

Frugal Knowledge Sharing for Frugal Innovation Diffusion in Africa: The Church Woman and Related Models

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ABSTRACT

This study explores the mechanisms of frugal knowledge sharing for frugal innovation diffusion drawing upon concepts from social capital and diffusion of innovation theories. Three frugal innovations projects from Uganda, Malawi, and Ethiopia are used to undertake a preliminary appraisal of a proposed theoretical model. The study identifies a frugal knowledge-sharing mechanism based on “the church lady model.” From a practice perspective, the study informs how to leverage social capital to facilitate frugal knowledge sharing. Insights drawn from this study cover the surrounding network structure, mode of communication, frugal knowledge-sharing modalities, and the opportunity for combination and exchange to spark varied frugal IS innovation projects. From a research point of view, it serves as a basis for frugal knowledge management for frugal innovation diffusion in an African context.

KEYWORDS

Frugal Innovation, Frugal IS, Frugal Knowledge Sharing, Innovation Adoption, Innovation Diffusion, Social Capital

1. INTRODUCTION

1.1. A Need for Frugal Knowledge Management

At a UNESCO conference in 1965 on the Application of Science and Technology to the Development in Santiago, Chile, the idea of intermediate technology as a viable tool for improving the lives of the poor was treated with ridicule; because technology was simply considered as “given”, and its transfer was believed imperative to speed up development disregarding potential misfits to the reality of developing nations (Nelson, 2014; Schumacher, 1973). Development starts, however, with people/citizens and their knowledge, organization, and discipline (Palvia et al., 2018; Schumacher, 1973). Tech hubs show innovation for development as a social process that contributes to human-centered development where the people involved perceive value in the process (Jimenez and Zheng (2018). This notion of people-centered development is critical for low-income countries, which often have high concentration of modern sectors in big cities, while there remain underdeveloped sectors in rural areas where more than eighty percent of the population live. To bridge this uneven development, the quest for inclusive innovations that enhance wide-ranging development has increased as mainstream innovations tend to be associated with widening inequality (Knorringer et al., 2016). This call for

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inclusiveness is one of the ideas that triggered the notion of frugal innovation. Over the past ten years, various frugal innovations projects have been launched, such as the Tata Nano Car project (Herstatt, 2012); and *Mitticool*, a natural refrigerator developed by an Indian entrepreneur, entirely made from clay to meet the needs of low income clients (Arshad, Radi, & Radic, 2018). Later, big companies embraced frugality and currently large number of frugal innovations originate from United States (Arshad et al, 2018).

Cognizant of the potential benefits of frugal innovation for Africa, the current study is motivated to address two crucial issues surrounding frugal innovation in Africa. First, the potential beneficiaries of frugal products in the African continent are typically illiterate or semi-literate consumers. Second, classic knowledge management systems are mainly designed for experienced and literate consumers who have purchased and used many products and have access to resources such as the Internet, which is not the case in the African context. Frugal innovation demonstrates how firms with limited resources develop new devices and methods for underserved customers in low-income countries and encourages multinationals to have a dual-business strategy, whereby they serve the lower levels of the pyramid alongside their conventional counterparts (Hossain, 2020). Therefore, there is a need for parallel frugal knowledge management system. With a view to meeting this need, this study explores frugal knowledge sharing mechanisms that could facilitate the diffusion and sustainability of frugal and other innovations benefitting the bottom of the pyramid. A frugal knowledge sharing system requires minimal resources for the exchange of useful expertise. It is typically achieved by relying on social capital, rather than economic capital, and is thus more attuned to the resources and culture of rural regions in developing economies. Table 1 contains key concepts used in the paper along with their definitions.

There has been growing optimism regarding the potential benefit of frugal innovations for the economic transformation of low-income countries. Frugal innovation can be an effective way to serve low-income customers sustainably with affordable products. It requires creative thinking to meet the needs of underserved customers in economically developing countries (Hossain, 2021). Frugal innovations provide low-income communities increased ability to purchase products that fit their needs, reducing the usage of natural resources, and creating inclusive economic growth through the involvement of local communities in the value chain (Baud, 2016; Knorringer, P., Pes'a, I., Leliveld, A. and Van Beers, 2016). Frugal innovation aspires to cut product cost while retaining customer value, and it is open to new business models. This implies that frugal innovation endeavors require a deeper knowledge and understanding of innovation adoption, implementation, and capacity to assess the innovation's impact on the lives of people and on the overall economic development of a nation. Therefore, it is imperative to explore frugal methods of sharing knowledge related to frugal innovations so that a wide range of people adopt the technology and improve their livelihood. To this end, this article draws insights from social capital, frugal innovations in general, frugal IS/IT innovations, knowledge management, and innovation adoption and diffusion theories and literatures.

Network connections and the associated social capital can facilitate knowledge sharing within a community of practice (e.g., Kankanhalli, Tan, & Wei, 2005; MacDonald, 2007; Nahapiet & Ghoshal, 1998). Social capital provides a framework for explaining knowledge sharing mechanisms through the dimensions of structures, relations, and contents (Widén, 2011). Social ties in Africa, in particular, are important instruments for information and knowledge sharing, because knowledge management is more of a cultural and organizational issue than technical (Brand, 1998). Therefore, building a culture and ethos of collaboration is critical for knowledge management. It is also important to note that the mode of collaboration and knowledge sharing varies across societies. A knowledge management system needs to account for situational variations and local customs. However, much of the conceptualization of knowledge management is western centered (Tilley & Giordano, 2003). Thus, we need to review the notion of knowledge management in the realm of developing economies and low-income countries.

Table 1. Definition of terms

Key concepts	Definitions
Frugal innovation	Implies products and services that meet the basic needs of consumers in low income countries
Social capital	A network of individuals with shared norms, beliefs, and trust (Koka & Prescott, 2002) and resources in a social structure that are potentially accessed and used (Lin, 1999). These resources include power, wealth, reputation, and information
Innovation	An idea, technology or the implementation of organizational practices new to an organizational community or to the adopting audiences (Bui, 2015; Rogers, 2003).
Culture	Shared values, shared symbols, norms a social collectivity that frames people's worldview (Lee et al, 2013; Granato, Inglehart, & Leblang, 1996).
Frugal knowledge	A rudimentary technical and persuasive marketing information system that adopters in a rural community need to make a sound innovation decision and successful implementation.
Neologorization	<i>A systematic and thoughtful process for coining culturally appropriate and easily comprehensible new and catchy terms or words.</i>
Frugal IS	<i>Information systems with basic functionalities designed, developed, and operate with minimal resources</i>
Frugality	Being sparing or economical with regard to resources

Innovation adoption and diffusion theories explain drivers of innovation adoption across cultures and over time (George, Mcgahan, & Prabhu, 2012, Rogers,2003). Enablers of frugal innovation are optimization of energy consumption in industries, collaborating with local companies, management support, paying attention to the needs of the local market and reducing the profit margin (Niroumand, et al. 2021). Since Rogers' (1962) book on the diffusion of innovation, there has been a great deal of interest across fields to understand what drives innovation adoption across cultures and over time, including in resource-limited settings (George et al., 2012). Without due consideration of the socio-cultural context, various innovation transfer initiatives can fail to persist in many African countries. For instance, Mengesha & Musa (2012) report the outcome of a project, Improving Productivity and Market Success (IPMS), launched in 2004 by the International Livestock Research Institute (ILRI) in collaboration with the Federal Democratic Republic of Ethiopia's Ministry of Agriculture. Knowledge management was considered one of the prime components of the project (ILRI, 2013). In line with this, the project focused on the establishment and operationalization of a functional knowledge management system at District, Regional, and Federal levels and rural development. In pursuit of this goal, twenty-eight knowledge centers across four regions of Ethiopia were established. Each center was equipped with five computers, a television set, DVD players, and a library containing books, manuals, and training guides in printed form and on CD or DVD player. At each knowledge center, a dial-up Internet connection was available but used infrequently due to high usage charges. During the project's lifetime, some knowledge centers managed to produce videos on bee keeping, fruit nursery management, onion production and marketing, soil conservation and rice cultivation. These were burned on CDs or DVDs and were distributed to other centers as training and motivational materials.

In essence, IPMS was a research for development project crafted with a western mindset that aimed at transforming small holders' subsistence farming to a commercial oriented agricultural system (ILRI, 2013). Effective use and sustenance of such projects is difficult in rural Ethiopia. The project was donor driven with an implementation period spanning from 2004 to 2012 and phased out in November 2012 as the project's funds were depleted (ILRI, 2013). This and many similar projects were not rooted in the socio-economic reality of Africa and were foreign to the environment. As a result, many projects have failed to sustain, although they promised rosy outcomes at the initial stages. Frugal innovation needs constraint-based thinking for frugal product development, which includes the identification of constraints or existing limitations behind the status quo, a root-cause analysis to understand the underlying causes for each of the observed constraints, a mapping of each of those causes to specific product characteristics or requirements, and development of a minimal viable product or a prototype (Agarwal et al. (2021).

A nation's socio-cultural and governance systems impact its economic development. Economically developing nations, in general, tend to share common cultural dimensions (Hofstede, 1983). African countries possess collectivist and "particularist" cultures (Michailova & Hutchings, 2006). A collectivist society is one in which people are integrated into strong cohesive groups where they remain loyal to the norms without questioning (Michailova & Hutchings, 2006). A "particularist culture" lacks a well-defined legal system; instead, relationships and associations determine what gets done in business, politics, and society (Michailova & Hutchings, 2006). The African culture embeds social, economic, and moral values (Granato et al., 1996). While social values define the beliefs and rituals of a society, economic values reflect the cooperation and support system of the society (Chigwata, 2016). The moral values is the basis for African indigenous legal systems and stresses the need to respect social values in order to lead a decent life in the community (Amanze, 2017; Granato et al., 1996). The deeply held kinship relations in Africa foster synergy and a mutually beneficial collaborative endeavors and shared concerns (Idang, 2015). This relational system for instance, embraces disciplining children of the neighborhood as one would admonish one's own child, with a deeply-shared belief that a well-behaved child will be beneficial not only to the immediate parents, but also to the society at large (Chigwata, 2016; Idang, 2015; Granato et al., 1996). Although this tradition is now under challenge and fading away in the western-oriented cities and towns, it still endures in rural areas.

In most African countries, modern and traditional administration systems run in parallel. Traditional leaders remain the most accessible and immediate form of local governance in rural areas (Chigwata, 2016). The modern governance system is mainly established in a top-down approach through elections or other means. The institution of traditional leadership has been historically regarded as the main ruling system accepted by the people at grassroots levels (Dlungwana, 2004). While modern governance follows a formal procedure, the traditional leadership structure tends to be informal. Mechanism for the integration of these two structures are needed to avoid conflicts and duplication of duties (Chigwata, 2016). Therefore, it is imperative to explore the traditional and modern social structure in order to learn how knowledge is shared and innovation is diffused across the society.

The remaining part of this article is structured as follows. First, the theoretical framework of the study is discussed. Second, the research methodology, data analysis, and presentation are described. Third, the discussion, summary, and conclusion of the study are presented.

2. THEORETICAL FRAMEWORK

This study uses social capital theory as an overarching theoretical lens, complemented by theories in innovation diffusion and knowledge management. To develop frugal knowledge management systems, exploring the socio-technical and cultural issues is needed in order to capture key contextual factors. With these underlying principles, the theoretical framework integrates constructs from social capital theory, diffusion of innovation, and knowledge management.

The concept of social capital, as an aggregate of actual or potential resources accessible through a durable network of mutual relationships, was first introduced by Pierre Bourdieu; however, the term social capital was coined by Glen Loury and later a more refined analysis of social capital was developed by Coleman (Portes, 1998). Proponents state that social capital inheres in the relations among individuals and contend that such linkages are valuable resources for social action (Nahapiet & Ghoshal, 1998).

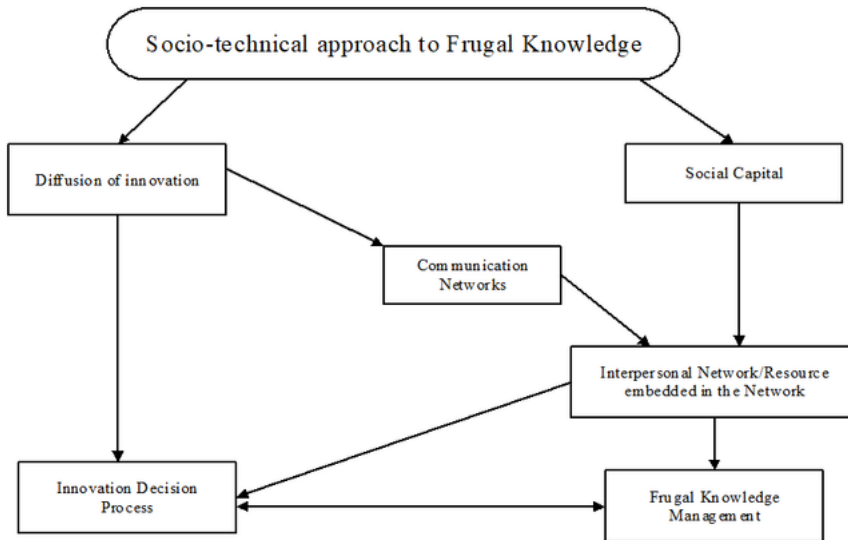
These days various forms and two streams of social capital have emerged and led to varied intellectual discourses. First, all forms of social capital constitute some aspect of the social structure. Second, they all facilitate the actions of individuals within the structure (Coleman, 1988). Similarly, two streams of social capital are also recognized: individual and collective (McMichael, 2010). ‘Individual social capital’ refers to resources embedded in a social structure to be accessed and used by an individual actor to undertake purposive action (Lin, 1999). It focuses on the capacity of an individual to invest in a network and gain returns. Whereas the collective level social capital views a group or social system as the beneficiary of collective individual actions. Here, the focus is on the importance of engaging in memberships in a community, developing trust, and a habit of reciprocity to enjoy group level benefits.

This study is based on the first stream of social capital theory and intends to explain how individual actors leverage social capital in order to diffuse frugal innovations and how corresponding frugal knowledge management systems thrive and support the institutionalization of frugal innovations. This is with a conviction that social capital is a resource that facilitates certain action, whether the actor is an individual or corporation (Coleman, 1988). Further, drawing upon the notion of social capital, this study proposes the development of knowledge management mechanism that facilitate the creation, capture, sharing, application, and storage of relevant knowledge surrounding an innovation. Ultimately, the intent is to instill a culture of knowledge creation and knowledge sharing using the social relationships in place and the social capital therein. The established social structure serves as a mechanism for knowledge creation and sharing. Infusing frugal knowledge management mechanism should require minimal resources when it emerges as a byproduct of a social capital embedded in the social structure. Innovations diffuse through the social system when transmitted through the existing channels and when communication impacts the cognitive process of the adopter and their innovation decision process (Lefebvre et al 2016; McMichael, 2010). Five stages are involved in the innovation adoption process (Rogers, 2003). The adopter first needs to gain knowledge of an innovation, then persuaded to use it. Next, the adopter decides to accept or reject the innovation. Following this, implementation and use of the innovation takes place. Finally, commitment of the adopter to continued use of the innovation is assessed.

The aforementioned innovation adoption process appears linear and assumes the adopter is a passive recipient. However, frugal innovation, as with many innovations, is a joint endeavor. The innovator is not the sole decision maker with regard to the design and development of the new product or service. Adopters can play active roles in the process of frugal innovation when it centers on their needs. Therefore, adopters can become part of the innovation team and the innovation process. The proposed frugal knowledge management system is expected to take into account the reciprocity involved in the social structure and in the social capital system. In addition, classic diffusion of innovation theory focuses on technical knowledge and information (Kaplan, 1999). However, this study deals with the sharing of both explicit and tacit knowledge. We integrate diffusion of an innovation, “individual social capital” theory, and concepts from knowledge management to explore phenomena surrounding frugal innovation (see Figure 1).

The preceding framework emphasizes that socio-technical elements of innovations cannot be investigated without considering the social system (McMichael, 2010). A socio-technical approach blends different factors assumed to impact the adoption and continuing use of innovation (McMichael, 2010). Closer scrutiny of the innovation diffusion processes helps to understand the knowledge sharing mechanisms. This implies that when we monitor a frugal innovation’s adoption and use scenarios,

Figure 1. Theoretical framework (adopted from McMichael 2010)



we are more likely to recognize the knowledge generative and sharing mechanisms embedded in the process.

Innovation diffusion begins with the communication network (Figure 1) in which an adopter is embedded in a network of social relations that limits and controls the technological choices made and learning conditions (MacVaugh & Schiavone, 2010; Cowan, 1985). The fundamental assumption is that a person's communication does not flow randomly but rather tends to occur through established social relations (McMichael, 2010). Therefore, communication networks signify sets of social relations, which form structures and pattern (McMichael, 2010). As Africa is mainly a communal society, people use social relationships to seek information and opinions for decisions they might make. The information people access through their social relations is regarded as a resource. In Africa, indigenous knowledge passes from generation to generation by word of mouth (Mekoa 2018; Ngulube, 2002), and it is an example of accessible social capital. With regard to the relative importance of mode of communication on clients adoption decision, mass communication increases the awareness level, but personal communication is more important for the adoption stage (Ball, Cullen & Gan, 1999).

In addition to communication, change agents are critical in terms of triggering and orchestrating personal communication in rural settings. In this regard, Rogers (2003) presents a case from a public health water boiling project in the Peruvian village of Las Molinos. Change agent and opinion leaders influence innovation adoption decisions in a direction deemed by the change agency (Bell & Ruhanen, 2016; Rogers, 2003). The lesson learned from this project attests that diffusion of innovation is not merely a technical matter, but is also a social process that requires coordination between people and organizations (Sugarhood, 2014; Rogers, 2003). Although the technology involved in the water boiling project was easy to comprehend and implement, the innovation failed to diffuse as intended, mainly due to the change agent's weaknesses. The mode of a change agent's contact with their clients is the major determining factor of adoption (Rogers, 2003).

Apart from exploring the conceptual linkages between social capital and diffusion of innovation, a comprehensive review was conducted to understand how social capital is related to knowledge sharing. Individual knowledge develops through practice and experience (Bencsik et al., 2016). Based on this notion, we argue that a social network ties individuals together and fosters the creation and sharing of frugal knowledge in the community where modern communication technologies are not

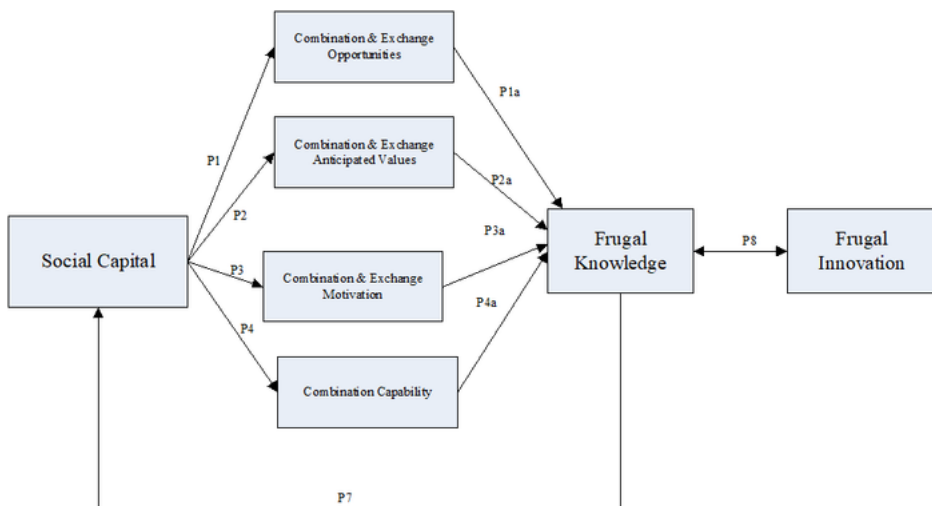
extensively used for knowledge management. Networks of relationships constitute a valuable resource for the conduct of social affairs and this relational dimension of social capital signifies assets created and leveraged through relationships (Nahapiet & Ghoshal, 1998). This implies that knowledge is a valuable asset created and shared via social relationships. Various studies based on social capital theory support this claim. For instance, all new resources, including knowledge, are created through two generic processes, combination and exchange, as they involve interaction and coactivity (Moran and Ghoshal, 1996), which are among the key mechanisms for creating social knowledge. Four conditions affect the deployment of intellectual resources (explicit or tacit) and their engagement in a knowing activity that involves combination and exchange (Nahapiet & Ghoshal, 1998):

1. The existence of opportunities to undertake combination or exchange, which is determined by accessibility to the objectified and collective forms of social knowledge;
2. The degree to which interaction, exchange, and combination prove valuable despite the uncertainty that surrounds the final outcome;
3. The presence of motivational mechanisms (incentives) to stimulate combination and exchange;
4. The extent to which combination capabilities are developed or exist.

Nahapiet & Ghoshal (1998) identify three highly interrelated dimensions of social capital: structural, relational, and cognitive. In line with Lin (1999), Coleman (1988) and Portes (1998), we consider social capital as a whole rather than treating it along the cited three dimensions. However, we draw insights from the work of Nahapiet and Ghoshal (1998) regarding the relationship established between social capital, the combination and exchange of existing knowledge, and the creation of new knowledge.

Considering the preceding four conditions and pulling together concepts from knowledge management and diffusion of innovation, ten propositions that explain mechanisms for frugal knowledge sharing and innovation adoption are formulated (Figure 2).

Figure 2. Frugal knowledge sharing mechanisms (extracted from Nahapiet & Ghoshal, 1998)



The following underlying assumptions were considered in developing Figure 2. First, social relations generally motivate the exchange of ideas and resources and influence the four conditions of resource exchange and combination (P1-P4). Bringing together the notion of social capital and knowledge creation and exchange, social capital resides in relationships, and relationships are created through exchange (Bourdieu, 1986). Social capital facilitates the development of intellectual capital by affecting the conditions necessary for exchange and combination to occur (Nahapiet and Ghoshal, 1998). By the same token, social capital nurtures the creation and sharing of knowledge through combination and exchange mechanisms. Networks and network structures in a social capital structure influence the range of information that is potentially accessible and made available for combination (Nahapiet and Ghoshal, 1998). This implies that social capital provides access opportunities to valuable piece of information. Based on this fact:

P1: Social capital delivers the structure and relations for information and knowledge exchange.

P1a: Social interaction in the form of exchange and combinations facilitates frugal knowledge creation and sharing.

For parties to engage in some social interactions, they must anticipate that the interaction, exchange and combination will prove worthwhile, although they might remain uncertain of the final outcome (Nahapiet and Ghoshal, 1998). Further, people participate in meetings expecting that they learn something, although they are unsure what and how they learn. Therefore:

P2: Anticipation of value from combination or exchange is a necessary condition for people to engage in social interaction.

P2a: People who participate in an expected valuable interaction are likely to attain value in the form of information and knowledge.

The presence of opportunities for social interaction and perceived value of the interaction are a necessary but not a sufficient condition for exchange and combination to take place. Parties engaged in social interaction expect that they will secure new value created by their engagement. To further clarify this point, Nahapiet and Ghoshal (1998) cite that access to electronic knowledge exchange does not automatically motivate people to share information. This implies the need for some motivational schemes or incentives. Therefore:

P3: People must be motivated to engage in combination and exchange interactions.

P3a: Motivated interaction is likely to create new values in the form of information and knowledge.

Although recognition of the value of information and desire to access and use is a necessary precondition, combination capability is an indispensable factor. Cohen and Levinthal (1990) states that the “absorptive capacity” of a firm depends upon the existence of related prior knowledge. Moreover, an organization’s absorptive capacity does not reside in any single individual but depends on a range of links and collective endeavors. Therefore:

P4: People engage in a social interaction that involves exchange and combination when they believe that they have personal combinatorial capability.

P4a: Combinatorial capability can create frugal innovation knowledge.

As we can observe in Figure 2, there is an interplay between social capital, frugal knowledge, and innovation adoption. Social capital is created and sustained through exchange and in turn facilitates exchange (Nahapiet & Ghoshal, 1998). In their study that explains the relationship between social

capital and the development of intellectual capital, Nahapiet & Ghoshal (1998) state that social capital facilitates the creation of intellectual capital and in turn intellectual capital also triggers the creation of social capital. Similarly, Putnam (1995) discloses that social capital is not a unidimensional concept, rather multidimensional. Therefore:

P7: Frugal knowledge stimulates the creation of social capital.

When innovative ideas or new technology are introduced in a rural society, potential adopters either accept, reject, or recommend new features to be added to the product. While making adoption decisions, first the adopter needs to gain knowledge of an innovation, then need to be persuaded to use it, following this the potential adopter decides to adopt or reject (Rogers, 2003). The innovator is expected to gather the opinions of clients to develop the next version of the product. There is a dynamic interactive process between frugal knowledge generation and sharing and the adoption of frugal innovation. Therefore:

P8: Frugal knowledge impacts an adopter's decision, which and in turn can generate valuable frugal knowledge for other adopters or for the innovators.

New knowledge is created in two major ways: incremental and radical (Nahapiet & Ghoshal, 1998). While incremental knowledge generation involves a continuous improvement in small steps, radical knowledge generation entails innovation, revolution, or a paradigm shift. The scholarly consensus is that both types of knowledge creation involve making new combinations (Nahapiet & Ghoshal, 1998).

Social capital tends to be contextual in nature, which makes transfer from one setting to another difficult. For example, ties, norms, and trust developed in a family or religious setting may not transfer into work situations (Fukuyama, 1995). Furthermore, social capital is a byproduct of other ventures and requires time, interdependence, and interaction in order to develop; hence its development requires focus and investment (Nahapiet & Ghoshal, 1998).

3. THE STUDY

Case study research is appropriate for an in-depth investigation of a complex socio-technical phenomena in a specific context. It is an empirical inquiry that investigates a contemporary phenomenon within its ongoing context (Yin, 2009). In general, case selections were done in order to maximize what can be learned in the period of time available for the study (Dube & Pare, 2003). This study selected case study in order to observe the phenomena surrounding frugal knowledge sharing across diverse settings and to make cross case comparisons (Yin, 2009). To this end the study considered different countries and different types of projects. In general, we noted that there is a paucity of cases on this topic and we reviewed those that were well described and where we thought informants were accessible. All the three frugal innovation selected in the context of Africa and use frugal knowledge sharing mechanism. The first case, development and marketing of a milk cooling device, involves farmers as co-designers and champions. The second case targets developing a frugal mobile phone-based cattle market information system that provides content using a local language. Pastoralists and agricultural extension workers were involved as co-designers, end users, and product promoters to develop easy to use mobile phone-based cattle market information. The third case deals with promoting a low-cost Agroecology knowledge where farmers are involved in the experimentation process and farmer to farmer training and knowledge sharing.

A guide was prepared to conduct in-depth interviews. It consists of the following questions:

- How was this project initiated?

- What was the main goal of the project?
- How the design of the system/device/ carried out?
- How the device was deployed and reached end users?
- How orientation and trainings were delivered to end users?
- What preventive, corrective maintenance and other after sales service schemes were employed?
- How far the device is diffused in the community/country?
- What is your future plan to sustain the project outcome?

In addition, an extensive review of project documents was conducted to generate the case data. Simple open coding supported by Nvivo software was carried out to analyze the interview data.

These three frugal innovation cases were used to evaluate frugal knowledge generation and sharing mechanisms presented in Figure 2. The first case is the Evakuula (Ever cooler) milk cooling system designed by Professor William Kisaalita, a Ugandan descendant and his associates at the University of Georgia, USA. The goal of the project is to double the income of farmers from milk sales and particularly to improve the life of women in a rural community. Throughout Sub-Saharan Africa, farmers take milk to the market in the morning. However, they usually milk in the evening. The evening milk perishes as it cannot reach the market quickly because of poor roads and lack of market access. The initial intent of the project is to create a system that cools milk overnight so that it will remain fresh until the farmers sell it in the market the next day. The device was tested successfully in three districts of Uganda and is now heading to large scale adoption in the region.

The second project is a mobile phone-based cattle market information sharing platform designed by researchers from Addis Ababa University, Ethiopia with funding obtained from the Ministry of Communication and Information Technology of Ethiopia. The objective was to improve the livelihood of pastoralist communities. Due to lack of timely and accurate market information, the bargaining power of the communities is very weak. Price makers are local brokers and traders, who amass higher gains from animal markets putting pastoralist communities at a disadvantage. Based on requirements gathered from the pastoralist community and other stakeholders, a prototype cattle market information system was developed and implemented.

The third case is the Malawi Agroecology project. This project was launched in October 2012 by Ekwendeni Hospital in collaboration with Western University, Chancellor College (University of Malawi), the University of Manitoba, Presbyterian World Service and Development, Canadian Food Grains Bank, and Cornell University. The goal is to improve food security and agricultural practices through a farmer-to-farmer model of education. The project promotes low-cost agricultural techniques and fosters farmer-led experimentation and farmer-to-farmer knowledge sharing. The project reveals that the involvement of farmers in scientific experimentation increases their observational skills and confidence. This project spurs rethinking of the dominant agricultural model that perceives farmers as passive adopters of scientific agricultural knowledge.

4. THE THREE CASES

The three frugal projects data were separately analyzed and a cross-case comparison and associations framework (Altmann & Engberg, 2016) applied. An analysis of each project follows.

4.1. Evakuula Milk Cooling System Project

The Evakuula Milk Cooling System project started as a student's capstone engineering project at the University of Georgia. The initial intention was to design a solar power system to replace diesel power coolers in rural areas. The original design, however, was not successful. The project team realized that it needed to focus on small holding farmers. The revised goal was to create a system that cools the milk from evening milking until it can be sold the next morning. In doing so, perishable

milk would be avoided, and the income of the farmers should increase. With regard to the design, the project pursued an inclusive, cyclic, and continuous improvement process involving farmers. While explaining the design and its major considerations, the leader of the project stated:

Product design is a continuous improvement process not done once. If you do not involve farmers you will not go further. We involved them all the way in the process. This is a three or more cyclic process. We involved farmers as co-designers. We followed the so called human centered design. Farmers know what works for them. Our first product was small that stores only 15 liters of milk. The farmers informed us that the product was too small to meet their needs. Based on their input, we redesigned the device to carry up to 80 liters of milk. We have chosen three farmers to work with the project team, and we called them innovators who test the product.

Furthermore, the respondent stated affordability, profitability, business model, competition, and cost are the most important design considerations. The project leader also reports that once the technological and business proof of concepts have been ensured, many people are interested to move to action. After the product is realized, the next challenge is testing in the intended setting and marketing the product. In order to promote this activity, a team consisting of three experts was established. Members of the team are individually responsible for marketing, installation, and community relationships. The marketer is a young literate woman who knows the local culture and language and engages in translations and product promotion. The technician is responsible to regularly visiting the community, troubleshooting problems, and providing technical support. An influential lady selected from the community champions product promotion and invites ladies in the community to attend demonstration sessions and persuade product purchase.

Customer orientation and training are in the local language. Initially, the project team planned to establish a center where farmers would come for training. It didn't work. As a result, one-on-one contact and house-to-house product demonstrations were started. In this way, some households committed to signing a contract for purchase. This mode of orientation and marketing requires two to three trips and is expensive. However, the results are positive.

Knowledge transfer and diffusion of the product is carried out using "the church lady model". In a rural Christian community, a church lady is influential, because she is considered as a trustworthy woman of God among church goers and sometimes beyond, and she is involved in church activities and services. Product marketing started with the church lady inviting women to learn about the innovation. Most women who respected her came and attended a meeting organized by the project team. This church lady also started orienting and training other women regarding the benefits of the product and how to operate it. Through word of mouth, product knowledge diffused through the community. Regarding the key role the church lady plays, the respondent stated:

The church lady who involved in the project was smart and intelligent in terms of bringing viable ideas. She told us that the "Community King" has cows and suggested to donate him one unit and we did. After a while, the Prime Minister of Uganda came to the village to visit the community king and saw the device in the house. Thereafter, he started to talk about the device through radio and also invited the Community King to deliver a speech about the device. In this way, the product information has easily diffused throughout Uganda.

The product is fault tolerant and easy to operate. Maintenance is not a major concern. However, at times operational errors cause the product to malfunction. Although demonstrations on how to use the product are conducted, orienting customers about required maintenance is difficult. The respondent stated the challenge surrounding maintenance as follows:

With regard to maintenance the main challenge we encountered was language barrier. There is no matching local language word for the word “Maintenance”. It is totally foreign to them. Later, we discovered that in many Bantu language there is no matching word for “maintenance”. During the demonstration session, all we did was telling users to clean the device regularly.

The plan of the project team is to scale by addressing three issues. First, continue reducing the manufacturing cost so that the profit margin increases. A larger profit margin will sustain the project. Second, developing a sound business model. The respondent stated that particularly, middle men who lend money to the community at a high interest rate should be avoided, and the project’s goal is to function both as a manufacturer and financier. Third, they want to reach other African countries, such as Kenya, Tanzania, and Zambia.

4.2. Cattle Market Information Sharing Platform

Two panel interviews and one individual interview were made at Oromiya Regional State, Addis Ababa, Ethiopia in the period April 2017 to January 2018. The first panel interview was with personnel at Oromiya Pastoralist Area Development Commission (OPADC) at its headquarters in Addis Ababa. Three cattle experts with long years of experience took part in a panel interview of about three hours. The second panel interview was held with Oromiya Trade and Market Development Commission. Two market experts took part in a panel interview held on January 6, 2018 of one hour and thirty minutes. The individual interview was held with the representative of the pastoralist community.

The interviews focused on the services that the respective regional offices deliver to the pastoralist community with regard to animal husbandry, market information, and how the services delivered reach and diffuse among the community. The Pastoralist Area Development Commission mainly focuses on providing animal husbandry, cattle disease treatment, and animal feeding support services. It delivers extension education and other support to the grassroot pastoralist communities through a development agent’s community. Different packages of training and awareness creation activities are conducted at varying level of the administrative hierarchies, spanning from top management down to grass root pastoralist communities. For example, package programs might be classified as fattening, honey production, poultry, availability and types of input materials, and selection of best breeds. The commission also creates awareness of animal diseases, supplying drugs, surveillance and mapping of infected locations. The knowledge reaches the pastoralist community in a top down communication channel. The Borena and Guji people have also developed accumulated knowledge regarding cattle disease management. Although elite animal experts in the region do not recognize these practices, the pastoralist communities have been employing various cattle management and disease control practices for several generations.

The interview with Oromiya Trade and Market Development Commission revealed that it is responsible for collecting and disseminating domestic market related information to concerned stakeholders. To this end, the commission organized 562 animal marketing centers across the region. It selected 67 of these centers as representative of their associated region and started operating them as market information hubs. At each center, there are two experts assigned to collect local market information on a weekly basis. A standard paper-based data collection instrument was developed to collect data from the local cattle market. So far, the most commonly used dissemination methods include paper-based reports and weekly community leader meeting updates. The former is not effective as there is significant literacy problem. However, the traditional information sharing channel is deemed effective.

Pastoralist community respondents report that the communities in the study area have started using mobile phones. New incidents occurring in the area are easily communicated to distant members through a traditional information relay practice called “Eya Dabarssa”. Over the years, this system has been more effective, even compared to phone messages, in terms of alerting the community for quick action. Respondents also mentioned that in larger regional cattle markets, such as Adola, Shakisso,

and Megado, business intermediaries are price makers. Yet, the community is devoid of cattle market information at regional and national level. Based on facts gathered from pastoralist communities and other stakeholders, a mobile application platform has been designed and developed. The app requires only three steps to provide six categories cattle market information in a local language. The product is supposed to be promoted and diffused through community development agents.

4.3. Agroecology Project

Facts about this project were elicited from project partner institutions publications, such as Cornell University, the project website,¹ and project reports. Launched in 2000 with thirty farmers, the venture has reached over 6,000 farmers. It is a participatory project, in which farmers try to improve soil fertility, food security, and nutrition through the use of grain or perennial legumes (e.g., peanuts or soya beans). Legumes fix nitrogen from the atmosphere, such that when the leaves and roots are incorporated directly into the soil, it adds nitrogen, organic matter and other nutrients. Farmers can then grow another crop in the improved soil the following year (e.g., maize) and eat the edible legumes. Subsequently, it is hoped that this will lead to an increased food productivity which will in turn enhance food availability within the households of resource-poor farmers.

The project is operated as participatory action research that involves scientists and farmers drawing on agroecology and co-production of knowledge practices (Bezner Kerr et al., 2018). The project uses farmer-to-farmer teaching about agroecology, nutrition, and local food market development to improve food security, nutrition, and local livelihoods. The agroecological methods are on par with nature's dynamic equilibrium ecosystem and emphasize the use of organic materials for soil enhancement and diversifying crops and crop rotation farming.

The project is sponsored by the government of Canada and implemented in two main locations: northern Malawi in Mzimba District, north of Ekwendeni; and Dedza District, in central Malawi. The project's objectives are:²

- Improve food security, nutritional status and sustainable agricultural practices of 6,000 farming households in central and northern Malawi.
- Test the potential for a farmer-to-farmer model of education for scaling up use of agroecological methods in Malawi.
- Determine the potential for local orange maize varieties as an acceptable socio-economic, cultural, and biological option to improve the vitamin A content of diets in Malawi.
- Extend agroecological methods to youth and farmer by using participatory training methods in food processing and local food market development to improve food security, dietary diversity, and income for 200 youth and a farmer association.
- Enhance gender equality by fostering women's access to resources and increasing their decision-making power over agriculture, food security, and disposition of income.

The fundamental assumption is that food insecure women, men, and youth will learn from fellow farmers to sustainably manage their soils, increase diversity and amount of food grown, and improve young children's nutrition. This project tends to promote low-cost and low-technology techniques combined with farmer-led experimentation and farmer-to-farmer knowledge and practice sharing as a viable approach to increasing agricultural output and ensuring food security at a household level.

Participating farmers first undergo agroecological principles training. Following this they choose several strategies to test, including some of the following elements: (1) integration of trees (use of fruit trees and/or agroforestry); (2) soil fertility and/or conservation strategy; (3) crop diversification, including legume intercropping and (4) livelihood diversification, such as dry season gardens, small livestock, and bee-keeping. These strategies were generated through a co-production process, which involved a combination of scientific review, dialogue, input from farmers, and joint decision-making by scientists and participating farmers.

The project reveals that rural communities in Malawi perceive significant changes in climate, and that participatory research with marginalized groups using agroecology supported experimentation, increases knowledge sharing and flows and challenges the dominant agricultural models (Bezner Kerr et al., 2018). The agroecological information provided and the encouragement of farmers to get involved in experimentation activities appears to increase farmers' confidence in their observational skills and in other farmers as important sources of agricultural knowledge. There is also evidence of increased collaboration within and among communities, including between spouses and those often excluded, such as AIDS-affected households. These findings point to the transformative potential of agroecology to produce a more sustainable food system when combined with participatory methods and attention to social inequalities (Bellamy, Sanderson & Loris, 2017).

Knowledge sharing among farmers takes place through drama, storytelling, demonstrations, and workshops. The project reports that a participatory workshop involving farmers and Cornell University researchers served as a platform for farmers drawn from different villages to share knowledge. In doing so, the project increased agroecological knowledge flow and sharing (Bezner Kerr et al., 2018). The project report indicates that there is room in economic development work to demystify science and acknowledge the co-production of knowledge in agriculture.

4.4. Cross Case Analysis

In order to observe commonalities and associations among the three cases, Altmann & Engberg (2016) framework is used along with additional dimensions of comparisons drawn from social capital and diffusion of innovation theories (Table 2). Key constructs from the theoretical model have been used as a basis for cross analysis.

As it can be seen from Table 2, the three projects pursued very similar mode of communication and knowledge transfer schemes, which were found appropriate to the context and resulted in favorable outcomes in terms of marketing and diffusing the innovation within the target communities and beyond. The lesson gleaned from the three projects relate to the surrounding network structure, mode of communication, frugal knowledge sharing modalities, and opportunity for combination and exchange can serve as a basis for the emergence and refinement of varied frugal IS innovations, as summarized in Table 2.

5. DISCUSSION

The literature on frugal innovation, frugal knowledge management, social capital, and innovation adoption theories reveal the relevance of the church lady and related agents in terms of orchestrating frugal knowledge sharing mechanisms. The conceptual model we have presented is a starting point to be refined by subsequent studies. However, it is wise to be cautious of the downside of social capital, because some social norms oppose cooperation, exchange, and retard receptiveness of innovations in the society. Further, social relations are extensively used for the conduct of grand and petty corruptions in some developing countries (Poeschl & Ribeiro, 2015).

The three cases elicited new concepts that can be added to the conceptual model and extend the horizon of knowledge sharing mechanisms in communal societies. Two fundamental concepts that are in line with the theorization of agency by Rogers and cognitive social capital (Nahapiet & Ghoshal, 1998) respectively are uncovered. First, Rogers (2003) states that the mode of a change agent's contact with the client is the major determining factor of innovation adoption. The case analyses surface that influential change agents in the community, like the church lady, development agent, farmer innovators, and opinion leaders, are critical to the course of diffusion of innovation and knowledge sharing. Second, the cognitive dimension of social capital such as language and codes, narratives from the theorization (Nahapiet & Ghoshal, 1998) are imperative in communities that heavily rely on face-to-face communication and word of mouth. The EvaKuula milk cooling project indicates that a community can lack comprehension of the necessity of maintenance. In most Bantu

Table 2. Cross case analysis

Dimensions	EvaKuula Project	Pastoralist market info project	Agroecology project
Frugal Innovation	Milk cooling device	Market Information platform	Agroecology knowledge sharing practices
Network Structure	Linkage between project team, opinion leader (church lady), and client	Linkage between regional cattle experts, development workers, and pastoralist community	Linkage between regional stakeholders, and farmer
Mode of communication	Face-to-face and word of mouth	Face-to-face and word of mouth	Face-to-face and word of mouth
Frugal knowledge: transfer of product and technical knowledge	Church lady led persuasion and marketing, and product demonstrations	Development worker based top-down and bottom-up knowledge transfer	Farmer-led experimentation and farmer-to-farmer knowledge transfer drama, storytelling, demonstration, and
Opportunity for combination and exchange	Involvement of consumers as co-designers and the commitment of the firm to embrace features suggested by consumers	Involvement of pastoralists in local and district cattle market hub and willingness to share their indigenous knowledge of animal disease treatment & range land management practices	Involvement of farmer production of knowledge the recognition by agricultural scientists to farmers indigenous knowledge
Anticipation of value	influential agents, such as the church lady, took part in product promotion and design voluntarily without immediate benefits	Stakeholders across the board took part in the project's activities in anticipation of future value	Farmers participated in agroecology project experimental activities in anticipation of future benefits.
Combination capabilities	Quick perception and valuable reflection of farmers on the frugal innovation	Stakeholders' quick perception of the frugal product idea	Farmers' perception engagement in experimentation
Results	Over 100 units sold. Product knowledge diffused in Uganda. Potential scale up to other African countries envisioned	Mobile phone-based market information sharing platform developed and validated	Farmer-led experimentation fostered knowledge among 6,000 farmers

languages spoken in Uganda and surrounding areas, there is no matching word for “maintenance”. This creates a real challenge in the course of training, demonstration, and narratives composition. The cases show that spoken words, demonstration, metaphors and scenario building are important means of knowledge sharing in rural African society. In this regard, shared interpretations and systems of meaning, and shared language and codes provide the foundation for communication (Gooderham, 2007). In addition, these cognitive dimensions of social capital effectuate the relational dimensions of social capital shaping world views of individuals in the society (Tsai & Ghoshal, 1998).

While reviewing the agroecology project in Malawi, we noted that researchers from Cornell University announced that they are developing a farmer-led curriculum that integrates teaching about

climate change, agroecology, nutrition, gender, and social equity using participatory methods such as theater and discussion. Therefore, dealing with linguistic issues and developing a culturally rooted terms for innovation like “Ever cooling” which is translated as “EvaKuula” to take into account African languages’ accent.

In recognition to the criticality of terms in the process of communication and knowledge sharing and the role of change agents, we decided to introduce two salient mechanisms, neologization and agentification. These constructs are added to the four conditions Nahapiet and Ghoshal (1998) introduced to investigate mechanisms for intellectual capital creation. English speakers first borrowed neologism from the French *néologisme* (Webster, 2018) . In order to stress the need for a systematic and thoughtful process of coining new and catchy terms that are culturally appropriate and easily compressible, we have added the term neologization in this theoretical piece. Therefore, the following two propositions are added:

P5: Social capital forms the basis for neologization.

P5a: Neologized terminologies facilitate communication and knowledge sharing.

Second, as we have deduced from the theorization of Rogers and from the case analyses, influential individuals in the community serves as a role model and are central for persuading the community, knowledge sharing, and championing innovation diffusion. These change agents are instrumental in facilitating frugal knowledge sharing and diffusion of innovations. Again, to stress the systematic process of identification, development, and collaboration with relevant change agents, the term “Agentification” is used. A closely related term “agencification” is used in public sector management to imply a program of transferring as many government activities into agency-type organizations (Pollitt, Talbot, Caulfield, & Smullen, 2005). In this regard, the following two propositions are formulated:

P6: Social capital fosters the identification and development of influential change agents.

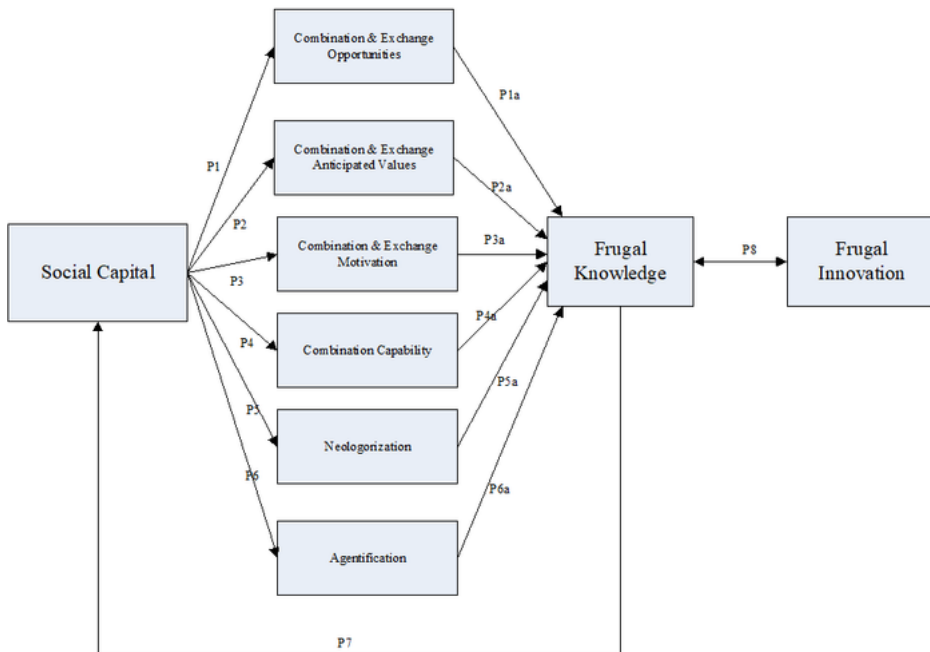
P6a: Agents foster knowledge sharing and innovation diffusion in the society.

Figure 3 depicts the revised frugal knowledge management and innovation diffusion mechanisms.

Apart from supporting the theorization of frugal knowledge sharing mechanisms, the lesson drawn from the three cases have practical implications for designing and developing frugal IS innovations. The three projects promoted participatory project execution approaches, where farmers were considered as co-designers, innovators, and experimental researchers. In addition, the farmer-to-farmer knowledge sharing platforms created by the project fostered human resource development in a rural setting. In relation to this, Jiménez and Zheng (2018) note that innovation contributes to human development if the people involved perceive value in the process, particularly in the form of improving their communities and society. The active and voluntarily involvement of farmers in project activities attest to the belief they have in the value of each project’s outcomes. First, the cattle market information sharing platform demonstrates how the pastoralist communities can get critical market information in their local language via cell phone applications requiring minimal interaction. This project outcome affirms the widely held belief that Information systems designers will have the opportunity to create radically different designs when practicing the notion of frugal IS (Pitt and Watson, 2011).

Frugal innovation entails not only new ways of achieving cost saving but also marks how a technology is used in ever more imaginative ways, such as when the penetration of cell phones enables multiple micro-business models to emerge (Qureshi, 2010). As such, the cattle market information sharing platform is a typical example of leveraging cell phone networks to reach and impact the lives of remotely located pastoralist communities in rural Ethiopia.

Figure 3. The church lady frugal knowledge sharing mechanisms



Moreover, the farmer-to-farmer frugal knowledge sharing practices witnessed in the Malawi Agroecology project heavily depend on storytelling, demonstration, and drama. The outcome of this project can be further pronounced and sustained with the help of frugal IS innovations that capture farmers' agroecological experimentations and practices using a mobile phone's digital camera. Video clips captured can be further processed and shared with other farmers who are not in the project. In doing so, the content developed in one location can be reused and shared repeatedly until knowledge diffuses across the community. Furthermore, the Evankula Milk Cooling project knowledge sharing techniques can also be supported by Frugal IS innovations, such as using a cell phone to record and disseminate product knowledge shared by the church lady and other product champions.

6. CONCLUSION

In a communal society, social capital enhances efficiency by streamlining communication and reducing knowledge sharing costs. The cost of establishing and maintaining social capital also appears to be minimal. Social interaction fosters rapid frugal knowledge generation and sharing. This catalyzes quick innovation adoption and diffusion. Reduction of communication cost is attained as a result of ease of access to information and low coordination costs (Nahapiet & Ghoshal, 1998). Social capital is an abundantly available resource in Africa that needs to be leveraged for frugal knowledge sharing and diffusion of innovations. The foundations of frugal innovation are the needs of people based in the lower pyramid of the social structure. Moreover, these innovations target the use of available resources to develop products and services that rectify social problems. People at this social structure are expected to play an active role in the process of developing frugal products and services. This entails a need for strong interaction between innovators and consumers. A frugal knowledge generation and sharing process can be deeply embedded in this dynamic social interaction. Therefore, it requires due attention and focus to create and nurture social capital to promote frugal innovation diffusion and frugal knowledge management.

To orchestrate social interactions and facilitate social relations, change agents are crucial. Prior scholars, such as Rogers (2003), have provided extensive rationales for its importance. The case studies demonstrate how the church woman, development agents, and farmer led-experimentation facilitate frugal innovation diffusion and frugal knowledge sharing. Further, metaphors, scenario building or narratives are imperative for the development of communities' knowledge and to nurture social relations. Therefore, addressing linguistic related issues is critical.

7. CONTRIBUTIONS

The lessons of this study are helpful for informing ongoing initiatives for frugal information systems innovations. The cattle market information sharing platform is a typical example of how the philosophy of frugality is put into effect to support the pastoralist community to get a fair price for their cattle. Pastoralist communities need continued support to lift them out extreme poverty rooted in a heavy dependence on cattle rearing for their livelihood. Over the years, various attempts have been made to help pastoralists switch to mixed farming, because the areas they inhabit are often affected by recurring droughts, which kill a substantial number of animals annually. Particularly, when droughts are forecasted, traders convince pastoralists to sell their cattle for unfairly lower prices. As demonstrated by the case, scaled down and easier to use mobile apps can deliver market information to remotely located pastoralist community in the local languages. In doing so, the bargaining power of pastoralists increases, and eventually the community will be capable of selling its cattle at a reasonable market price. The use of mobile applications to access market information is also practiced in other part of the world. For instance, while explaining the ubiquity features of frugal information systems, Watson, Kunene, and Islam (2012, 2013) state that fishermen in India can get market prices for fish via their cell phones while at sea, which helps them to increase their profits.

The app development project can be a win/win solution for both software developing companies and to the beneficiaries. Software developing companies can quickly develop a bunch of frugal products at a low cost and market them to rural pastoralist communities at an affordable price. The frugal knowledge sharing mechanisms proposed in this study will inform functional and non-functional requirements to develop mobile apps. In this regard, frugal innovation generally enables developing economies to overcome resource constraints by creating affordable, simple, and sustainable products and services (Ahuja and Chan, 2016). Africa has good track record of frugal IS innovation. For instance, Ahuja and Chan (2016) state that in Kenya the M-PESA mobile payment service helps to overcome the lack of physical banking branches by allowing people to use a simple SMS-based transaction system to send and receive digital currency. Furthermore, Orlikowski and Barrett (2014) disclose that more than two-thirds of the Kenyan adult population uses M-PESA and over 30% of Kenyan GDP flows through this system. Similarly, Barclay (2014) argues that application of frugal information systems assists cyber law development process, criminal investigations, and broaden the spectrum of criminal legal and justice system processes in small economically developing nations like Jamaica.

Global climate change and increasing population growth mean that all societies need to do more with less. Frugality is important for all nations, and we can use cases from heavily resource constrained countries to learn frugality-driven innovative practices. The mantra of sustainability – reduce, reuse, and recycle –calls for the universal sharing of knowledge of practices that conserve resources and use them prudently.

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ENDNOTES

- ¹ <http://soilandfood.org/projects/malawi-farmer-to-farmer-agroecology-project/>
- ² Ibid.

APPENDIX

Interview Guide

Dear respondent,

We are conducting a study on promoting frugal innovations through knowledge sharing systems. To this end, we intend to make an in-depth case analysis on a selected frugal innovation projects to learn how they were initiated, developed and deployed to end users. We are also interested to know how training/orientation and field operation support is provided. Furthermore, we want to understand the mode of preventive and corrective maintenance and other after sales support services provided to end users. The information you will be giving is highly valued and determines the outcome of the study.

Name of the project: _____

Respondent's role in the project: _____

Questions

1. How was this project initiated?
2. What was the main goal of the project?
3. Would you tell us how the design of the system/device/ carried out?
4. How the device was deployed and reached end users?
5. Would you please tell us how orientation and trainings were delivered to end users?
6. Would you also tell us about the preventive, corrective maintenance and other after sales service schemes?
7. Would you please tell us how far the device is diffused in the community/country?
8. Would you please tell us your future plan to sustain the project outcome?
9. If you have additional information, you are welcome. We also appreciate if you share with us project related.

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