifs de vie profondément ancrés chez les agriculteurs, et que générer des profits n'est qu'un moyen d'atteindre leurs fins/leurs objectifs de vie. En outre, l'article constate que la structure des modèles mentaux diffère selon le sexe de l'adoptant et entre les adoptants et les non-adoptants. L'étude conclut que la structure et le contenu des modèles mentaux des agriculteurs diffèrent selon le type d'agriculteur. Les implications des résultats de l'étude pour la politique sont discutées.

Keywords Quality seed · Adoption · Smallholder farmers · Mental models · Gender · Kenya

Introduction

Potato (*Solanum tuberosum*) is the fourth most important crop globally. It is a major food staple and food security crop, and a major source of livelihood, for smallholder households in the tropical highlands of Sub-Saharan Africa (SSA) (Haverkort and Struik 2015). More recently, potato has played a major role, in its producing areas, of relieving pressure on cereals caused by recent episodes of world food price increases (Muthoni et al. 2010). These episodes of food price increases/inflation date back to 2007/08, when prices of major cereals, the main food staples in most countries of SSA, increased sharply. It is estimated that potato constitutes more than 50% of the food and income sources of such households in Kenya (Muthoni et al. 2010; Mpogole et al. 2012). Further, potato is currently a multibillion-Naira enterprise in Nigeria, where it has been a major staple (Zang 2014) and is growing in importance in Ethiopia (Abebe et al. 2013), Rwanda, and Burundi as a food staple. Thus, it is considered a hidden treasure for smallholder farmers in many highland and temperate areas of developing countries (Lutaladio and Castaldi 2009). Indeed, early estimates indicated that demand for potato in Sub-Saharan Africa (SSA) will increase by 250% by 2020 (Scott et al. 2000). This was before the food price inflation witnessed since 2008.

Despite the importance and growing demand for potato, expansion of its production in tropical highlands of Africa has been seriously undermined by the lack of good-quality seed potato, that is, seed that has been inspected and certified as free from pests and diseases by an authorized seed certification agency. Most farmers rely on own-saved seed or seed purchased from local sources (usually family, friends, neighbors, and local markets). Such seed is often loaded with diseases (especially viruses) and pests (Turkensteen 1987; Gildemacher et al. 2009; Hirpa et al. 2010) that seriously reduce yield. Studies indicate that more than 60%



of potato growers in SSA do not use quality seed (Kanyeka et al. 2007; Al-Dalain 2009; Namwata et al. 2010). In Kenya, it is estimated that more 76% of smallholder farmers use seed from noncertified sources (Mcguire and Sperling 2016). The most common sources of seed among these farmers in Kenya were own-saved seed, friends, family, and local ware potato markets.

In this work, we used a novel methodology based on a theory that combines principles of economics and social psychology to investigate what motivates potato farmers to adopt quality seed potato. Adoption literature typically argues that farmers' decision to adopt a new or improved technology is motivated by the incentives and capacity to do so (Otieno et al. 2012; Timu et al. 2014). The former usually focuses on the benefits of adopting improved technology, with benefits defined in terms of financial gain. Hence mainstream neoclassical economic thinking is that farmers will adopt a new or improved technology when such benefits outweigh the cost of changing to the new technology (Ali and Abdulai 2010), given the capacity¹ to do so. More specifically, it is assumed that farmers are driven to adopt a new or improved technology by the desire to maximize net returns (profits) (Becerril and Abdulai 2010). Rogers (1995, pp. 212–219) summarized these drivers into five constructs, namely relative advantage, complexity, observability, compatibility, and trialability, with the first construct being an *incentive* while the rest are *capacity* constructs. However, this model of the farmer decision-making process has come under increased criticism for not taking into account some of the institutional factors that influence individuals' behavior in the modeling of human decision-making process and behavior (Lynne 1995; Mason and Ricker-Gilbert 2013). It especially has been criticized for ignoring the role that human/personal values, and mental models in general, play in the decision-making process (Heisey and Brennan 1991; Gowdy and Olsen 1994; Lynne 1995; Kaufman 2007; Mason and Ricker-Gilbert 2013). Recent studies acknowledge that human beings are influenced by social, psychological, and cultural factors, and that these factors in turn influence the decision-making process (Demeritt and Hoff 2015); For instance, while neoclassical microeconomic theory considers economic actors to be selfish (i.e., act in self-interest), there is evidence that individuals' decision-making and actions are influenced by what others in their circle of influence (i.e., network) are thinking and expect from them (Fourcade 2011). We, in this study, therefore use a theory that allows for understanding of the adoption decision-making process in the context of how the adopter "sees the world," and how these decisions are conditioned by self-identity in their social, psychological, and cultural context.

This study differs from previous adoption studies by examining the content and structure of mental models associated with adoption of quality seed potato and personal values that drive such decisions; That is, it goes beyond the usual microeconomic analysis, which focuses on *incentives* and *capacity* variables, to assess psychosocial factors that underlie the decision to adopt a new or improved technology. Specifically, it examines personal life goals or aspirations (i.e., values) that underlie the adoption decision-making process, over and above the incentive and capacity factors. It uses the means-end chain (MEC) approach, developed by

¹ Capacity in this case refers to availability of human skills, land, finances, among others, needed to adopt the improved technology.



Gutman (1997) and Olson and Reynolds (2001), that applies the principles of social psychology to explain economic behavior. Our study is therefore in line with current thinking that emphasizes the need to understand individuals' mental models and how they influence their behavior and, subsequently, their development outcomes (Hoff 2015; Banson et al. 2015; World Bank 2015). We find that farmers' decision to adopt quality seed potato is driven by social factors, particularly the need to realize a set of personal values in life, and that increased income/revenues is merely a means to these higher life goals and not the ends in themselves. Thus, our study explains the structure of incentives aside from the profit-making goals usually assumed by neoclassical economic theory.

The rest of this paper is organized as follows: [Theoretical Framework for Analysis of Motivations](#) section outlines the theoretical framework and discusses the means-end chain approach to unearthing deep-seated meaning representations (i.e., mental models) associated with quality seed potato adoption decision-making by smallholder potato growers. In [Empirical Methods](#) section, we present the empirical methods used to select respondents from among potato growers in the Mount Kenya region. The region is one of the leading potato-producing areas in Kenya. It has, since 2011, benefited from quality seed produced by a private firm, Kisima Farm Ltd., which is currently an important source of quality seed potato for thousands of smallholder farmers within 40 km radius from it, selling certified/quality seed at a lower price than government sources. In [Findings](#) section, we discuss the results of the analysis of motivations to adopt quality seed from Kisima Farm. We especially examine whether the content and structure of mental models associated with purchase of quality seed potato differ between male and female adopters of quality seed potato. We further compare the structure of mental models of users of quality seed potato with that of nonusers. Finally, in [Summary, Conclusions, and Implications](#) section, we present the conclusions of the study and discuss the implications of our findings for policy and the breeding process.

The Context

Recent studies indicate that the majority of smallholder farmers rely on self-saved seed or seed from local sources (McGuire and Sperling 2016). Seed from such sources is usually infected with viruses that can significantly reduce yield. Indeed, use of poor-quality seed has been associated with the current low yields in smallholder farms, which is about 8–10 tons per hectare compared with 20–30 tons per hectare in more developed countries. In Kenya, yields average 8.7 tons per hectare (Okello et al. 2017). Thus, there exists a large yield gap that could be reduced by application of quality seed (Walukano et al. 2016; Nyongesa and Schulte-Geldermann 2015).

To tackle the quality seed potato bottleneck and reduce the yield gap, a number of strategies are being applied in Sub-Saharan Africa. One such strategy, involving public–private partnerships comprising the government, a private-sector actor, and a research organization, has been seeking ways of shortening the process of producing new/quality seed. This effort led to the invention of a state-of-the-art technique for producing quality seed within a very short time. The method, known as 3-G (for three generations) makes seed potato available to farmers after only three



generations of field testing compared with the traditional 5–6 years (Sharma and Pandey 2013; Chindi et al. 2014). The private-sector partner is normally strategically located in the producing area, hence closer to the majority of smallholder producers, which increases farmer access to seed. This model of making quality seed potato accessible to smallholder farmers has been pilot-tested in Tanzania, Ethiopia, and Kenya. Okello et al. (2014) found that the majority of smallholder farmers were willing to pay a higher price for this kind of quality seed potato than the prevailing market prices for local seed. However, to date, there has not been a systematic study of what would motivate smallholder farmers to adopt quality seed potato.

Theoretical Framework for Analysis of Motivations

This study used the means-end chain (MEC) theory, which draws from economic psychology (Reynolds and Gutman 1988). The theory was, until recently, used in the context of consumer products. In general, the theory posits that an individual's decision to purchase or consume a product is driven by the characteristics of the product and the benefits the product offers, and that the benefits of purchasing or consuming the product are, in turn, associated, with a range of personal/social life values (or core goals) one wishes to fulfill in life.

The MEC theory is essentially a hierarchy of an individual's perceptions of a product's features/characteristics, known as *attributes* (A), how the features relate to the product's benefits/outcomes, also known as *consequences* (C), and, ultimately, how the consequences are associated with core/personal life goals that motivate the use/consumption of the product, i.e., *values* (V). The *attributes* are usually at the base of the MEC analytical hierarchy, and are the most recognizable features of the product to an individual. They are features that confer some benefits (utility) to an individual (i.e., a farmer, in our case). In the context of this study, attributes can include high-yielding or drought-tolerance nature of a variety.

Attributes, in turn, are associated with one or several *consequences*, which are defined as the desired outcomes that an individual wants from a product. These consequences can be direct, indirect, physiological, psychological, or sociological in nature (Gutman 1997); For example, use of fertilizers (an *attribute*) in soil fertility management can be associated with higher yield (first *consequence*) (Okello et al. 2014). This higher yield can lead to better/good nutrition (second *consequence*), which is, ultimately, driven by the desire to be healthy (*value*). It may also include having more potato (food) at home (a *consequence*), in our study context, resulting in a sense of security (a *value*) against shortage of food (i.e., food security).

Values are therefore the end states of the MEC and are cognitive representations of an individual's existential goals. Values are hence similar to needs/desires that motivate the actions that are taken or decisions that are made by an individual. Roccas et al. (2002) argue that *values* represent the personal standards that guide an individual's thoughts and actions, and are cognitive representations of an individual's needs and desires, on the one hand, and of societal demands on that individual on the other; That is, *values* are translations of an individual's needs into



a socially acceptable form that could be presented and defended publicly (Mason 2004).

In the context of this study, therefore, the MEC posits that the decision to purchase (i.e., adopt) quality seed, or otherwise, is driven by the characteristics/features (i.e., *attributes*) of the seed. Such characteristics/features can include superior yielding ability or cooking quality. In line with Rogers' (1995) adoption model, these features can be observable, compatible with farmers situation or noncomplex, so that the farmer has *capacity* to adopt quality seed. The characteristics (i.e., *attributes*) confer on the seed some benefits (i.e., *consequences*), including increased income, which in the context of Rogers' model of technology adoption is the relative advantage (i.e., *incentive*) to adopt quality seed. The benefits ultimately meet the aspirations or life goals (i.e., *values*) that motivate potato production, which could be in the form of a healthy life or happiness.

In MEC analysis, the attribute–consequence–value (A–C–V) sequence forms a chain known as a *ladder*. A collection of all the ladders for a given domain forms a hierarchical value map (HVM) that illustrates all the major means and end values, and describes individuals' behavior based on their core values. These maps usually contain many product attributes that are linked to a set of consequences, which are, in turn, mapped to a set of personal/core values. A HVM basically represents how various constructs related to a product (i.e., attributes, consequences, and values) are mapped (i.e., arranged) in an individual's mind, sometimes being referred to as a mental representation of the laddering constructs. The arrangement relationship between the various constructs and how they are arranged in the HVM thus provides the structure of mental models underlying a decision-making process.

Personal values are deep-seated in individuals' minds and thus can only be recovered using techniques that enable an individual to “bring them to the surface.” One of the recommended techniques for recovering mental constructs is the laddering technique, discussed in [Interview Procedure](#) section below. This technique has its roots in personal construct theory developed by Kelly (1977) and is extensively used in many consumer studies that attempt to delve into the subconscious world of an individual's mind (Modesto et al. 2006; Nunkoo and Ramkissoon 2009). It was recently applied by Okello et al. (2014) and Lagerkvist et al. (2012) in agriculture.

Empirical Methods

Study Area and Sampling Procedure

The information used in this study was collected from potato farmers in six districts of the Mt. Kenya region (Fig. 1), namely Buuri, Igembe Central, Igembe South, Laikipia East, Meru Central, and Tigania East. These districts were chosen due to their proximity to Kisima Farm Ltd., thus ensuring that farmers in the targeted area were either aware of or using certified seed at the time of study. In addition, these districts, and the Mt. Kenya region in general, represent one of the most important potato-producing areas in Kenya. In each of these districts, the study focused on





Fig. 1 Map of Kenya showing the study area

villages with smallholder potato farmers who had purchased and planted quality seed during any of the four seasons of the 2 years preceding the study.

The study respondents were selected using the following procedure: First, a list of all villages in each of the selected districts was obtained from local agricultural officers and area administrators and 34 villages were selected based on the number of households who purchased quality seed during the 2 years preceding the study.

Second, for each village, a list of all the farmers who had purchased quality seed potato from Kisima Farm Ltd. during the 2 years prior to the study was drawn up with the help of local administrators (village heads), frontline extension workers, and contact farmers. A second list of potato growers who did not purchase seed potato from Kisima Farm Ltd. was also drawn up. Third, from each village, three farmers were randomly selected from the two lists using probability proportionate to size sampling; That is, more respondents were drawn from the list with more names



(i.e., the longer of the two lists). This procedure yielded a total of 102 farmers for the interviews. However, six of the selected laddering farmers declined the interviews, citing time constraints, resulting in a 6% nonresponse rate. Among those interviewed, 51 were users of quality seed, while the rest (i.e., 45) were nonusers. The village headman and/or frontline extension worker who assisted in the household listing facilitated access to the sampled respondents, and guided the interview team around the villages. However, each interviewer verified the details of the respondent prior to proceeding with the interviews.

The interview team comprised two trained research assistants supervised by the lead author. Both had conducted laddering interviews before, but were thoroughly trained prior to onset of interviews as a refresher, and to give them adequate understanding of the context of the study area and culture/customs of the community. Trial runs (i.e., pretest) interviews with four nonsampled farmers were conducted under the supervision of the lead author, and lessons and experiences from this exercise were used to refine the interview procedure. The interviews ran from March to May 2014. The interviews were conducted in either Kiswahili or local language depending on the preference of the respondent. The interviewers were both fluent in the languages used for interviews and understood local culture.

Interview Procedure

This study used both hard and soft laddering techniques [see Lagerkvist et al. (2012) for a discussion on this] to generate mental constructs that farmers relate with the purchase of quality seed potato. In hard laddering, the interviewer intervenes during the interview to clarify unclear constructs and issues or unblock the interview when the respondent is unable to proceed or the responses become circular. In soft laddering, on the other hand, the respondent talks freely about the product without such interruptions. As recommended by Reynolds and Gutman (1988) and Okello et al. (2014), the interviewer started each laddering interview as follows:

Ms/Mr ... we noted that you, in the last 2 years, decided to purchase and use quality seed potato (continued growing your own-saved seed or seed you purchased from local sources). Why did you decide to invest in the purchase and use of quality seed potato (choose to plant own-saved seed or seed purchased from local sources) during this period?

Based on the response to this question, characteristics (*attributes*) that attracted the respondent to invest in the purchase and use of quality seed potato (continue growing own-saved seed or seed purchased from local sources) were listed. Next, the interviewer used a series of “why is that important to you” questions to conduct laddering interviews on each of the attributes identified by the respondent. This method of interview has the advantage of “inducing” individuals to dig into the subconscious mind and retrieve the motivations that drive actual actions or decisions and the associations among the constructs in the respondent’s mind (i.e., mental maps of the constructs).

Following the interviews, a set of summary codes were developed to ensure that all the attributes, consequences, and values mentioned by all the respondents were



covered. The coding process allows the analyst to group together constructs from different respondents that are similar or are closely related,² and for the analyst to provide a term or meaning that captures different constructs. Subsequently, the personal values stated by the various respondents were sorted following the classification of Reynolds and Gutman (1988), de Souza Leao and de Mello (2007), and Okello et al. (2014), after similar coding as in the case of the attributes and consequences. Broadly, these studies categorize values into two broad dimensions, namely: (i) values relating to the type of personal objectives/goals an individual has; and (ii) values that reflect the type of behavior that one might use to achieve these goals. The former includes desires for “healthy life” or “happiness,” while the latter could include “being helpful” to others or “being independent,” which most people would associate with not bothering people by relying on them to meet personal needs.

The coded data were then entered into and analyzed using MECAnalyst 1.0.15 software. This software constructs an implication matrix that captures how concepts that have been mentioned are linked to each other, both directly and indirectly, and the frequency of association. It also enables aggregation of several means-end chains (MECs) (also known as ladders) into a hierarchical value map (HVM). The HVM in this case depicts the cognitive or motivational decision structure of the farmer regarding investment in the purchase and use of clean seed (Grunert and Grunert 1995). To assess differences in the motivational structure of male and female users of quality seed, HVMs were generated for these two groups separately. In addition, differences in the motivation to invest in the use of quality seed between users and nonusers were captured by generating different HVMs for each group.

Findings

Characteristics of the Study Respondents

The summary statistics of the farmers who participated in the laddering interviews are presented in Table 1. It shows that the participants had an average age of approximately 50 years but the quality seed potato users had slightly higher level of education. Indeed, the results show that users of Kisima seed had, on average, postprimary level of education. This implies that quality seed users are likely to be better at obtaining processing and using production and marketing information³ than their counterparts. Users were also better off than their counterparts in terms of asset ownership, measured in terms of value of livestock owned by the household. In addition, users differed from their counterparts in terms of distance to the source of quality seed (i.e., Kisima Farm Ltd.), with nonusers being located, on average, much

² For instance, different respondents may say that good taste results in “being satisfied,” “feeling full after eating,” or “finishing my meal.” An analyst during coding may decide to use the construct “satiated” to capture these three constructs from different respondents. Coding helps reduce the number of constructs that can be captured in a HVM, which is especially useful when the sample size is large and different respondents use different words/terminologies/phrases to describe the same construct.

³ We thank an anonymous reviewer for suggesting this point.



Table 1 Summary characteristics of participants of the laddering interviews, for users versus nonusers

	Users (<i>n</i> = 51)		Nonusers (<i>n</i> = 45)	
	Mean (SD)		Mean (SD)	
	Male	Female	Male	Female
Age (years)	48 (11.66) ^a	52 (9.03)	51 (13.68)	50 (14.50)
Education (years)	9.9 (2.36)	9.6 (5.59)	8.7 (3.26)	6.5 (3.49)
Distance to Kisima Farm (km)	21.84 (21.40)	27.47 (23.40)	13.96 (11.13)	30.79 (21.93)
Distance to market (min)	22.86 (14.45)	31.82 (31.64)	35.65 (28.34)	44.58 (40.94)
Value of livestock owned (*000 Ksh)	156 (153)	109 (105)	145 (141)	111 (110)

^aNumbers in parentheses are standard deviations; Ksh = Kenyan Shillings; The exchange rate at the time of this study was 1 US dollar = 86 Kenyan Shillings

further away from Kisima Farm than users. This implies that users face lower transaction costs, especially those associated with transportation of seed, than nonusers. This could be one of the reasons why the latter did not purchase quality seed. Indeed, past studies indicated that seed potato tends to be bulky, hence farmers can incur prohibitively high transport costs, especially where roads are poor or do not exist.

Motivations for Use of Quality Seed Potato

Figure 2 presents the aggregate hierarchical value map (HVM) for 51 male and female users of quality seed interviewed in this study. The map is based on a cutoff⁴ level of four, implying that a construct is included in the displayed map if at least four respondents mentioned it. The map shows that the major characteristics (i.e., *attributes*) that motivate potato farmers to invest in quality seed potato are “high yield,” “good taste,” “early maturity,” “disease resistance,” and “long-shelf life,” as shown by bold arrows⁵ that link these attributes to the next set of mental constructs. The number (nr) of respondents who mentioned high yield was 37, representing 66% of the responses (sub). The attribute “high yield” is associated in the minds of quality seed potato users with two *consequences* (i.e., benefits), namely “increased income” and ability to “educate children,” while “long shelf life” is associated with “increased income” only. This latter finding suggests that users are attracted to the quality seed potato because they can store it longer, which, in turn, enables them to engage in arbitrage; That is, long shelf life enables farmers to sell potato later in the harvest season—usually at higher prices. However, long shelf life may also be due to the desire to reduce postharvest losses.⁶

More than one-third of study respondents also mentally associated quality seed with “early maturity.” Both “high yield” and “early maturity” were directly linked

⁴ See Gengler et al. (1995) for a discussion of the importance of setting a cutoff level in HVM.

⁵ The bolder the arrow, the greater the number of respondents who mentioned the two linked constructs. Orange colors represent *attributes*, green the *consequences*, and pink the *values*.

⁶ We thank an anonymous reviewer for this suggestion.



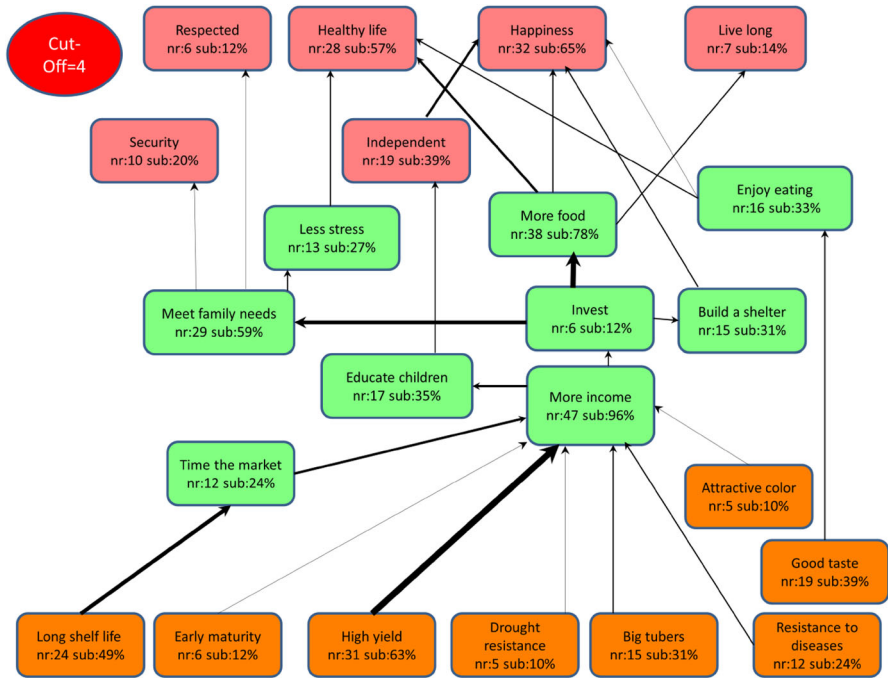


Fig. 2 Aggregate HVM for male and female quality seed potato purchasers

to “more income” arising from increased sales and the anticipated higher prices from arbitrage (due to early readiness of the crop for sale). Results show that a large proportion (100%) of the respondents identified “more income” as a major driver of the decision to purchase quality seed. This finding is in line with the adoption literature, which argues that farmers will adopt a technology if it is superior or has relative advantage over the existing technology (i.e., own seed, in this case) (Rogers 1995). This finding also corroborates Muthoni et al. (2013), who indicated that the majority of potato farmers grow it for both income and food. Notably, a larger percentage of the respondents mentally associated increased income with ability to educate children, highlighting the importance that these farmers attach to their children’s schooling.

The construct “invest,” which follows from having more income, was mentioned in the context of being able to put extra earnings from the increased income into some productive use that can generate medium- and long-term income flows for the household in the future. This consequence was associated with three other consequences: meeting continued needs of the family, being able to buy food into the future, and ability to construct a better family house/residence. The construct “meet family needs” was in turn associated with another consequence—“less stress,” by which the respondents meant avoiding the worries and anxiety of not being able to provide food and other material needs for the family.



The ability to meet family needs enables one to satisfy two personal values, namely “security” and “respect.” The mental association between satisfaction of family needs and security was made in the context of the household being secure from food shortages. The value “respect” was, on the other hand, mentioned by most respondents in the context of the feeling of being perceived by the community as successful in caring for one’s family. As shown also in Fig. 2, the respondents associated “less stress” with “healthiness” or, as the majority stated, a healthy life. This personal value was also linked to two other consequences, namely “enjoy eating” and having “more food.” Having more food is also mentally associated with the value “live long.”

The *attributes* “good taste,” a sensory attribute, and “long shelf life” were not mentally associated with “more income.” Instead, the former was associated with the *consequence* “enjoy eating,” while the latter was mentally linked to “more food.” The latter finding indicates that users of quality seed are motivated by the fact that it stores for longer, thus increasing the amount of food available to the household (i.e., making the household food secure). The final attribute, “disease resistance” was, as in the case of “high yield” and “early maturity,” also mentally associated with the consequence “increased income.”

Figure 2 further shows that two other personal values motivate the decision by potato growers to purchase quality seed. These are “independence” and “happiness.” The former was linked to ability to educate children as a result of having increased income. The respondents who made this mental association between educating children and independence argued that, when children are educated, they are able to get good jobs and meet their own needs rather than continue to depend on their parents. Such parents are “happy” because their children are, in their view, no longer dependent on others (and especially them) for financial and material support. The value “happiness” was also associated with being able to “enjoy eating” because the food tastes good.

Two other notable points arise from the aggregate HVM in Fig. 2. First, use of quality seed potato increases income, due to increased yields, which, in the minds of respondents, plays a major role in their meeting family needs and having a decent family house. Second, a relatively large number of respondents associated “long shelf-life” with the ability to time the market, and hence make more money from potato sales.

Female Potato Farmers’ Motivations for Using Quality Seed

Figure 3 presents the HVM for 21 female users of quality seed potato who took part in this study. The map is based on a cutoff level of three, implying that any construct (i.e., attribute, consequence, and value) is included in the map only if it is mentioned by at least three respondents.

The figure shows that female potato growers were motivated to purchase quality seed by six attributes, namely “good taste,” “drought tolerance,” “long shelf life,” “resistance to diseases,” “big tubers,” and “high yield.” These attributes lead to various benefits/consequences. Notably, however, “long shelf life” and “high yield” stand out as the most important, as shown by the thick bold lines, just as in



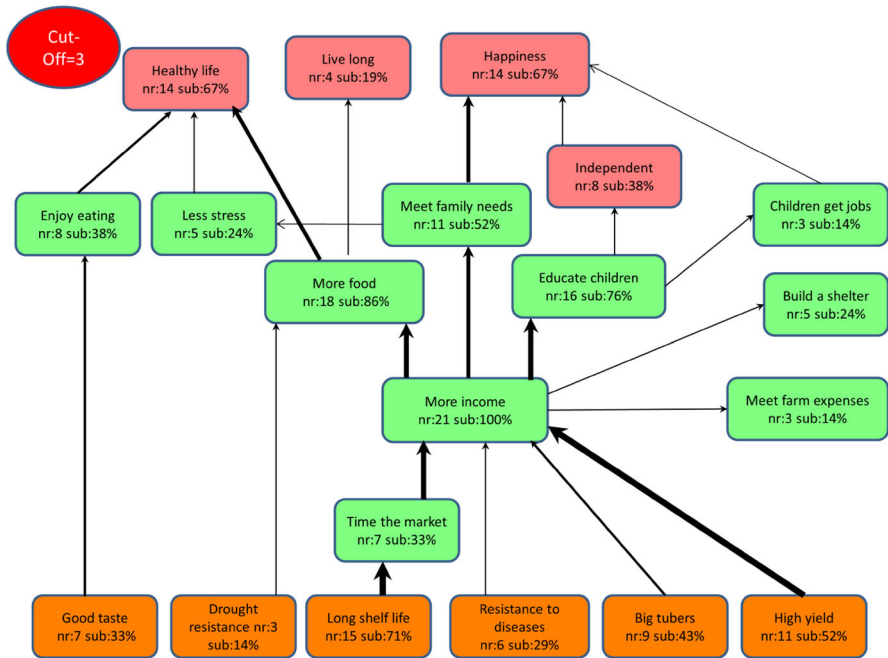


Fig. 3 Hierarchical value map for female quality seed purchasers

the case of the aggregate HVM. Indeed, 71 and 52% of female respondents associated their decision to purchase quality seed with these attributes. As in the aggregate map, “long shelf life” is associated with the “time the market,” which suggests that female quality seed users were attracted to this technology by tubers that can keep longer, thus allowing them to engage in arbitrage. As shown in Fig. 3, two other attributes, namely “big tubers” and “resistance to diseases,” are also mentally associated with increased income. This finding could be because consumers prefer medium-sized tubers while processors (e.g., manufacturers of potato chips, tortillas, and fries) prefer large-sized tubers (Abebe et al. 2013).

Female quality seed users associated increased income with three main benefits/consequences, namely having “more food” in the household (86%), children’s education (76%), and can “meet family needs” (52%). The other benefits of income (paying for farm expenses and building family house) were of little importance to female quality seed potato users. The latter finding that the majority of female quality seed potato users did not mentally associate increased income with building of family house is contrary to expectations but may be because men are often seen as being responsible for building a family house (Johansen 2014). The family needs included purchasing clothes and medical services. Meeting family needs was, in turn, associated mentally with “less stress,” which, as before, is associated with the anxiety of one’s failure to provide basic family needs.

The female users also mentally associated quality seed potato with two additional characteristics, namely “good taste” and “disease resistance.” The former was



mentally associated with the ability to “enjoy eating,” implying that food made from these potatoes is sweet to eat. Disease resistance was, on the other hand, associated with having “more food” in the household. The finding that women attach great value to the sensory and availability attributes of seed potato is in line with the fact that women tend to be responsible for food preparation and, in some cases, sourcing. In the African context, for instance, women are normally associated with deciding what food, and even the amount, the family eats (Quisumbing 1995; Gladwin et al. 2001; Yngstrom 2015). This role of women in ensuring availability of food in the household probably explains also why yield is a very important attribute to them, ranking the highest among all the attributes, as shown in Fig. 3.

These various consequences/benefits of quality seed potato are linked, in the minds of the female quality seed users, with four personal values, namely “independence,” “healthy life,” “long life,” and “happiness.” As shown by the bold arrows in Fig. 3, “healthy life” and “happiness” dominate the rest of the personal values. The figure shows that 67% of the female quality seed users are motivated to purchase the new seed potato varieties by the desire to have a healthy life and live a happy life. Figure 3 also shows that some 38% of the female respondents associated quality seed with “independence,” as discussed above. It enables children to get good education, get good jobs and, hence, support themselves rather than continuing to depend on parental support. The females’ HVM thus indicates that women are motivated to purchase quality seed potato by the desire to live a long, healthy, independent life that is afforded from the income from potato sales and access to good food.

Male Potato Farmers’ Motivations for Purchasing Quality Seed

The HVM for male quality seed potato buyers is presented in Fig. 4. Thirty male quality seed potato users took part in the study. The map is based on a cutoff level of three, indicating that attributes are displayed in the map only if at least three respondents mentioned it. The map shows that male farmers were motivated to purchase quality seed by largely the same set of attributes (characteristics) as their female counterparts, namely that quality seed will produce potato with “good taste,” “big tubers,” and that they are “resistant to diseases,” have “long shelf-life,” “high yield,” and are “resistant to pests.” In addition, however, the male respondents identified “early maturity” as a key characteristic/attribute that motivated their purchase of quality seed. The importance of early maturity is perhaps associated with the fact that prices tend to be higher earlier in the season before the glut that ensues during peak harvest time (Mulatu et al. 2005; Muthoni et al. 2013). It could also be simply because early-maturing varieties make food available faster and earlier than the rest.

Figure 4 further shows that “high yield” emerged as the most important attribute/characteristic that motivated male respondents to purchase/use quality seed. More than 70% of the respondents attributed their decision to purchase quality seed potato to this attribute. It was followed, distantly, by “good taste” (40%) and “long shelf-life” (37%). It follows that the majority of the male respondents are mostly motivated to use quality seed by “high yield” as compared with their female





Fig. 4 Hierarchical value map for male quality seed users

counterparts, most (71%) of whom were motivated to buy quality seed by the “long shelf-life.” Indeed, only about one-half of the female farmers mentally associated “high yield” with their decision to use quality seed.

All the above attributes, except “good taste,” are associated with more income in the minds of male quality seed users. Even “long shelf life,” which female quality seed users first associated with the timing of the market (i.e., exercising arbitrage), is, in the minds of male farmers, directly linked to the ability to earn more money. The figure also shows that the majority of male users of quality seed potato mentally associated high yield with more income, with 93% of the respondents making this mental link. Another major difference in drivers of purchase of quality seed between female and male respondents is with respect to the attribute “drought resistance.” While female quality seed users associated this attribute with “more food” (i.e., increased availability of food in the household), their male counterparts mentally linked this attribute to increased income, likely due to reduced losses. It is also interesting to note that fewer males (only 27% of the respondents) were motivated to purchase quality seed potato by the desire to “enjoy eating” than female respondents (38%). This suggests that male quality seed potato buyers were more interested in attributes that relate to the market for the potato tubers while their female counterparts are motivated by food attributes.

Figure 4 shows that increased income enables male farmers to get several other consequences/benefits. These are the ability to “meet family needs,” “invest in a business,” “pay for farm expenses,” “educate children,” and “build a family



house.” Meeting family needs and educating children are two dominant uses of increased income, as shown by bold arrows. Notably, unlike the case of female quality seed users, the use of increased income by male users is quite diverse, perhaps reinforcing the popular notion that men are providers. Specifically, while female respondents associated increased income with three dominant uses, their male counterparts have no outstandingly dominant use of increased income.

Male seed potato users mentally associated the ability to “educate children” with “independence,” which is a value. This suggests, as in the case of female users, that male quality seed users can use the increased income to educate their children, which, in turn, enables the latter to be independent. Ability to “meet family needs” was, on the other hand, mentally associated with less stress (a consequence) and ultimately to having a “healthy life” (value), and directly to having “security” (especially from lack of food), which is also a value.

Figure 4 further shows that increased income enables male quality seed users to “invest,” which, in turn, enables them to have more food. The consequence “invest” was mentioned in the context of doing nonfarm business that then generates additional income for the family, some of which is used to purchase food. Further increased income can, in the minds of male quality seed users, be used to buy farm inputs, which also results in the household having “more food.”

The male quality seed users mentally associated having more food with the achievement of three life goals (i.e., personal values): “happiness,” a “healthy life,” and a “long life.” These farmers also derived happiness from the ability to build a family house (shelter) out of income from increased potato yields. Additionally, Fig. 4 shows that enjoyment of eating, as a result of the “good taste” of the quality seed, is associated mentally by male quality seed users with a “healthy life” (a value). Overall, the figure shows that male and female quality seed users share four personal values when it comes to the decision to purchase and use quality seed potato, namely “healthy life,” “happiness,” “independence,” and “long life.” A notable difference between the two genders is that, in addition to these shared values, male respondents’ decision to purchase quality seed is driven by the need for security (i.e., desire to have secure livelihood). This sense of security arises from the ability to meet family needs, especially by having enough food.

Motivations for Using Seed Potato from Local Sources

The above discussion has highlighted the mental constructs associated with male and female quality seed users’ decision to use quality seed potato. A question that remains is: what kind of mental models motivate other farmers to use seed of poor quality from local sources instead? That is, what mental models are associated with nonadoption of quality seed? Are users of seed from local sources driven by a different set of mental constructs? If so, how does the structure of the mental models of users of quality seed differ from that of their counterparts? To investigate these questions, we conducted the same kind of laddering interviews among male and female farmers who used seed from local sources (Fig. 5). Some of the seed purchased by these respondents from the local sources was of different varieties of



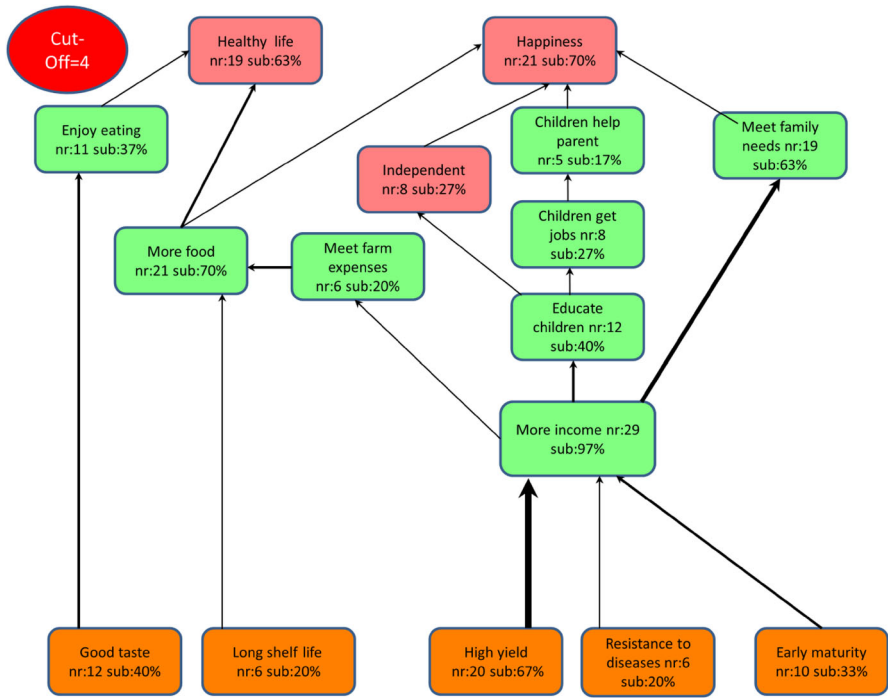


Fig. 5 Aggregate HVM for male and female farmers who purchase seed potato from local sources (i.e., nonadopters)

potato, while others were of the same variety as those produced by Kisima Farm but had been planted for several seasons, hence had accumulated diseases.

The HVM in Fig. 5 resembles that in Fig. 2, with which we compare it, in several aspects. First, it shows that the attributes/characteristics that motivate the purchase of seed potato from local sources are similar to those of users of quality seed. They are “good taste,” “long shelf life,” “high yield,” “disease resistance,” and “early maturity.” Second, as in the aggregate HVM for male and female quality seed users, yield is the main attribute that motivated the farmers that use local sources of seed potato to purchase low-quality seed potato. This is not surprising. The majority of the farmers in the study area grow potato for both food and income (Muthoni et al. 2013). Thus, it is expected that they will seek to grow varieties that are high yielding, even if the seed they plant is not certified.

However, there are major differences in the structure of the mental models between the aggregate HVM for users and nonusers of quality seed potato; For instance, the set of attributes that motivate the purchase of quality seed is much smaller. Notably, “drought tolerance” and having “big tubers” are important motivators of the users of quality seed, which do not feature in the HVM for nonusers of quality seed. Figure 5 also shows that nonusers of quality seed are driven by a much smaller set of benefits/consequences than their counterparts who use quality seed. More specifically, there are distinctions in the way some of the



consequences linking the above attributes to values are arranged in the minds of the nonusers of quality seed potato.

First, the majority of the nonusers associated the “long shelf life” of the seed potato purchased from local sources with more food being available in the household, indicating that such farmers were more concerned about the length of time they can store the tubers for food during the season. Second, increased income from potato sales was mentally associated with, essentially, two consequences. These are being able to “educate children” and “meeting family needs,” as shown by the bold arrows and the percentage of respondents who mentioned these constructs. Third, the structure of the mental constructs linking “educate children” (a consequence) with happiness (a value) is more elaborate. This emphasizes that educating children enables them to get jobs and hence help the parent, especially when the parents get older. This hope of getting support during old age, a form of social security, is therefore what makes parents happy.

Figure 5 further shows that, apart from happiness, only two other personal values drive farmers’ decision to grow seed potato purchased from local sources. These are “healthy life” and “independence.” As before, these values are mentally associated with having “more food” and “enjoy eating,” and with children getting jobs and hence being able to support themselves, respectively. In general, nonusers of quality seed are motivated to buy from local sources to meet family and food purchase needs, based on which they can be independent, happy, and healthy. Further, while quality seed users have a keen interest in timing the market and on producing potato tubers that appeal to consumers, the nonusers are more interested in aspects of the varieties that are related to household food availability.

Summary, Conclusions and Implications

This study sets out to investigate what motivates smallholder farmers to invest in quality seed potato and assess the differences in the content and structure of mental models associated with adoption decisions between female and male users, and also users and nonusers, of quality seed. The study finds that income, while being the most important motivation, is not in itself the end-goal of farmers’ decision to invest in the purchase and use of quality seed potato. Rather, it is only a means to the more deep-seated life goals (i.e., personal values) that farmers pursue. These life goals (or personal values) include happiness, independence, healthy life, security, and long life, which arise when the increased income from the use of quality seed is used to educate children, meet family needs (including buying more food), reinvest in farming to sustain production, and provide family shelter, among others.

Comparison of the structure of the mental models of female and male users of quality seed potato reveals important differences in mental constructs that motivate the decision to invest in the purchase and use of quality seed potato between these two groups of farmers; For instance, while a much larger share (73%) of male users were motivated by “high yield,” the greater share (71%) of their female counterparts were instead motivated by “long shelf life.” The other difference relates to taste. A relatively higher proportion of male (40%) compared with female



users (33%) of quality seed identified “good taste” as an attribute driving their adoption decision. These findings lead us to conclude that there are some differences in the structure of the mental models associated with the adoption of quality seed potato between male and female users.

This study also finds some differences in the content and structure of the mental models between users and nonusers of quality seed potato. The users tend to be more market focused, while nonusers are household focused. Notably, while the users are motivated by long shelf life as a way of earning more money through arbitrage sales or reduction in postharvest losses, the nonusers view it as being necessary for keeping food longer, thus making it available to the household for an extended period after harvest. The focus on household food availability by the nonusers of quality seed is further demonstrated by a higher proportion of this group desiring to have potato seed that can mature earlier. The study therefore concludes that farmers who purchase seed potato from local sources are more concerned about having sufficient food supply in their households. It is also concluded that the content and structure of the mental models differ between users and nonusers of quality seed.

Several implications arise from this study. First and foremost, this study establishes that income (profit-making) is not really the ultimate goal that farmers seek to meet when deciding whether to adopt a new or improved technology such as certified seed. Rather, the farmers are driven by deep-seated life goals for which profit-making (hence having more income from farming) is only a means rather than an end.

Second, the mental considerations that go into the process of deciding to adopt improved technology are somewhat different between male and female users of quality seed, and also between users and nonusers. This, in a way, implies that breeding for new/improved potato varieties should consider the differences in the attributes sought by male and female farmers.

Third, the finding that all the categories of respondents interviewed in this study consider long shelf life an important attribute of improved/quality seed signals that potato farmers are concerned about postharvest losses during storage for market and/or food. This therefore implies the need for continued efforts to breed for this trait or to find technologies that prolong the shelf-life of potato.

Acknowledgements This research was undertaken as part of the CGIAR Research Program on Roots, Tubers and Bananas (RTB). Funding support for this study was provided by the Syngenta Foundation for Sustainable Agriculture (SFSA) for funding this research. We thank the Africa Enterprise Challenge Fund, USAID, and SFSA for supporting the smallholders to access seed potato produced by the Kisima Farm Limited, a private seed company.

Open Access This article is distributed under the terms of the Creative Commons Attribution 4.0 International License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made.



References

- Abebe, G.K., J. Bijman, R. Kemp, O. Omta, and A. Tsegaye. 2013. Contract farming configuration: smallholders' preferences for contract design attributes. *Food Policy* 40: 14–24.
- Al-Dalain, S.A. 2009. Effect of intercropping of zea maize with potato *Solanum tuberosum* L. on potato growth and on the productivity and land equivalent ratio of potato and zea maize. *Agricultural Journal* 4 (3): 164–170.
- Ali, A., and A. Abdulai. 2010. The adoption of genetically modified cotton and poverty reduction in Pakistan. *Journal of Agricultural Economics* 61 (1): 175–192.
- Becerril, J., and A. Abdulai. 2010. The impact of improved maize varieties on poverty in Mexico: A propensity score-matching approach. *World Development* 38 (7): 1024–1035.
- Banson, K.E., N.C. Nguyen, O.J. Bosch, and T.V. Nguyen. 2015. A systems thinking approach to address the complexity of agribusiness for sustainable development in Africa: A case study in Ghana. *Systems Research and Behavioral Science* 32 (6): 672–688.
- Chindi, A., G.W. Giorgis, A. Solomon, L. Tessama, and K. Negash. 2014. Rapid multiplication techniques (RMTs): A tool for the production of quality seed potato (*Solanum tuberosum* L.) in Ethiopia. *Asian Journal of Crop Science* 6 (3): 176.
- Demeritt, A., and K. Hoff. 2015. *Small miracles-Using behavioral insights to explain public policy*. World development report 2015. Washington, DC: World Bank.
- Fourcade, M. 2011. Cents and sensibility: Economic values and the nature of 'nature'. *American Journal of Sociology* 116 (6): 1721–1777.
- Gengler, C.E., D.B. Klenosky, and M.S. Mulvey. 1995. Improving the graphic representation of mean-end results. *International Journal of Research in Marketing* 12: 245–253.
- Gildemacher, P.R., P. Demo, I. Barker, W. Kaguongo, G. Woldegiorgis, W.W. Wagoire, M. Wakahiu, C. Leeuwis, and P.C. Struik. 2009. A description of seed potato systems in Kenya, Uganda and Ethiopia. *American Journal of Potato Research* 86: 373–382.
- Gladwin, C.H., A.M. Thomson, J.S. Peterson, and A.S. Anderson. 2001. Addressing food security in Africa via multiple livelihood strategies of women farmers. *Food Policy* 26 (2): 177–207.
- Grunert, K.G., and S.C. Grunert. 1995. Measuring subjective meaning structures by the laddering method: Theoretical considerations and methodological problems. *International Journal of Research in Marketing* 12 (3): 209–225.
- Gowdy, J.M., and P.R. Olsen. 1994. Further problems with neoclassical environmental economics. *Environmental Ethics* 16: 161–171.
- Gutman, J. 1997. Means-end chains as goal hierarchies. *Psychology and Marketing* 14: 545–560.
- Haverkort, A.J., and P.C. Struik. 2015. Yield levels of potato crops: Recent achievements and future prospects. *Field Crops Research* 182: 76–85.
- Heisey, P.W., and J.P. Brennan. 1991. An analytical model of farmers' demand for replacement seed. *American Journal of Agricultural Economics* 73 (4): 1044–1052.
- Hirpa, A., M.P. Meuwissen, A. Tesfaye, W.J. Lommen, A.O. Lansink, A. Tsegaye, and P.C. Struik. 2010. Analysis of seed potato systems in Ethiopia. *American Journal of Potato Research* 87: 537–552.
- Hoff, K. 2015. Behavioral economics and social exclusion: Can interventions overcome prejudice? *World Bank Policy Research Working Paper* (7198), Washington DC.
- Johansen, S. 2014. *Family men: Middle-class fatherhood in industrializing America*. Abingdon: Routledge.
- Kanyeka, Z.I., E. Sangu, D. Fargette, A. Panel-Galzi, and E. HÄ. 2007. Distribution and diversity of local strains of rice yellow motile virus in Tanzania. *African Crop Science Journal* 15 (4).
- Kaufman, B.E. 2007. The institutional economics of John R. Commons: Complement and substitute for neoclassical economic theory. *Socio-Economic Review* 5: 3–45.
- Kelly, G.A. 1977. Personal construct theory and the psychotherapeutic interview. *Cognitive Therapy and Research* 1 (4): 355–362.
- Leão, A.L.M., and S.C. Mello. 2007. The means-end approach to understanding customer values of an on-line newspaper. *BAR-Brazilian Administration Review* 4 (1): 1–20.
- Lagerkvist, C.J., M. Ngigi, J.J. Okello, and N. Karanja. 2012. Means-End Chain approach to understanding farmers' motivations for pesticide use in leafy vegetables: The case of kale in peri-urban Nairobi, Kenya. *Crop Protection* 39: 72–80.
- Lutaladio, N., and L. Castaldi. 2009. Potato: The hidden treasure. *Journal of Food Composition and Analysis* 22 (6): 491–493.



- Lynne, G.D. 1995. Modifying the neo-classical approach to technology adoption with behavioral science models. *Journal of Agricultural and Applied Economics* 27: 67.
- Mason, J. 2004. Personal narratives, relational selves: Residential histories in the living and telling. *The Sociological Review* 52 (2): 162–179.
- Mason, N.M., and J. Ricker-Gilbert. 2013. *Disrupting demand for commercial seed: input subsidies in Malawi and Zambia*. New York: Elsevier 45 (C): 75–91.
- McGuire, S., and L. Sperling. 2016. Seed systems smallholder farmers use. *Food Security* 1–17.
- Mpogole, H., M.E. Mlambiti, and R.M. Kadigi. 2012. Round potato (*Solanum tuberosum*) production in southern highlands of Tanzania: Are smallholder farmers becoming commercial. *Journal of Extension and Rural Development* 4 (4): 385–391.
- Modesto, V.T., A. Akemi Ikeda, and C.M. Cortez. 2006. Laddering in the practice of marketing research: Barriers and solutions. *Qualitative Market Research: An International Journal* 9 (3): 297–306.
- Mulatu, E., O.E. Ibrahim, and E. Bekele. 2005. Improving potato seed tuber quality and producers' livelihoods in Hararghe, Eastern Ethiopia. *Journal of New Seeds* 7 (3): 31–56.
- Muthoni, J., H. Shimelis, and R. Melis. 2013. Potato production in Kenya: Farming systems and production constraints. *Journal of Agricultural Science* 5: 182–197.
- Muthoni, J., M.W. Mbiyu, and D.O. Nyamongo. 2010. A review of potato seed systems and germplasm conservation in Kenya. *Journal of Agricultural and Food Information* 11: 157–167.
- Namwata, B.M., J. Lwelamira, and O.B. Mzirai. 2010. Adoption of improved agricultural technologies for Irish potatoes (*Solanum tuberosum*) among farmers in Mbeya Rural district, Tanzania: A case of Ilungu ward. *Journal of Animal and Plant Sciences* 8 (1): 927–935.
- Nunkoo, R., and H. Ramkissoon. 2009. Applying the means-end chain theory and the laddering technique to the study of host attitudes to tourism. *Journal of Sustainable Tourism* 17: 337–355.
- Nyongesa, M., and E. Schulte-Geldermann. 2015. Unlocking the potential of the potato subsector in Kenya—A roadmap for revitalizing the subsector. In *Potato and sweetpotato in Africa: Transforming the value chains for food and nutrition security*, 453.
- Okello, J.J., Y. Zhou, N. Kwikiriza, S. Ogotu, I. Barker, E. Schulte-Geldermann, E.O. Atieno, and J.T. Ahmed. 2017. Productivity and food security effects of using of certified seed potato: The case of Kenya's potato farmers. *Agriculture & Food Security* 6 (1): 25.
- Okello, J.J., C.J. Largerkvist, M.W. Ngigi, and N. Karanja. 2014. Means-end chain analysis explains soil fertility management decisions by peri-urban vegetable growers in Kenya. *International Journal of Agricultural Sustainability* 12: 183–199.
- Olson, J.C., and T.J. Reynolds. 2001. The means-end approach to understanding consumer decision-making. In *Understanding consumer decision making: the means-end approach to marketing and advertising strategy*, ed. J.C. Olson, T.J. Reynolds, and N.J. Mahwah, 3–20. NJ: Erlbaum.
- Otieno, Z.A., J.J. Okello, and R.A. Nyikal. 2012. The role of varietal crops in the adoption of improved dryland crop varieties. *African Journal of Agricultural and Resource Economics* 6 (2): 176–193.
- Quisumbing, A.R., L.R. Brown, H.S. Feldstein, L. Haddad, C. Peña, A. de Jager, and Z.M. Ahmad. 1995. *Women: The key to food security*. IFPRI Working Paper No. 338.19 W872, Washington, DC.
- Reynolds, T.J., and J. Gutman. 1988. Laddering theory, method, analysis, and interpretation. *Journal of Advertising Research* 28: 11–31.
- Roccas, S., L. Sagiv, S.H. Schwartz, and A. Knafo. 2002. The big five personality factors and personal values. *Personality and Social Psychology Bulletin* 28 (6): 789–801.
- Rogers, E.M. 1995. *Diffusion of innovations*, 4th ed. New York: Free Press.
- Scott, G.J., M.W. Rosegrant, and C. Ringler. 2000. Global projections for root and tuber crops to the year 2020. *Food Policy* 25 (5): 561–597.
- Sharma, A.K., and K.K. Pandey. 2013. Potato mini-tuber production through direct transplanting of in vitro plantlets in green or screen houses—a review. *Potato Journal* 40 (2).
- Timu, A.G., M.R. Mulwa, J. Okello, and M. Kamau. 2014. The role of varietal attributes on adoption of improved seed varieties. *The Case of Sorghum in Kenya: Agriculture and Food Security* 3 (9): 1–7.
- Turkensteen, L.J. 1987. Survey of diseases and pests in Africa: fungal and bacterial diseases. *Recent and Future Developments of the Potato in the World* 213: 151–160.
- Walukano, W., P.N. Pali, L. Wairegi, et al. 2016. Yield gap analyses to inform policy on Sustainable Crop Intensification pathways in Uganda. In *A paper presented at the Tropentag conference on international research on food security*, Vienna, Austria September 18–21, 2016.
- World Bank. 2015. *Mind, society and behavior. World development report*. Washington, DC: World Bank.



- Yngstrom, I. 2015. Women wives and land rights in Africa: Situating gender beyond the household in the debate over land policy and changing tenure systems. *Oxford Development Studies* 30 (1): 21–40.
- Zang, C.P. 2014. Recent increased incidences of potato late blight on the Jos Plateau: A case for intercropping. *Agriculture, Forestry and Fisheries* 3 (5): 363–367.

