ASSESSING INFORMATION SHARING STRATEGIES TO ADDRESS MILK LOSSES AMONG DAIRY FARMERS IN PERI-URBAN BAMAKO, MALI

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A Thesis Submitted to the Graduate School in Partial Fulfilment for the Requirements of the Award of a Master of Science Degree in Agricultural Information and Communication Management (AICM) of Egerton University

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DECLARATION AND RECOMMENDATION

Declaration

I declare that this thesis is my original work and has not been submitted before wholly or partially for any award in any institution.

Signature…….. Date……...

Sidibe M'Baye Thiam

Recommendation

We confirm that this thesis was prepared under our supervision and has our approval to be presented for examination as per Egerton University regulations.

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DEDICATION

I would like to dedicate this thesis to my late parents: Seydou Thiam and Mariam N'Diaye.

ACKNOWLEDGMENT

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ABSTRACT

Information Communication Technologies (ICT) have been used as one of the intervention strategies in the reduction of loss along the agricultural value chains in the developing countries. ICT has been used in Malian agriculture in general as an intervention strategy to acquire information in agriculture sector, but not necessarily in dairy sector alone. In recent years, there has been an improvement in the dairy sector due to the development of peri-urban dairy farming. This has resulted in the intensification of milk production around the peri-urban because of information on improved breeds and access to feeds. The peri-urban dairy farming is still experiencing many challenges such as lack of market information, poor infrastructure and no proper processing resulting into losses. The objective of this study was to assess the information sharing strategies to address milk losses among dairy farmers in peri-urban of Bamako. Data was obtained through structured questionnaires and interviews. Multiple-stage sampling procedure was used to select the respondents (n=171). Data was analysed using SPSS software version 20. The study found that sources of milk losses, spillage and spoilage, were significant a 1% at both cooperative and farm levels. The spoilage was the major cause of loss. The most common information sharing pathway used by dairy farmers was the mobile phone with 93% at the farm and 71% at the cooperative. The cooperative was the most frequent source of information. The most sought types of information by farmers were feed at 42%, animal health at 14% and cooperative issues at 13%. The mobile phone was found to be suitable information sharing pathway that can contribute towards reducing milk losses among dairy farmers. In order to reduce milk losses, the study recommended putting more efforts in good handling practice and investment in dairy sectors. Similarly, capacity building of farmers and cooperative members and workers should be enforced for efficient information sharing. A suitable mobile application should be developed for better information flow among farmers.

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LIST OF ABBREVIATIONS AND ACRONYMS

BHEARD	Borlaug Higher Education for Agricultural Research and Development
CGIAR	Consultative Group on International Agricultural Research
DNPIA	Direction Nationale des Produits et Industries Animales
FAO	Food and Agriculture Organization of the United Nations
FCFA	Franc Communauté Financiere Africacaine
GDP	Gross Domestic Product
ICT	Information Communication Technology
IER	Institut d'Economie Rurale
IICD	International Institute for Communication and Development
ITU	International Telecommunication Union
MISTOWA	Market Information System of West Africa
NARS	National Agriculture Research System
RDA	Rural Development Administration
RGPH	Recensement General de la Population et de l'Habitat
SMS	Short Message Service
SOLAIMA	Société Des Laiteries Du Mali
SPSS	Statistical Package for Social Science
TV	Television
UNDP	United Nations Development Program
UNESCO	United Nations Educational Scientific and Cultural Organization
USAID	United States Aid for International Development
WBG	World Bank Group

CHAPTER ONE

INTRODUCTION

1.1 Background Information

Livestock production is important in Mali's agricultural sector and contributes approximately 30% of GDP (DNPIA, 2010). Economically the livestock sector is in the third place after cotton and gold with a contribution to earnings estimated to 8 million dollars per year (Konate *et al*., 2001). At least, 90% of farmers in Mali practice livestock keeping for milk production, some of which is sold to bring cash income to the family (DNPIA, 2015). Livestock production has increased, and provides adequate products (milk and meat) for domestic consumption, and a marketable surplus commercial production system for milk and meat (FAO, 2012).

The dairy sub-sector in Mali has the potential to contribute to national development goals and provide growth to the livestock sector (DNPIA, 2010). The dairy sub-sector is rapidly growing particularly in the peri-urban areas. Malian dairy sub-sector is changing rapidly because of strong market for dairy products. The market-oriented cooperatives are growing and private-sector service providers are stepping into the domain to give information on dairy farming. There are many players who are involved in the supply chain including, the farmers, transporters, cooperatives, traders, retailers and customers. Thus, the stimulus has stable prices and profits which are higher (SOLAIMA, 2014). The peri-urban dairy farmers are facing many challenges due to lack of information and knowledge on good dairy farming practices.

Lack of information on milk production and milk handling practices, such as feeding, milk and milk preservation will lead to loss of milk due to spoilage and spillage. Many small dairy farmers are using non-food grade plastic container to store and transport the milk instead of the standard aluminium or steel containers that are recommended because they cannot afford them. However, it is difficult to sterilize the plastic container and can result in milk loss through spoilage (Technoserve, 2008).

Although statistics differ from one source to another, milk production is estimated to be about 2 billion litres per year and the losses along the milk value chain are estimated to be 65% of the national production in Mali (DNPIA 2015). This loss is associated with players (farmers, informal traders, cooperatives, distributors and retailers) not having access to the accurate information about milk production and handling practices. In spite of the increase in volume of

production, dairy farmers still experience market information challenges resulting into low profit and forced consumption or spoilage. Nevertheless, Mali still imports 10 to 15 billion FCFA (Franc de Communauté Francophone d'Afrique) (200 million to 300 million of US Dollars) worth of dairy products and yet the consumption is below the national target which is 40 litres per capita (DNPIA, 2010). Unfortunately, a large portion of the production takes place where demand is low (for example, in the Mopti Region). This geographic situation makes it difficult to build viable value chains to connect producers with urban consumers or with processing plants who serve the urban consumers. Therefore cooperatives and milk kiosks have been erected at peri-urban Bamako to provide services (Staatz *et al*., 2011).

Although milk production is important in rural areas, particularly for women, it is the peri-urban demand and supply of fresh milk and milk products that has been growing fastest during the past 10–15 years (DNPIA, 2010). Peri-urban milk production has become more intensive than rural milk production because of rural -urban migration impacting on milk demand; this has stimulated government to import exotic dairy breeds and improve the local breeds; it has also developed the production of quality feeds and/or provision of these feeds. They are easily available at the urban market setting, especially in Bamako city. Today with the help of Non-Governmental Organizations (NGOs) and some development partners, many dairy cooperatives have been created. The purpose of these cooperatives is to help farmers to increase their production and income. Cooperatives help farmers to have access to inputs, market, knowledge and extensions services. Cooperatives are used by both government and NGOs to extend training and capacity building of the farmers (SOLAIMA, 2014).

Small dairy processing unit are emerging rapidly located in the peri-urban areas. However the proportion of local milk processed by those units is relatively small due to poorly organized value chain linking producers and processors. The growing sector of the peri-urban dairy sector is encouraging some private investors to open up some small animal feed processing unit as well. Today the animal feed is available in the urban market even though is not affordable for all the farmers (SOLAIMA, 2014).

During the period of market liberalization and Structural Adjustment Programs in the 1990s, the dairy sector in Mali faced profound challenges. In order to look for new market opportunities, farmers need to be innovative, in order to become more efficient producers and effective

entrepreneurs. Farmers need information and new technologies for effective production. The access to the right information about dairy production is a key to improved production. Information on market issues are needed (Shepherd, 1997). The Mali formal and informal milk processing plants faced many challenges such as the lack of market and market information, lack of proper cooling facilities since the privatization of the national milk firm (MaliLait) due to structural adjustment program in the 1990s(SOLAIMA, 2014). These challenges can be overcome by putting in place a proper market information system throughout the value chain. Today the main constraint in Mali's dairy value chain is lack of flow of information from the farmers to buyers. The use of Information and Communication Technology between (farmers, traders, distributors and retailers) can reduce milk loss transaction costs and increase incomes and lower consumer prices (Ali and Kumar, 2011).

1.2 Statement of the Problem

Mali has great potential in dairy sub-sector, but the government has done little efforts to formalize the sub-sector. Only few NGOs are intervening with limited capacity which is inconsistent. The sub-sector is growing rapidly, particularly in the peri-urban of Bamako because of increased demand for dairy products in the capital city. The milk loss along the milk value chains is estimated to be 65% of the national production, because the main players (farmers, informal traders, distributors and retailers) do not have access to accurate information about milk production and processing practices. This lack of access to correct information on dairy farming includes undefined sources of information, type of information, and means of sharing information. Though increasing national production estimated at 2 billion litres, farmers face low profit due to the losses caused by spillage, spoilage and forced consumption. There are many ICT pathways that are convenient to reduce milk losses but are aware of them. Therefore, this study aimed at assessing the information sharing strategies to reduce milk losses among dairy farmers in peri-urban Bamako.

1.3 Objectives

1.3.1 General Objective

To contribute to improved food security and income of dairy farmers by assessing the role of information sharing in reducing milk losses in peri-urban of Bamako.

1.3.2 Specific Objectives

1. To determine the sources of the milk losses and extent of their influence on the quantity of milk losses at farm and cooperative levels.
2. To identify existing Information sharing strategies at farm and cooperative levels to address milk losses and recommend at least one communication intervention that can help dairy farmers to reduce milk losses at farm and cooperative levels.

1.4 Research Questions

1. What are the sources of milk loss and at what extent does it affect the quantity of milk loss at farm and cooperative levels?
2. What are existing Information sharing strategies at farm and cooperative levels to address milk losses, and what is the best communication intervention that can help dairy farmers to reduce milk losses at farm and cooperative levels?

1.5 Justification

Milk production in Mali has been about 2 billion litres/year but only 45% of this is used (DNPIA, 2015). Nevertheless, the country is still importing 10 to 15 billion FCFA (200 million to 300 million of US Dollar) worth of dairy products and yet milk consumption is below the national target that is 40 litres per capita (DNPIA, 2010). In Mali, the dairy sub-sector can have the potentiality to contribute to the GDP and provide growth to the livestock sector. The sub-sector is rapidly growing particularly in the peri-urban areas, but there is need for both efficient production and marketing of milk and milk products. Marketing of these products is slow because the main players in milk value chains are farmers, informal traders, distributors and retailers who do not have the access to information that they need (Ali and Kumar, 2011). Using Information and Communication Technology (ICT) can facilitate communication and transmission of information and update of knowledge more efficiently between the farmers and the processing units.

1.6 Limitations and Scope of the Study

This research will deal with dairy farmers located in the peri-urban areas of Bamako. The target population will be the dairy farmers, the cooperatives, the small processing firms and the retailers. One of the limitations is that this study is only focusing on peri-urban areas of Bamako. The findings may not be generalized for the whole country.

1.7 Operational definition of terms

ICT: any technology tools used by dairy farmers as means of communication.

Information sharing strategies: the different methods used by dairy farmers to get or share information among themselves.

Milk losses: the quantity of milk that have been utilize by dairy farmers due to spillage, spoilage or given away.

Force consumption: the quantity of unsold milk

Dairy farmers: farmers who own cows and utilize them to produce milk for commercial purposes.

Peri-urban of Bamako: surrounding cities of Bamako, the capital city of Mali.

Spillage: the quantity of milk fallen out of the container by accident.

Spoilage: the quantity of milk becomes inappropriate for consumption and sales.

CHAPTER TWO

LITERATURE REVIEW

2.1 Malian agriculture

Mali is the eighth-largest country in Africa. It is located in West Africa, has an area of 1,240,000 square kilometres and a population of 15,768,227 million of people (UNDP, 2015). It has eight regions and in the north it reaches deep into the middle of the Sahara Desert. Agriculture is the back bone of Malian economy and 80% of its population is involved in agricultural activities. Livestock is one of the major sources of income for many farmers, particularly in the northern regions (Staatz *et al*., 2011).The agriculture sector is predominantly smallholder, which is very underdeveloped because of many barriers such as cultural, socio-economic, high illiteracy rate and lack of information to improve farming activities. Mali's agricultural sector has the potential for growth and expansion with 43.7 million hectares of cultivable land only 7% is now cultivated (USAID, 2012).

2.2 Livestock production in Mali

Livestock production is one of the key economic and social importance to Mali. It accounts for approximately 30 % of the agricultural GDP, hence up to about 90 % of farming households own some form of livestock (DNPIA, 2010). According to USAID (2012) Mali has a potential to become a sub-regional supplier of meat and animal products, but policy reforms are needed to increase investment in the sector. Although there are many opportunities for investment in meat and dairy sub-sectors, such investment is unlikely to occur due to lack of trust from investors in the sectors. Everyone involved in the supply chain, all benefits from the savings made from these efficiencies as prices are more stable and profits are higher (USAID, 2012).

2.3 Dairy Farming

Over the last decade, the dairy sector is growing rapidly, improving production and productivity driven by increasing demand from a growing population (Muriuki, 2011). This progress has been realizable through the improvements in animal nutrition, health, breeding, feeding. Dairy farming contributes to the wellbeing of people in many ways such as making quality food products available to consumers, increasing farm incomes and production of organic fertilizer. There are also some harmful characteristics associated with dairy farming; it can contribute to environmental pollution and some practices raise questions about food safety and health. The complexity of these consequences must be understood first in order to inform the public about

these consequences before taking any decision concerning issues or make any investment decisions related to the sector (Muriuki, 2011). Today Agriculture is knowledge and technology-intensive and livestock keeping according to traditional practice depends on a broad network of people, organizations, and institutions, which constitute their knowledge base and source of technologies. Farmers are currently experiencing a fundamental change in the mechanisms of knowledge and technology base farming (Meijerink and Liang, 2000). Currently farmers are playing multiple roles as sources, disseminators, and users of information; this is forcing farmers to capitalize their working knowledge based solutions (Ramkumar, 1995).

2.3.1 Dairy Farming in Mali

Dairy plays a major role in Mali's economy by contributing to the livelihoods of many rural communities, who are engaged throughout the value chain. It is providing a source of cash for many women in some rural communities mostly Fulani. Mali's dairy subsector is changing rapidly because of strong market for dairy products can be offered to producers by encouraging them to invest in new technologies in response, market-oriented cooperatives are growing and private-sector service providers are stepping into the domain. Even though the dairy farming in the peri-urban is growing very fast but the milk production around Bamako is not growing at the same rate. The current milk market has low output production and the fundamental growth will require adoption of more rigorous formal business procedures (SOLAIMA, 2014).

In Mali the annual milk production from all dairy species was estimated to be about 2 billion litres and only 45%- 50% is consumed (DNPIA, 2015). The post-harvest milk losses are very high throughout the value chain according to (SOLAIMA, 2014). Some of the causes are: poor information flow along the value chain, wastage due to the low market demand, the spoilage due to poor handling time, distances and roads constraints. The main cause of milk spoilage in Mali is attributed to the high temperature, the absence of cooling facilities and the lack of adequate transportation, which accelerate the spoilage of the milk. During the rainy season, when production is high and roads are inaccessible losses are higher as well. It is almost impossible to bring milk to the market in some areas because of the bad road condition during the rainy season, which has been a major constraint in increasing the production because the producers are forced to consume milk themselves, otherwise it is wasted. Developing a good communication strategy

and transformation units may reduce forced consumption and throwing away of milk (SOLAIMA, 2014).

In Mali, a large portion of the production takes place where demand is low (especially, in the Mopti Region). This geographic situation makes it difficult to build viable value chains to connect producers with urban consumers or with processors who serve the urban consumers due to many barriers such as the lack of education, lack of adequate information system, and market (Staatz *et al.,* 2011). Whereas in countries like Netherlands or USA researchers had found that the most important, constraint dairy farmers have, is finance, followed by marketing, and feed (Huirne *et al.,* 1997).

2.4 Information and Communication Technology

According to the World Bank (2011), Information and Communication Technology (ICT) has been regarded as the driver of economic growth which has seen 10% of the world's population moves out of poverty as the number of Information Communication Technology users have increased tremendously over the last decade. Today the internet and portable phone users in the third world countries have reached about 3.7 billion. Information Communication Technology is no longer a luxury product, but an essential tool that can be exploited by the poor. The expansion of Information and Communication Technology in the least developed countries is attracting the construction of Information and Communication Technology infrastructure all over Africa. As a result, it has attracted investment opportunities which in turn create employment for the unemployed (World Bank, 2011).

2.5 Information and Communication Technology in Agriculture

Agriculture has been the backbone of the Sub Sahara Africa economy and ICTs' have revolutionized our life in every way by making it easier to overcome distance and time barriers in the dissemination of agricultural information, research and education. The use of Information and Communication Technology such as instance mobile phones and internet may provide vital information to farmers on available opportunities to access support services that may increase production and profitability of dairy milk products. The services may include access to inputs and services such as feed, nutrient supplements, drug and transport facility for delivering milk to the market (Ali and Kumar, 2011). It can also facilitate the communication and transmission of information and update of knowledge more efficiently between the farmers and the processing

units. The flow of information within the agricultural sector is the key in improving smallholder agricultural production (Lwoga *et al.,* (2010).Today the new Information and Communication Technologies are bringing, sustaining and empowering farmers with new technologies such as updated knowledge and information strategies on the farming practices, market information and prices, consumer preferences, finance sources, environmental issues, weather, and soil conditions (Sahdev, 2006). Information Communication Technology (ICT) can help farmers to reach out to local markets and reduce the transaction cost between farmers and processing plant. Today Information and Communication Technology is the adequate solution that can facilitate the dissemination of information about losses of milk along the informal dairy value chain.

Even though many studies have been conducted on Information and Communication Systems and their effects on agriculture, only a few have addressed dairy farmers and their information needs. There is significant exchange of information between farmers and the main actors within the value chain. They have observed that most of the farmers were very active in the dissemination of the technology and the information in the innovation (Rolls *et al.,* 1994). According to Ali and Kumar (2011) studies have proven that the introduction of telecommunication technologies into agriculture has improved livelihoods of rural communities particularly in Africa. It has also been proved that Information Communication Technology has an important influence on improving agricultural production, such as post-harvest and marketing activities.

Today countries like Kenya, Ghana and India have managed to introduce ICT projects that are supporting agriculture in rural communities and are having positive impacts on the livelihoods of those people through high production in agriculture (Alemna and Sam, 2006). The government of Zimbabwe has formulated the National ICT Policy after realizing the potential that ICT can bring to the country. The policy was to put in place guidance and direction to the formulation and implementation of ICT in agriculture, tourism, environment, mining, manufacturing, transport, among others (Government of Zimbabwe, 2012). In Zimbabwe the Government had released that the absence of ICTs and market information has been identified as the cause of low productivity in agriculture in developing countries. Today Zimbabwe Farmers Union (ZFA) encourages making use of ICTs to increase productivity Kabanda (2011). The e-agriculture is a way to boost agricultural production through ICT by improving information and knowledge sharing Haythornthwaite (2005). ICT has been uniquely used as technological intervention to overcome

challenges the traditional barriers to social change and economic development in rural areas (Sreekumar, 2007). Therefore, the aim of this study was to assess the use of ICT in the peri-urban dairy value chains of Bamako in Mali and recommending the best ICT strategy that can be used to reduce milk post-harvest losses.

Using Information and Communication Technology would improve information sharing strategies and provide opportunities and sustainability to farmers and improve their livelihoods. There are numerous models of information systems such as transfer and development processes. The development of Information technology can be even more effective with various information sources available to users. These processes do not only show the flow of information, but they are adapted and transformed continually through communication (Garforth and Usher, 1996). According to IICD (2014) Information Communication Technology has enabled various data collection and the dissemination of significant information to farmers on their farming practices, such as weather and climate. Moreover, local information that are important regarding appropriate types of inputs, such as seeds, fertilizers, animal health products, and pesticides can be accessed by farmers through Information and Communication Technology.

2.5.1 Mobile phone technology used in agriculture

Mobile phone technology is rapidly replacing the traditional agricultural information system based on radio and message board. In order to make the information flow more efficiently the use of mobile phone technology such as text messages are likely to be the most appropriate approach to provide information needed to make the value chains more efficient to farmers and processors. It will help poor farmers, especially the peri-urban farmers to access vital information. It has been proven that the easy access to mobile phone can have a positive impact on the accessibility to information and have been sustainable in reducing poverty .It has been identified as a main opportunity in connecting potential fully (Silarszky *et al.,* 2008). Today the majority of small scale dairy farmers have access to mobile phone which can allow them to access to dairy information in real time at the regular base (Baumüller, 2010). It is also enabling the access to qualitative and quantitative information at various levels and increasing agricultural information efficiency (Aker and Mbiti, 2010). The access to mobile phone has reached over 60% in Asia, Latina America and Africa over the past decade. Africa has today about 374 million subscribers. Today over 89% of the population in Mali is using Mobile phone (BuddeComm, 2015). Mobile phone technology is becoming very popular in Africa, and has

been extensively used by farmers in the rural areas for many farming purposes such as market price information, and agricultural knowledge transfer (Dannenberg and Lakes, 2013). It was mostly adopted by well-off, the most educated residents in the urban area. In many poor countries mobile phone adoption is growing faster than expected. Mobile phones increase farmers' productivity, and allow them to save money by avoiding the cost of travelling (Aker and Mbiti, 2010). Mobile phone technology can completely transform smallholder farmers' access to critical and timely information according to Fiona Smith director of the MyAgro program. New MyAgro services have developed and allowed farmers to call a helpline and get assistance from an agriculture extension service provider, to receive initial daily agriculture alerts through SMS or voicemail. Mobile phones provide the best way to reach farmers with appropriate and personalised information. The most frequent users are the most influential farmers in their communities, and can provide advice to other farmers (Orange, 2015). According to Orange, (2014), farmers have improved market efficiency through the use of Information and Communication Technology they provided. *Sènèkèla* is an agricultural mobile phone application provided by Orange Mali that offers a variety of information on agriculture and market prices. Customers can access agricultural information and market prices in French and Bambara languages.

2.5.2 The impact of ICT on agriculture

Information and Communication Technologies play an important role in addressing and uplifting challenges faced by rural communities. Agriculture sector in the developing countries is confronting many challenges of increasing production to feed a growing population. The role of ICT, is to enhance food security and support rural livelihoods, has been recognised and was officially endorsed at the World Summit on the Information Society in 2003-2005. The use of computers, internet, geographical information systems, mobile phones, as well as the traditional media such as TV or radio have relatively contributed to the alleviation in the rural livelihoods (Jac *et al.;* 2007). The post-harvest loss can be lowered if the perishable products can be sold sooner Information Communication Technology has created WhatsApp and other platforms over mobile phone technology, where farmers can communicate directly and exchange information from one source to another (Gillwald *et al.,* 2008).

The information flow among farmers remains very central, therefore new sources of information are needed in sharing agricultural information such as GIS is increasingly used in forecasting the modern agriculture (Rolls and Slavik, 2003). According to De Silva and Ratnadiwakara, (2008) the information flow is an important provider to overall costs of transaction from planting decision to selling and make-up around 11% of total production costs. However the poor state of Information and Knowledge management sharing strategies is a serious problem in many African countries (Johnson and Flaherty, 2011). Information Communication Technology, particularly mobile phone is often perceived as a 'game changer' for most of small-scale agriculture farmers.

According to Röling (1988) information system apply to agriculture as a mechanism, in which information is produced, received, changed, combined and answered to reinforce utilization of awareness by farmer. In addition, information and communication system provides the basic structure and components of information system, and to give an understanding on what method to use in order to improve and how to make that system works effectively (Demiryurek *et al.,* 2008). According to Ramkumar (1995) actor-oriented information system method, is a social, cultural and economic considerations. The method supports farmers to understand their own relationships with others complexes information systems. The agricultural information system is, however complete method that can be used to classify, evaluate, and design a better social, cultural and economic system. There have been only few studies that are addressed to the dairy farms and information sources and their consequences on agricultural assets are important for policy reform. The rapid propagation of Information and Communication Technology has provided an opportunity of transferring agricultural knowledge via information systems in the developing countries. The current argument is that whenever farmers in the developing countries can able to increase their productivity via Information Communication Technology using mobile phone technology (WB, 2011). Policies implementation would facilitate the construction of ICT infrastructures for the benefit of all in developing countries (Omekwu, 2006). Information Communication Technology is a unique technological intervention that challenges the traditional barriers to social change and economic development in rural areas (Sreekumar, 2007).

According to Thioune (2003) developing countries have perceived significant changes in rural development through Information and Communication Technologies. These changes have been noticed especially in education, health, economics, communications, leisure, agriculture and

travel. The introduction of information technology in rural communities could contribute to growth in many developing countries. Some of those noticeable examples can be seen in Ghana, Kenya, Uganda, Bangladesh, and India. The role of Information Communication Technology is to promote rural livelihoods in the developing countries. In rural Ghana micro-finance institutions have adopted Information Communication and Technology with the purpose to reduce administrative costs and to increase the quality of the service. Information Communication Technology reduces administrative costs for example, the cost effective way of sending money through mobile phones. In Ghana through Information Communication Technology by World Possible program, distant learning centres have been introduced to the rural communities (Alemna and Sam, 2006).

2.5.3 Agricultural Knowledge and Information system (AKIS)

According to Roling (1988) an agricultural knowledge and information system is a network made up of organisations and people who are linked by commercial, social and professional relationships. Agricultural information can influence agricultural productivity by helping to inform results concerning land, labour, livestock, and capital. Reliable information and knowledge can improve significantly agricultural production. Agricultural information systems can be developed through education programmers, research, extension services, and others. It is accomplished by creating information systems to disseminate information to farmers. Nowadays better decisions on good farming practices are taken better production systems and market opportunities (Anderson and Feder, 2007). Today, innovation in agriculture knowledge exchange can improve the performance and production of agricultural activities. It also reduces the risks, and provides access to information for smallholder farmers and their organizations to connect combined Value Chains. This has shown the positive enclosure of developing Information and Communication Technology affecting smallholders in the Agricultural Value Chains; this support is being provided thorough capacity building of stakeholders with the business holder throughout the Value Chain (IICD, 2014). In Mali IICD is helping fruit producers to use mobile phones and internet to collect data on mango producers on a web based platform that enables them to access the European market to intensify the exportation of fruits and vegetables to Europe. Information system is supporting the project to identify farmers and their production systems for analysis purpose, and decision-making support service. It has also used Information and Communication Technology to improve health service delivery through the telemedicine

delivery model. The rural community health centres are able to contact a specialist doctor through Information Communication Technology (IICD, 2014).

2.5.3 Community Tele-centres in Mali

The Malian government has been assisted by many development partners like USAID, UNESCO to implement community Tele-centres all over the country. The main goal of the Tele-centres is to contribute to the networking and the strengthening and capacity building and information and knowledge sharing centres. Tele-centres have been used as training centres; eliminate the lack of information and knowledge within communities, to overcome the documentation problem, to reduce children diseases due to malnutrition through video contents. Tele-centres are helping farmers to post and have information on crops and market prices across West Africa trough MISTOWA project. Tele-centres are helping communities to access to better farming information via online and offline networks. Tele-centres offer trade exchange, farming tips, and knowledge sharing system amongst rural farmers (Afriklinks, 2009).

2.5.4 Challenges of mobile phone usage in Agriculture

The mobile phone has many positives impact on the rural livelihoods; however it can also have some challenges due to language barrier and illiteracy. Studies have found out in Kenya and Ghana that the less educated the farmers are the less likely they are to use the SMS. The poor network signal can also be a challenge to the farmers. Farmers are also facing the problem of charging the phone batteries if they are not connected to the electricity network (Frempong *et al.*, 2007).

2.6 Theoretical framework

The theoretical framework of this study was based on Agricultural Information Management System (AIMS). The AIMS is define as a system in which the information related to agriculture is generated, transformed, transferred, consolidated, received and fed back in a way that these processes work in in harmony to support the use of knowledge by actors (Roling, 1988). Theoretically, the AIMS is seen as an automated or manual system that involve machines, people, and/or structured methods for collecting, processing, transmitting and disseminating data that represents information. As supposed by Ciborra (2002), the information system concerns the effective use of information technology in society at large, institutions and organization. Therefore, the AIMS is a social system where the attitudes are highly affected by mains, norms,

beliefs and usefulness of the technology. The AIMS consists of components (system mechanism and system operation) and subcomponents (interface, network, control and management). Also, the AIMS analysis in a specific farming system can help identifying basic component and structuring the system, the different sources of information (Demiryurek, 2000).

2.7 Conceptual Framework

Smallholder dairy farmers have different socio-economic and institutional characteristics which include their education level, age, gender, and experience, group membership, herd size, access to inputs and services. Farmers also have different information strategies with different communication channels (electronic devices) and sources of information such as cooperatives, neighbours and extension agents. The types of information sought by farmers also include feed, health and market information. It is assumes that farmers faced the same issues such as transaction costs in milk marketing in terms of searching for adequate market and market information. Though their experiences and exposure are not the same, they express perceptions and preferences of information systems that will help them to reduce milk losses, thus increase outputs and incomes.

Conceptual framework

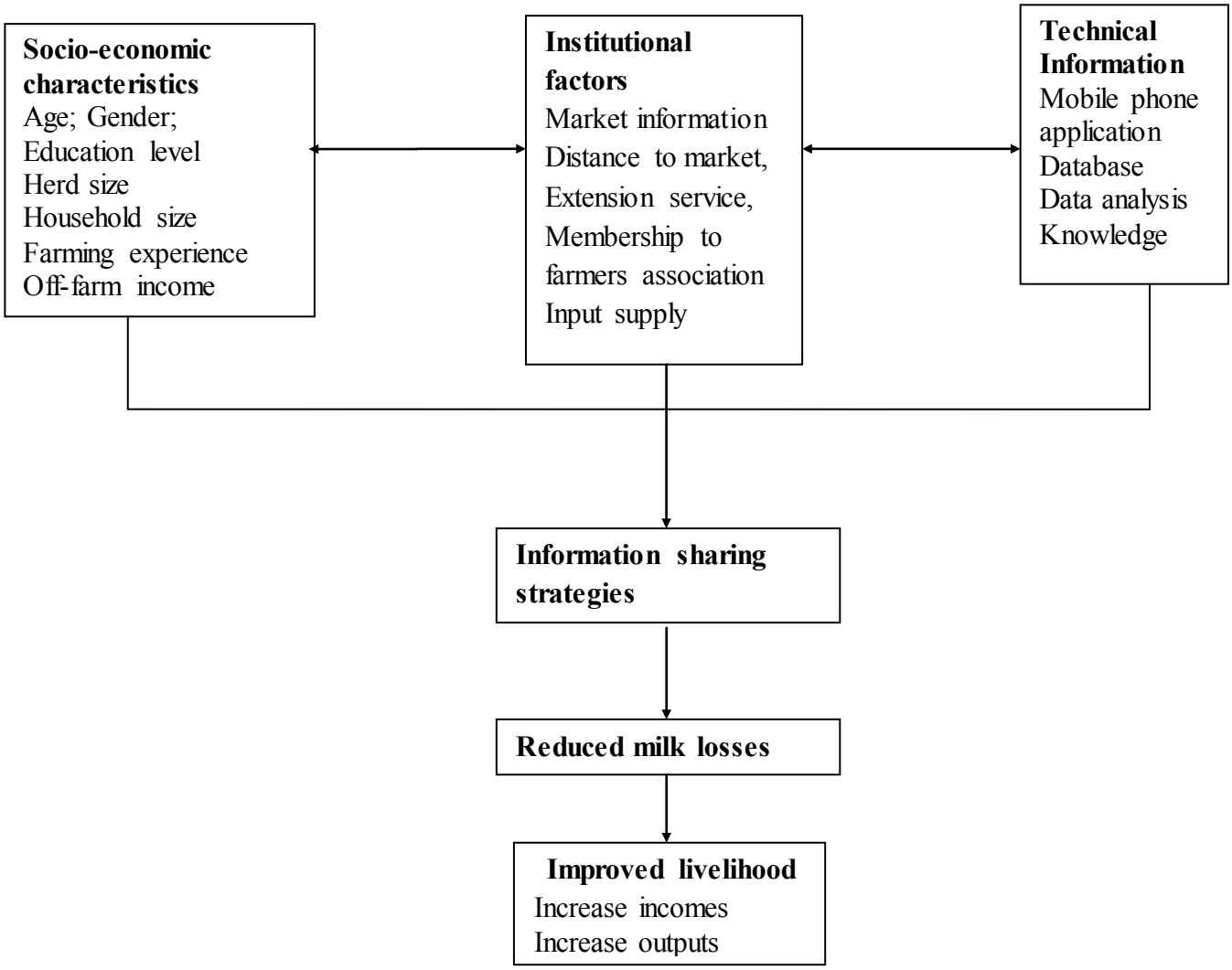

Figure 1: Conceptual framework

CHAPTER THREE
METHODOLOGY

3.1 Study area

This research took place in Bamako peri-urban areas. Bamako peri-urban was chosen because of its proximately and easy access to the capital city Bamako and its growing population. It has a population of 1.8 million (RGPH, 2009). It is located between 12° 39'N8° 0' W/ 12.650° N8.000° W. The district of Bamako is located within the second region Koulikoro. It has large number dairy farmers. Most of the dairy farmers are located around Bamako and some of them do practice mixed farming. The peri-urban areas were selected because most the dairy farms are within Bamako. Ouélessebougou is located in the rural commune of Kati, and Kati is in Koulikoro Region. The commune of Ouélessebougou has an area of nearly 1,118 square kilometers. The town of Ouélessebougou is located between 12° 0' 0" North and 7° 54'40"West. The commune had a population of 55,056 habitants in 2009. Kasséla is located between 13° 37' 0" North, 7° 26' 0" West. The town has 50,000 inhabitants takes about 2:58 hour by local transportation. Sanankoroba is in the Cercle of Kati Koulikoro Region, southern Mali. The commune had a population of 37,294 in 2009. The town is distant from Bamako by 34 km south on the Route National 7 (RN7). It is located between 12° 23′ 55″ N, 7° 56′ 16″ W. Tienfala is a small town and commune on the Niger River in the Cercle of Koulikoro in the Koulikoro Region of south-western Mali. As of 1998 the commune had a population of 4128. It is located 30 kilometers from Bamako. It is located between 12°44′10″N 7°45′1″W (Google map, 2015).

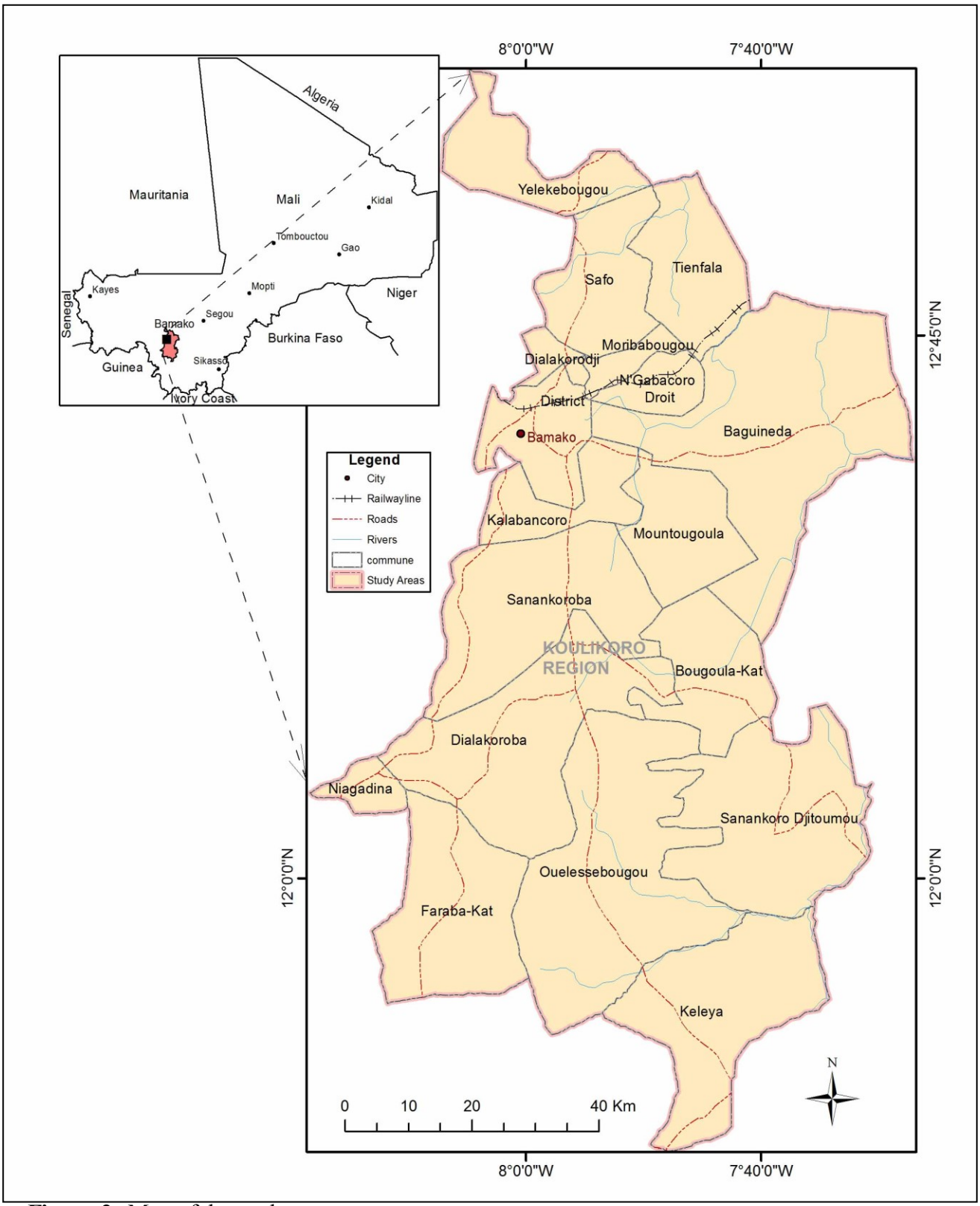

Figure 2: Map of the study area

Source of the map: Ethiopian mapping agency, prepared by *Geoffrey Maina* department of environmental science, Egerton University.

3.2 Study design

In this study, the cross-sectional design was used since it allows collecting data at one point in time as well as from a large population. Additionally, the design was preferred due its appropriateness with qualitative and quantitative data.

3.3 Sampling procedure

The target population for the study was dairy farmers at per-urban of Bamako. A random multi-stage sampling technique was used to select the target population. At the first stage, four cooperatives were purposively selected due their being the most important in dairy production of the area. At the second stage, a stratified sampling was used to select dairy farmers. At the last stage, a linear sampling method was used to select cooperative members and non-members from the list of cooperatives.

The sample size for producers was determined using the formula by Yamane (1964).

The formula is: $n = \frac{N}{1+N(e)^2}$

Where:

N= Population of dairy farmers

n = sample size

e= level of significance at 0.05 confidence level

1= constant value

$n = \frac{262}{1+262(0.05)^2} = 158$ Dairy farmers

$\text{Oulessebougou} = \frac{70(158)}{262} = 42$

The sample interval of linear sampling procedure was calculated using the following formula: $l = \frac{N}{n}$, whereas N is total population on the list and n the proportion of farmers to be interviewed.

Table 1: Population of dairy farmers in peri-urban area of Bamako

Villages	Number of Dairy Farmers	Sample size	Sampling interval
Oulessebougou	70	42	2
Tienfala	58	35	2
Kassela	65	39	2
Sanankoroba	69	42	2
Total	**262**	**158**	

3.4 Method of date collection procedure

The study used Interview method from farmers while focus–group method was used to collect data from cooperatives. The semi-structured question was used to collect data from farmers while the interview guide was used to collect from farmers' cooperatives. The collected information consisted of information on farmers' socio-economic characteristics, sources, types and channels of information used by dairy farmers. The data was collected by well-trained enumerators from DNPIA in order to ensure a high and efficient response rate.

3.5 Data analysis

Data entry and cleaning were conducted using the SPSS software (version 20). The descriptive Statistics (Mean, Standard Deviation, Variance, and Graphs) was used to summarize, organize and describe characteristics of the population. The inferential statistics such as Chi square was used to determine the significance level of sources of milk losses and information sharing strategies.

3.5.1 Objective 1

A descriptive statistics, percentage and overall means, was used to determine the different sources of milk losses. Additionally, Chi-square test was conducted for determine the statistical significance of the different milk losses.

3.5.2 Objective 2

In order to identify the information sharing strategies at farm and cooperative levels, the Chi-Square test and descriptive Statistics (Mean, Standard Deviation and Graphs) were applied to to

determine the sources and types of information. The Chi-square test was applied to show the level of significance among variables. Additionally, to recommend at least one ICT intervention, a descriptive statistics such as mean, standard deviation, graph and figure were used to define the most commonly used Information Communication Technology that can help farmers to reduce milk losses at both farm and cooperative levels.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Results

4.1.1 Objective 1: Sources of the milk losses and extent of their influence on the quantity of milk losses at farm and cooperative levels.

The result of milk losses recorded monthly at the farm level is shown in Table 2. The total losses recorded through spillage and spoilage at farm level were significant at 1% significant level (P=0.000, x^2= 49.07); (p=0.00, x^2=18.318). This is due to poor collection process, poor hygiene, inadequate handling equipment and infrastructure.

Table 2: Sources of milk losses at farm level (%)

	Overall		FC				Overall		Spill				Overall		Spoil			
	Yes	No	Yes	No	Chi2	p-value	Yes	No	Yes	No	Chi2	p-value	Yes	No	Yes	No	Chi2	p-value
Kassela	0	20	0	100	5.119	0.163	0	20	0	100	49.07***	0.000	0	20	0	100	18.31***	0.000
Ouel	2	24	7	93			10	15	41	59			5	20	20	80		
Sanank	1	26	4	96			1	26	2	98			2	25	7	93		
Tienfala	0	27	0	100			1	27	2	98			0	28	0	100		
Total	**3**	**97**					**12**	**88**					**7**	**93**				

Note: ***, significant at 1% level of probability; Ouel=Ouelessebougou, and Sanak=Sanakoroba.
FC: forced consumption;

Results in Table 3 Shows the milk lost at farm level for spillage (mean =0.06, Sd= 0.24, P=0.00), spoilage (mean =5.53, Sd= 55.58, P=0.260), Forced Consumption (mean =0.04, Sd= 0.31, P=0.29). The p-value is significant for both spoilage and spillage at 1% respectively.

Table 3: Descriptive statistics of milk loss at farm level (ANOVA)

	Overall		Kassela		Ouelessebougou		Sanankoroba		Tienfala			
Variables	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd	F -stat	p-value
Spoilage	5.53	55.58	0	0	1.05	2.99	19.57	106.71	0	0	1.35	0.260
Spillage	0.06	0.24	0	0	0.22	0.41	0	0	0.02	0.46	10.40***	0.000
F. consumption	0.04	0.31	0	0	0.11	0.54	0.04	0.29	0	0	1.26	0.29

Quantities and sources of milk losses incurred at the cooperative level of peri-urban dairy system are shown in Table 4. Each cooperative was found to handle different quantities of milk, Tienfala cooperative handling the least at 45,000 litres monthly whereas Kassela handling the highest 114,000 litres per month. The milk losses among the cooperatives were found to be significantly different P<0.0001. The higher the quantity of milk to handle, the higher the loss. Kassela had recorded the highest at 5.72% while Tienfala had recorded the least at 0.06%. Among the sources of milk losses, spoilage at 54.82% and forced consumption at 45.17% were the highest for Sanankoroba and Kassela respectively, whereas Sanankoroba recorded zero spillage at the cooperative level on the monthly basis.

Table 4: Sources and quantities of milk losses at cooperatives level (monthly)

Cooperatives	Monthly reception (Litres)	Monthly losses (Litres)	Monthly losses (%)	p-value (overall)	Source of losses (Litres)		
					Spillage	Spoilage	Forced consumption
Tienfala	45,000	250	0.06[c]	<0.0001	NA	NA	NA
Sanankoroba	90,000	2,258.67	2.51[b]		0	1282	977
Oulessebougou	54,000	1,823.33	3.38[b]		NA	NA	NA
Kassela	114,000	6,526	5.72[a]		1	3,534	2,991
Total	303,000	10,858*	3.58*		1	4,816	3,968
Milk losses (%)					0.01%	54.82%	45.17%

Note: Means with same letter along the column are not significantly different at P<0.05 using Tukeys' Honestly Significantly Difference (HSD). NA; No available data, * data based on information provided all information on milk losses

Estimated economic milk loss (dollars) at both the farm and cooperative level is shown in Table 5. The total estimated economic loss from 171 farmers and 4 cooperatives in peri-urban Bamako, Mali is $7,098.28. The highest loss was recorded at the cooperative level at $6,514.8 while the farm level was $583.44.

Table 5: Estimated economic milk loss in US dollars at both the farm and cooperative level

Level	**Quantity of milk lost (litre)**	**Estimated unit price (litre)**	**Estimated loss (monthly)**
Farm	972.4	$0.6	$583.44
Cooperative	10,858.0	$0.6	$6514.8
Total	11,830.4	$0.6	$7,098.24

Use of milk cooling facilities among dairy farmers at the farm level and its effect on milk losses is shown in Table 6. Among farmers 95% did not have any cooling facilities ((P=0.000, x^2= 18.23) had zero losses.

Table 6: Availability of milk cooling facilities (%)

Milk cooling	**Overall**	kassela	Ouess	Sananko	Tienfela	Chi2	p-vlue
No	95	100	100	98	83	18.23***	0.000
Yes	5	0	0	2	7		
Total	100	100	100	100	100		

Note: ***, significant at 1% level of probability.

4.1.1.2 The challenges identified through interviews at the farm and cooperative levels in relation to milk losses

The challenges faced by the farmers and the cooperatives that affect the milk losses as identified through interviews are shown in Table 7a and Table 7b. Poor infrastructures and poor milk handling practices are the main challenges to milk losses at the farm level. Also poor infrastructure, lack of market and unqualified personnel are the main challenges at the cooperative level.

Table 7a: The challenges faced by dairy farmers in relation to milk losses

Challenges at farm level		Frequency	Percent
Access to land	No	51	29.82
	Yes	120	70.18
Access to credit	No	113	66.08
	Yes	58	33.92
Access to inputs	No	141	82.46
	Yes	30	17.54
High price inputs	No	18	10.53
	Yes	153	89.47
access to extension	No	140	81.87
	Yes	31	18.13
Animal Disease	No	98	57.31
	Yes	73	42.69
Infrastructure	No	63	36.84
	Yes	108	63.16
Poor organization	No	102	59.65
	Yes	69	40.35
Thief animal	No	45	26.32
	Yes	126	73.68

Table 8b: The challenges faced by dairy cooperatives in relation to milk losses

Cooperative	Challenges identified through interviews
	1. Manual milk collection (process is underdeveloped)
	2. insufficient cooling and storage equipment before and after pasteurization
	3. insufficient transportation to local distribution points
	4. insufficient market information availability
	5. inadequate appropriate trained workers
	6. Unreliable electricity supply
	7. Long distance between farmers and cooperatives(Time)

4.1.1.3 Socio-economic characteristics of the peri-urban dairy farmers of Bamako, Mali

Age group distribution among the peri-urban dairy farmers is shown in Figure 3. The dairy farmers who are below 50 years old were about 65.6% (112/171) while farmers above 63 years were 13.5% (24/171). Peri-urban dairy farmers who are between 36-50 years were the highest though not signficantly different from those below 35 years and those between 51 years and bove.

The implication that peri-urban dairy farmers are young and can be trained and can adopt technology.

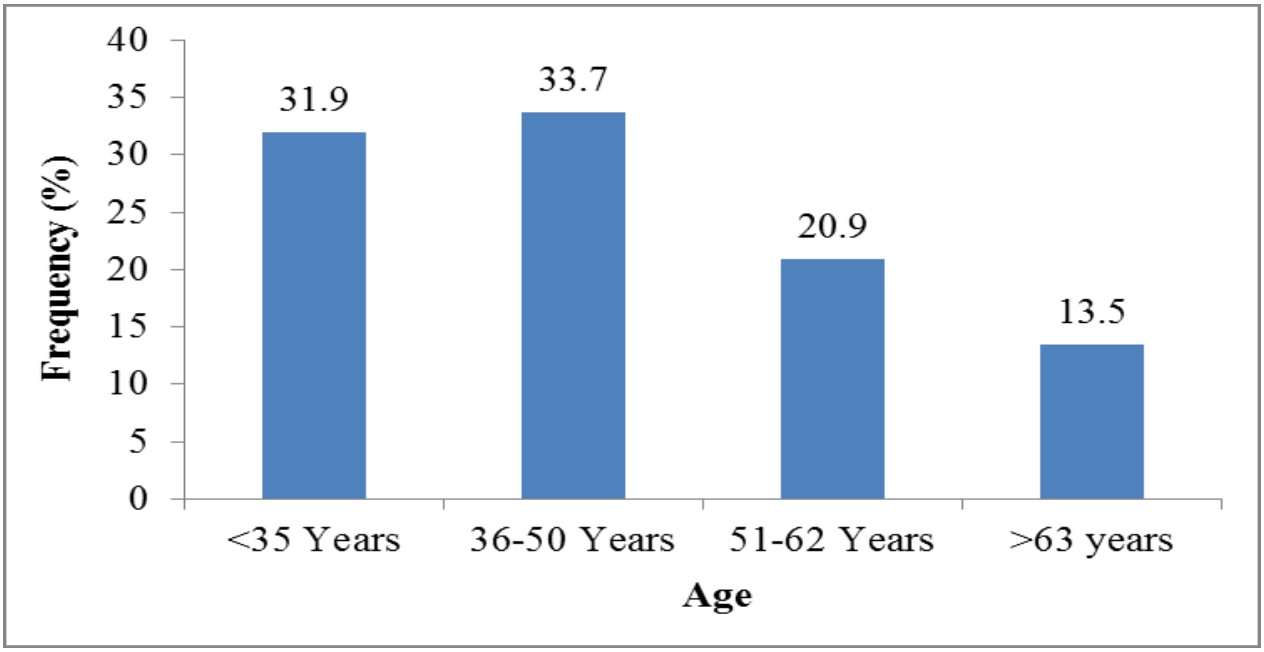

Figure 3: Frequency of age categories of the peri-urban dairy farmers in Bamako, Mali

The educational levels among the peri-urban dairy farmers is shown in Figure 4. There was a signficant difference between educational levels of peri-urban dairy farmers. Illiterate dairy farmers were the highest with 74.3% (127/171) while primary level was the lowest with 2.9% (5/171).

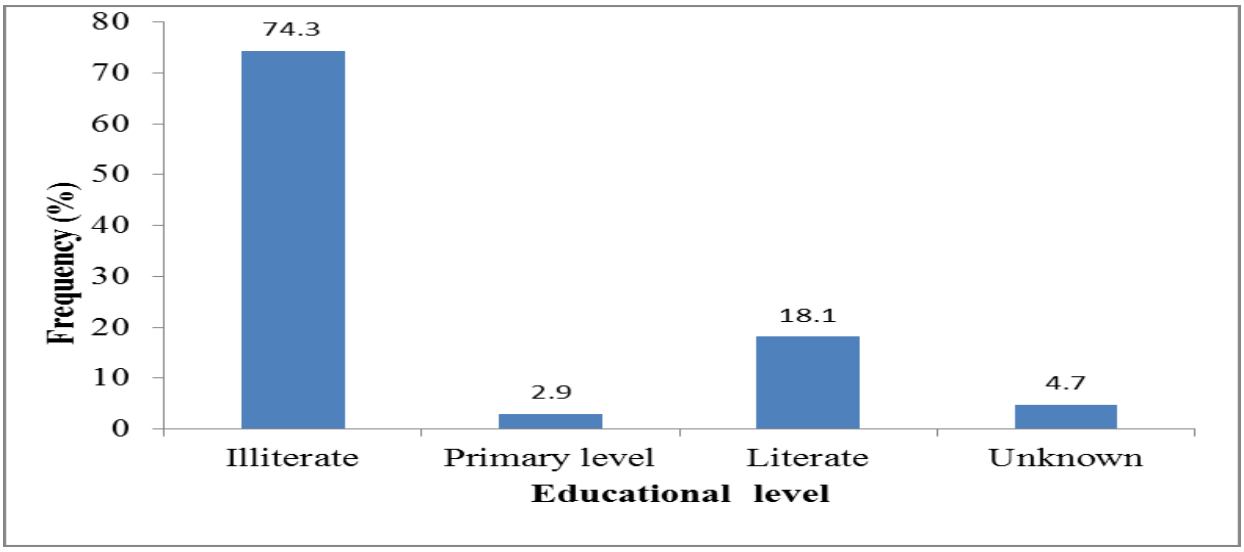

Figure 4: Frequency of educational level of peri-urban dairy farmers in Bamako, Mali

The gender distribution among the peri-urban dairy farmers is shown in Figure 5. There was a signficant difference between gender of peri-urban dairy farmers. Male dairy farmers were the highest with 98.2% (168/171) while female were 1.8% (3/171). All the female peri-urban dairy farmers were illiterate. Male farmers can easily adopt technology to address losses.

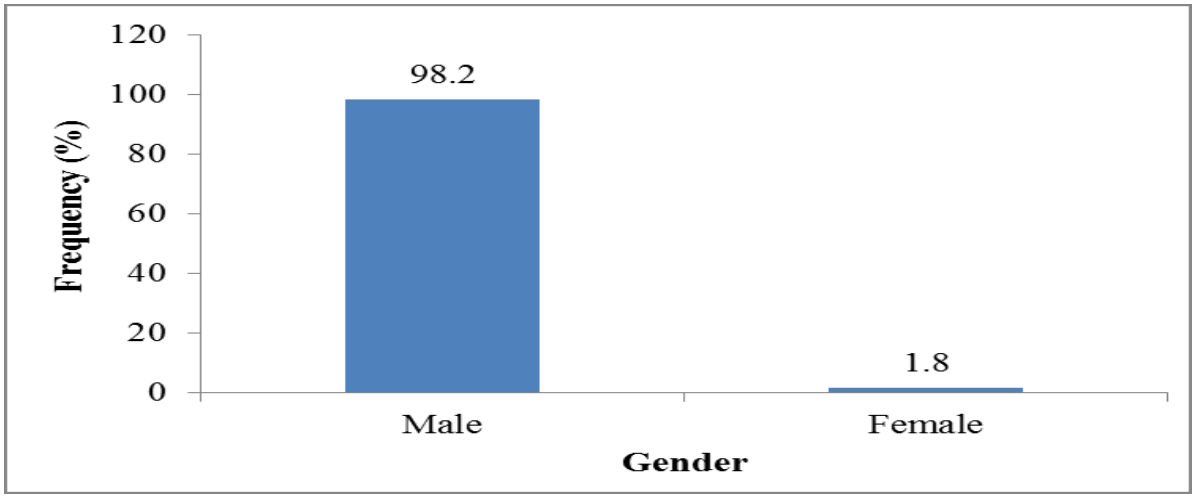

Figure 5: Frequency of gender of peri-urban dairy farmers in Bamako, Mali

4.1.1.4 Types of the peri-urban dairy farming system practice in Bamako, Mali

The type of farming practised among the peri-urban dairy farmers is shown in Figure 6. There was a signficant difference between type of farming practised by peri-urban dairy farmers. Traditional dairy farming was the highest practised with 89.3% (153/171) while mixed dairy farming practice was the lowest with 3.0% (5/171). Illitrerate peri-urban dairy farmers were majority practicing intensive farming mostly zero grazing with 92.3% and mixed farming with 80.0%. The traditional farming should be improved to intensive farming system in order to reduce losses.

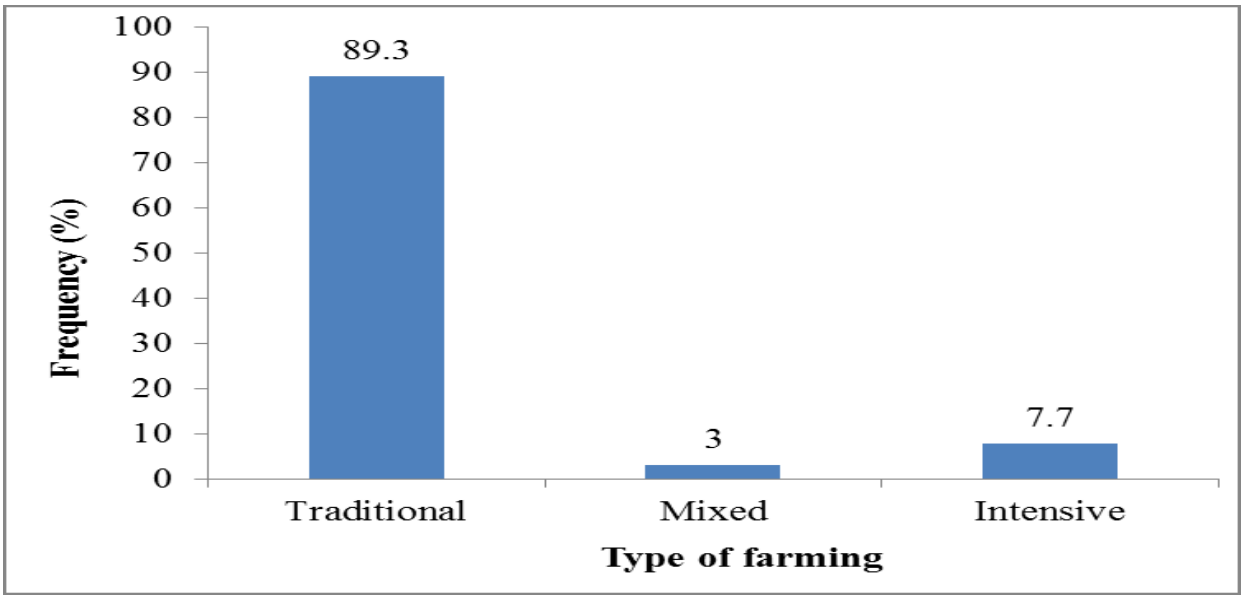

Figure 6: Frequency of farming system of peri-urban dairy farmers in Bamako, Mali

4.1.2 Objective 2: To identify existing Information sharing strategies at farm and cooperative levels to address milk losses and recommend at least one communication intervention that can help dairy farmers to reduce milk losses at farm and cooperative levels.

4.1.2.1 Government institutions and their roles in term of information sharing

The government establishments identified through interviews that are involved in information sharing with dairy farmers and cooperatives are shown in Figure 7. The only information provided under the division of animal production on milk production is breeding and animal health. This information is disseminated through the government extension workers through farm visits and cooperatives.

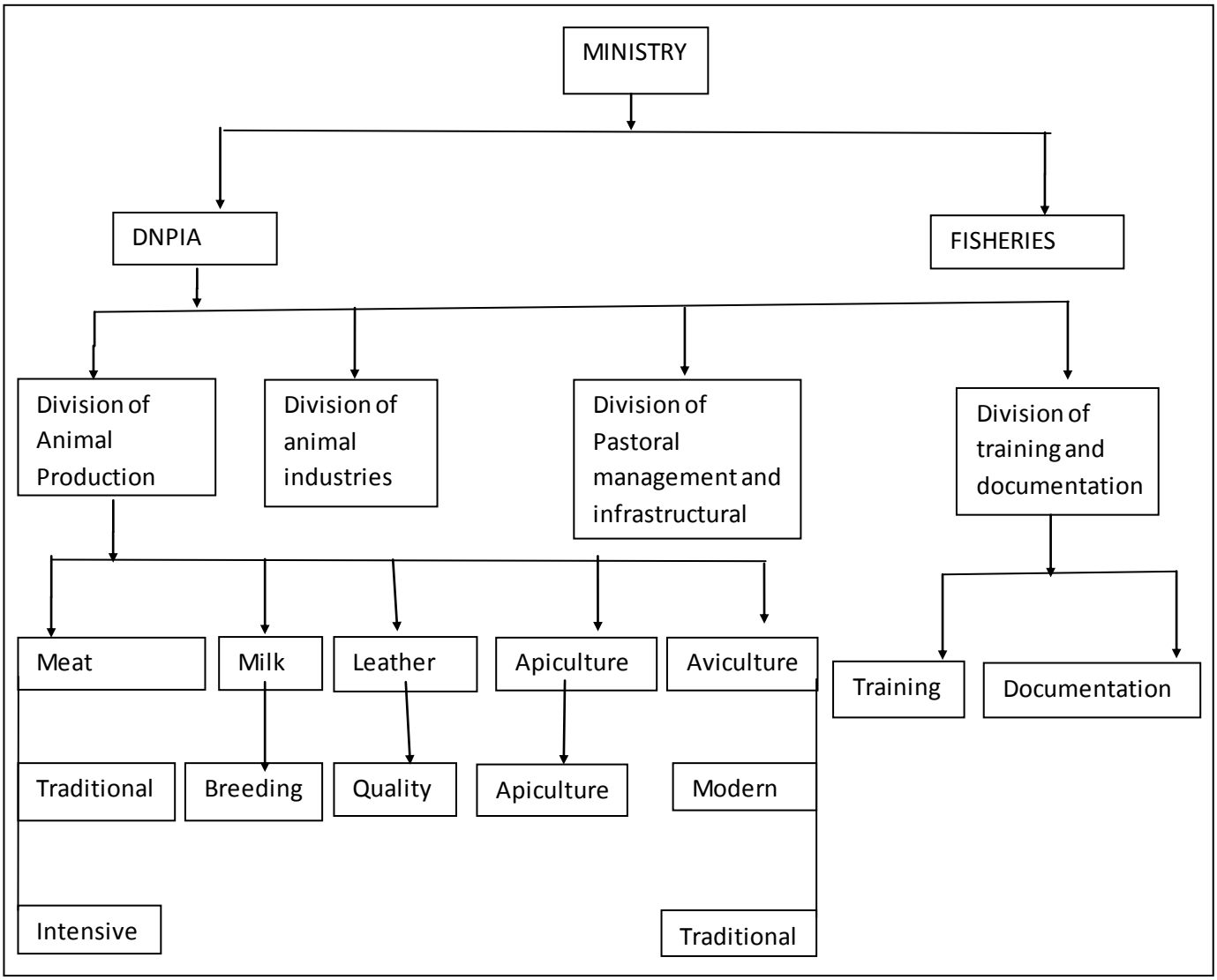

Figure 7: Government institutions that are involved in information and communication with dairy farmers and cooperatives

Flow diagram of information sharing strategies network and diffusion in Bamako peri-urban farming system is shown in Figure 8. Among the main communication platform at all levels of the peri-urban dairy, mobile phone was the most commonly used. The communication network involved use of mobile phone by farmers and transporters to acquire information whereas the cooperatives were using the mobile phone as well to respond to farmers.

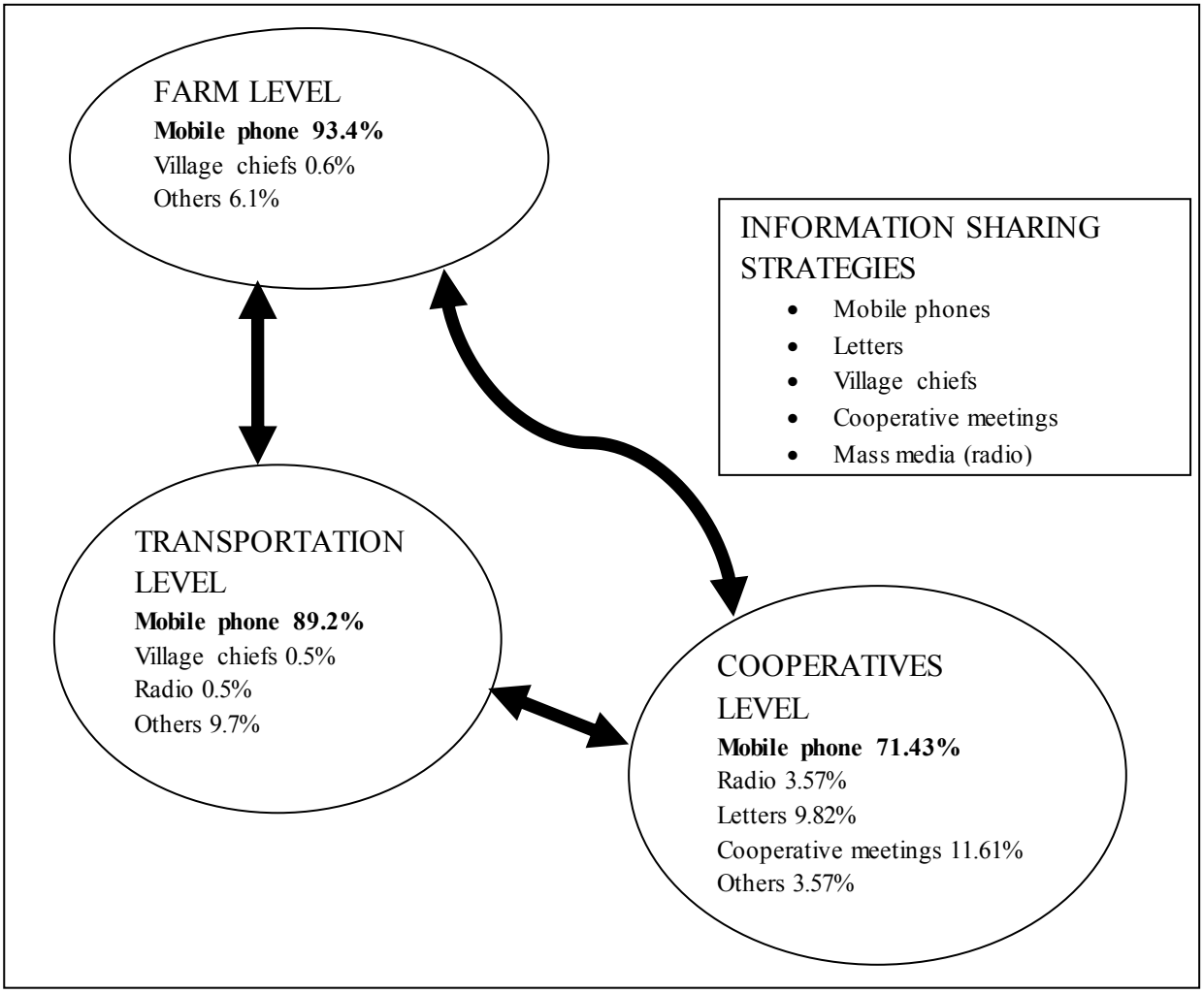

Figure 8: Flow diagram of information sharing strategies network and diffusion in peri-urban farming system, Bamako Mali

4.1.2.2 Sources and type of information used by the peri-urban dairy farmers in Bamako

Type of information that peri-urban dairy farmers are looking for at the cooperative level is shown in Table 8. Among all the information by the cooperatives, information on feed was the most sought after at 42.07% whereas the least sought after information was milk quality at 1.98%. All the cooperatives have at least one extension worker coming from the local Non-governmental organizations (NGOs) and government.

Table 9: Types of information shared by cooperatives

Type of information shared	Frequency (%)
Feed	42.07
Breed	6.93
Land ownership	2.97
Hygiene	11.39
Animal health	14.85
Cooperatives issues	13.37
Milk quality	1.98
Milk price	3.96
Finance	2.48

As shown in Table 10, Mobile phone was the most used information sharing pathway by the cooperative members to seek information. Extension workers and village chief were the least information sharing pathways used by the farmers to seek information from the cooperatives (P=0.003, x^2=25.23).

Table 10: Information sharing pathways (%)

Village	Overall	farmer–to-farmer	Mobile phone	Radio	village chief	chi2	p-value
Kass	20	0.00%	22%	0%	0%	25.23***	0.003
Ouelss	26	8.33%	26%	50%	100%		
Sanan	27	8.33%	29%	0%	0%		
Tienf	27	83.33%	23%	50%	0%		
Total	100	100%	100%	100%	100%		

Note: ***, significant at 1% level of probability

Information pathways used to get different types of information by peri-urban dairy farmers within cooperatives are shown in Table 10. Mobile phone was the most common type of information pathway used by dairy farmers for all types of information coming from the cooperatives.

Table 11: Types of information sorted for by channels

Type of information	Information pathways used in %						
	Farmer to farmer	Cooperative	Extension worker	Letter	Village chief	Mobile phone	Radio
Feed	1.14	12.50	1.14	12.50	1.14	70.44	1.14
Breed	0	7.14	0	0	0	85.72	7.14
Land ownership	0	0	0	0	0	100.00	0
Hygiene	0	20.00	0	5.00	0	75.00	0
Animal health	0	37.04	0	3.70	3.70	55.50	0
Cooperatives issues	0	3.45	3.45	10.34	0	79.31	3.45
Milk quality	0	0	0	20.00	0	80.00	0
Milk price	0	0	0	0	14.29	85.71	0
Finance	0	0	0	0	0	66.67	33.33

Sources of information used by the peri-urban dairy farmers in Bamako are shown in Figure 9. The cooperative was the highest source of information used by the farmers at 80.2% whereas the middlemen were the least source of information used by dairy farmers at 0.5%. Other sources of information used by farmers were neighbours 4.4%, farmer to farmer 13.7% and informal traders at 1.1%.

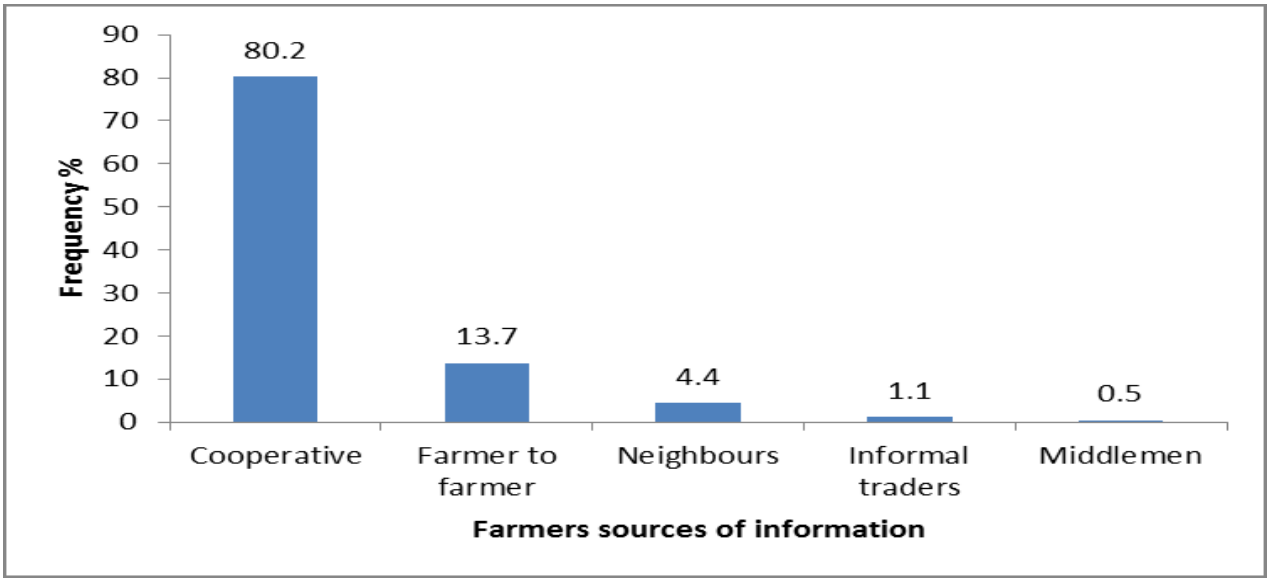

Figure 9: Sources of information used by the peri-urban dairy farmers in Bamako, Mali

Type of information sought by the peri-urban dairy farmers from cooperatives in Bamako is shown in Figure 10. Milk price was the highest sought after type of information at 59.3% whereas information on animal health was the least sought after at 1.1%. Other types of information sought by the farmers were milk quality at 15.9%, milk market availability at 3.8%, animal feed at 5.5% and any other available information at 14.3%.

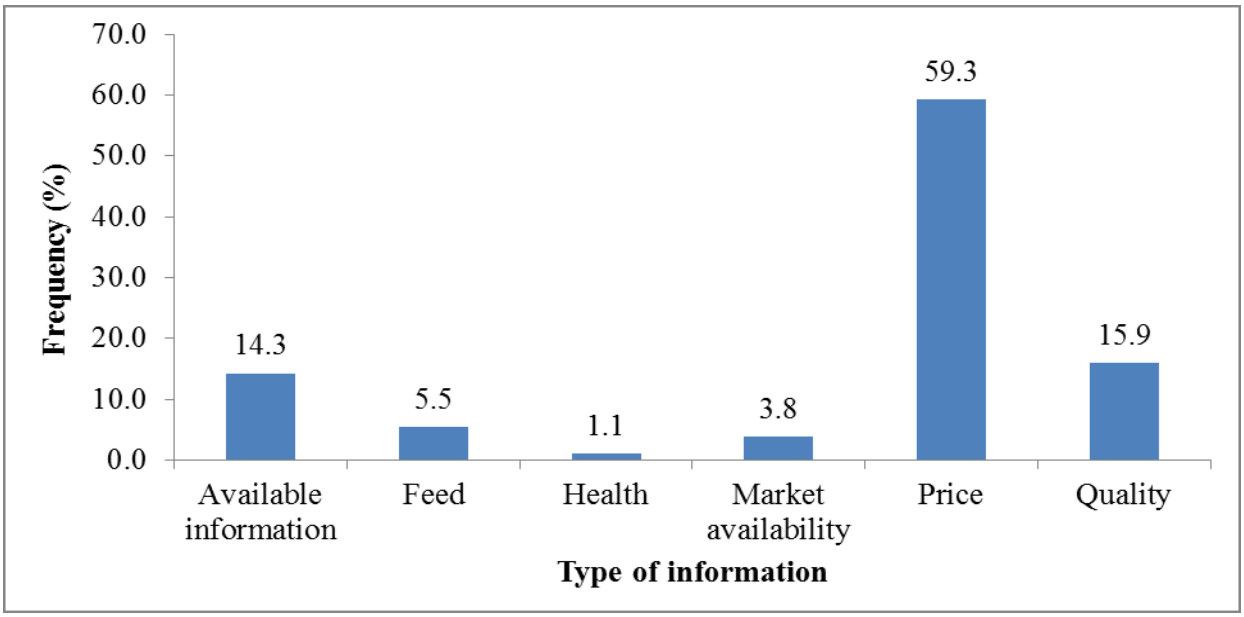

Figure 10: Type of information sought by the peri-urban dairy farmers from cooperatives

4.1.2.3 Most Common channels pathway an information sharing used in the peri-urban dairy

Common information sharing pathways used in the peri-urban dairy are shown in Figure 11. Mobile phone use was the most common information sharing pathway along the peri-urban dairy with 93.4% at the farm level, 89.2% at the transportation level and 71.43% at the cooperative level.

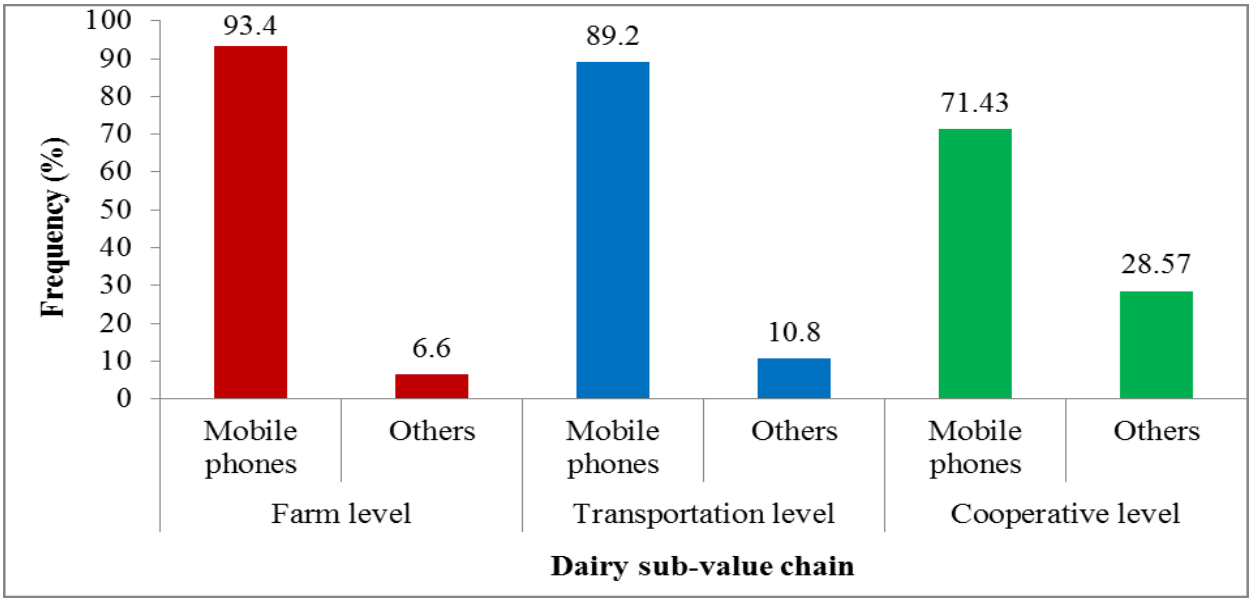

Figure 11: Common information sharing pathways used by dairy farmers

4.1.2.4 Recommended ICT intervention to reduce the milk losses and increased income at farm and cooperatives level

Recommended ICT to reduce the milk losses and increase income throughout the peri-urban dairy value chain is shown in Figure 12. The recommended ICT solution is the development and use of a mobile application that will link all dairy actors along the value chain with relevant information from the cooperatives. The information will help actors to reduce milk losses and increase both productivity and income throughout the value chain.

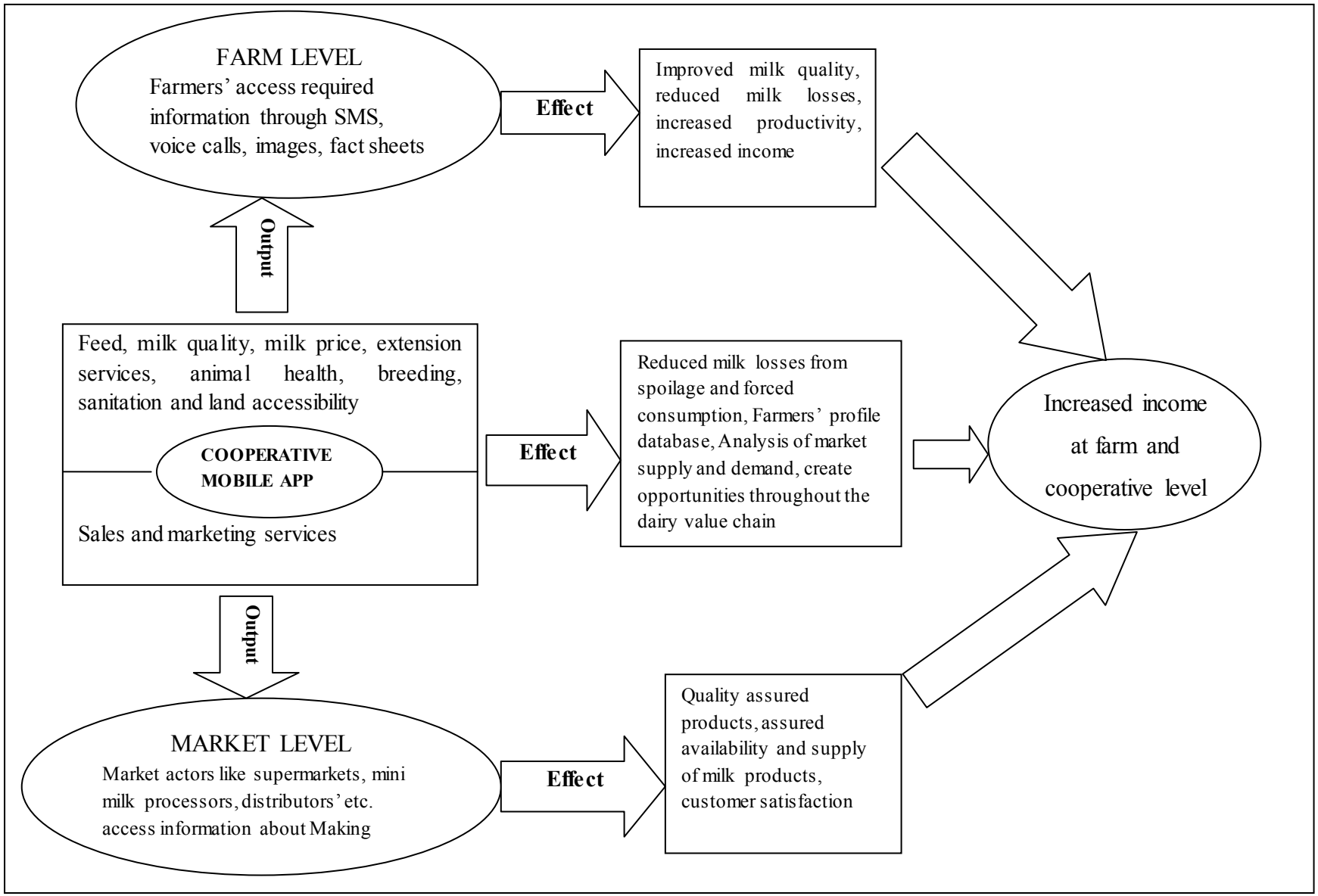

Figure 12: Recommended ICT to reduce milk losses and increased income at farm and cooperative levels

4.2 Discussion

4.2.1 Sources and quantities of milk losses of the peri-urban dairy farmers of Bamako

The total milk losses recorded at the farm level per month at farm and cooperative levels were significant at 1% significance level. This is explained by many challenges that face farmers and cooperatives as indicated in Table 7a and Table 7b. Kassela cooperative recorded the highest milk losses whereas they have the biggest potential of receiving over 15,000 litres per day compared to the current capacity of 3800 litres per day. Each cooperative was found to handle different quantities of milk, Tienfala cooperative was handling the least at 45,000 litres monthly whereas Kassela handling the highest 114,000 litres per month as shown in Table 4. Kassela recorded significantly higher milk losses at 5.72% among the cooperatives while Tienfala had the lowest at 0.06%. The differences in milk losses among the cooperatives was attributed to some of them lacking power supply, lack of qualified persons, inadequate sanitation practices, lack of cooling facilities and lack of market availability. It is also noticed, the higher the quantities of milk handled by the cooperative, the higher the loss recorded due to many constraints identified through interviews as shown in Table 7a and 7b.

Milk lost through spoilage was the highest among all sources of milk losses accounting for 98.00% as shown in Table 2 at the farm level due to poor milk collection process, lack of proper handling equipment, poor hygiene, lack of cooling facilities, lack of clean water, lack of quality control tests and bad road conditions (Lore *et al.;* 2005). Milk lost through spoilage was at 54.82% at the cooperative level was due to the lack of qualified personnel, lack of value addition, lack of cold chain, lack of market, of equipment and unreliable power supply as shown in Table 6. Poor handling of milk at the farm and long distances to market can result in significant losses due to spoilage (lore *et al.;* 2005). The use of cooling facilities was recorded mainly where employees were handling the milk, indicating that these are big farms with serious investments. Chilling of milk immediately after harvesting is highly recommended so as to curb the growth and activities of spoilage microorganisms.

The frequency of spillage among respondents was the highest form of milk losses at the farm level with 12%. The spillage at the farm level was more frequent where children were handling milk due to lack of experience. Spillage, spoilage and forced consumption were not reported in farms with milk cooling facilities as shown in Table 6. Spillage almost occurs during the transportation and within premises and also through adulteration (Lore *et al.;* 2005).

Spillage is attributed to the practice of transferring milk from equipment to another and mechanical faults in equipment handling milk. Sanankoroba had recorded zero spillage at the cooperative level on the monthly basis as shown in Table 4.

Milk loss through forced consumption was 45.17% at the cooperative level as shown in Table 4. The cooperatives had recorded the highest levels of forced consumption because of lack of market, lack of processing dairy products with longer shelf-life and unreliable cooling facilities. These are the main factors forcing the cooperatives to give away the milk before it gets spoiled. Losses through forced consumption occur because the seller does not get the full value of milk had been sold but retains some value (Lore et al.; 2005). The lost could be reduced by product diversification where dairy products such as cheese, butter, dried milk and others that have a longer shelf life to be processed by the cooperatives. In most of the rural milk-producing areas, the road infrastructures are in poor condition and the situation gets worse during the rainy season, which coincides with the high production season. As a result farmers produced more than what they can sell, this aggravates significant losses due to forced consumption or spoilage. Policies briefs are needed to support training to dairy farmers on hygienic methods of milk handing in order to contribute to reducing losses due to spoilage, because damages due to poor handling and packaging are ranking among the most important causes of milk losses (Lore *et al.*, 2005). Causes and factors that are influencing milk losses are: marketing constraints, poor rural infrastructures and poor farm practices Lore *et al.*, 2005).

Milk losses have a big economical effect on the development of the dairy cooperatives. The estimated total economic loss by sampled farmers and four cooperatives of the peri-urban system of Bamako is $7,098.24 as shown in Table 5. However, the major economic loss is at the cooperative level at $6514.80. According to DNPIA (2015), the national milk production in Mali is estimated to be 2 billion litres with estimated losses of 65%. This translates to economic losses of about $780,000,000 per year. This loss has a negative impact on the national Gross Domestic Production. An accurate assessment of the level of post-harvest milk and dairy product losses is necessary for identifying specific links in the milk chain where significant losses occur. This in turn will facilitate targeting of practical solutions to the problem and justifying interventions aimed at reducing or eliminating these losses. A dynamic is needed from government to reduce post-harvest milk losses, contamination and spoilage (Lore *et al.*, 2005). Interventions for reducing post-harvest milk losses could be having proper training of farmers (Omore et al., 2001),

the adoption of new dairy technologies, Government policy and regulation and an adequate information sharing strategies along the value chain is ICT (Lore *et al*., 2005). Studies have shown that any information and communication technology (ICT) intervention that improves the livelihoods of poor rural families is likely to have a significant impact (direct and indirect) on enhancing agricultural production, marketing and reducing post-harvest losses (Mugwisi *et al*., 2014).

4.2.1.2 Socio-economic characteristics of the peri-urban dairy farmers of Bamako

The dairy farmers who are below 50 years old were about 65.6% while farmers above 63 years were 13.5% . Peri-urban dairy farmers who are between 36-50 years were the highest though not signficantly different from those below 35 years and those between 51 years and above. The majority of the dairy farmers belonged to middle age category. This implies that the middle age are more engaged in dairy farming in Bamako due to the need to earn a living. This is the group that is in reproductive stage so the families need good and services for example education, health and food. Being near the peri-urban, urban market, is an advantage for them to access to the market. This age group also is ready to adopt new technologies to improve their businesses. This age group is more likely to overcome the challlenges identified through interviews shown in Table 7a and 7b. According to Mohamed (2007), the young farming household belong to economically active group which are more likely to adopt new technologies so as to increase their incomes.

Education level of the peri-urban dairy farmers was a very important factor in this study because it helped to determine the degree at which peri-urban dairy farmers can adopt the new technology of information sharing. The low level of education level had implications on the use of ICT (eg. Mobile phones) . Previous studies have shown literacy is important in the use of mobile phone for information access due to difficulty of searching mobile phone menus (okello *et a.l,* 2010). The educational levels among the peri-urban dairy farmers is shown in Figure 4. There was a signficant difference between educational levels of peri-urban dairy farmers. Illiterate dairy farmers were the highest with 74.3% while primary level was the lowest with 2.9%. All the female peri-urban dairy farmers were illiterate. According to Koskei *et al*. (2013) the basic access to education increases the likelihood of information sharing and uptake of good dairy information technologies to reduce milk losses and achieve higher income. Studies have shown that farmers' educational level can increase the probability of adopting new agricultural

technologies such as yields , fertilizers and pesticides (Feder *et al.*,1985). The education level of a member in the household can significantly affect positively the adoption of new technology skills and knowledge (Jolliffe, 2002). However, when developing an ICT strategy, the education level of the farmers should be taken into consideration.

The gender distribution among the peri-urban dairy farmers is shown in Figure 5. There was a signficant difference in gender distribution among peri-urban dairy farmers. Male dairy farmers were the highest in number with 98.2% while female were 1.8%. The female dairy famers were between 36-62 years old. This gender imbalance among the dairy farmers in Mali is a common phenomena, particularly in the pastoral culture where women are more involved in the commercialization of dairy products than the actual farming. According to ILRI (2009), male farmers are more engaged in social networks, thus it gives them a greater chance to acces to agricultural information than women. In many African societies , gender affects on how farming operations are undertaken particulartly the adoption of dairy new technologies (Johnson and Flaherty, 2011).

4.2.1.3 Type of farming system practiced by peri-urban dairy farmers of Bamako

There was a signficant difference between type of dairy farming practiced by peri-urban dairy farmers. The type of dairy farming highly practiced was the traditional with 89.3% while mixed dairy farming practice was the lowest with 3.0% as shown in Figure 6. Illiterate peri-urban dairy farmers are majority practicing intensive farming with 92.3% and mixed farming with 80.0%. However, these illiterate farmers who are adopting these modern methods of dairy farming are wealthy pastoralists who inherited livestock from their ancestors . The dairy farming system in Mali is not well developed/ defined. However there is a growing initiative through private entreprenueurs eg (NGOs, and some rich business men who are embrecing the sector) especially at the peri-urban to valorize the dairy value chain.

The peri-urban subsystem exploites opportunities for urban and peri-urban resources for production and it is always around the capital cities of Bamako. This has led to improve dairy breed around the city of Bamako and also stimulated the need for improved feeding , hence importation of animal feed to Bamako peri-urban. Some entrepreneurs are formulating feeds for sale. This has improved milk production DNPIA(2010). Due to the lack of infractructures, most of this milk is spoiled. Consequently, this has had an effect on milk losses. Also, this increase in

milk production has resulted in the emergence of new informal milk trade in Bamako and other urban centers in Mali. The informal milk market offers cheap milk to consumers compared to processed products from the cooperatives.

4.2.2 Government institutions and their roles in term of information sharing by dairy farmers in the peri-urban of Bamako

The government institutions that are involved in dairy sector are under the Ministry of Livestock and Fisheries as shown in Figure 7. The government is very active in animal production such as meat, breeding, leather, apiculture, aviculture, training and documentation. But the milk sub-sector is almost non-existent. The only information provided under the sub-division under milk production is breeding and animal health. This information is disseminated through the government extension workers through farm visits and cooperatives. This is so because in the 1990's during the market liberalization and Structural Adjustment in Africa, the dairy sector in Mali was 100% privatized, therefore there is no longer any direct investment from the government into dairy sector (SOLAIMA, 2014). This lack of direct investment of the government into the dairy sector has affected the type and strategies in information sharing in this sector and this information flow is not uniform. First, the extension workers available to work directly with farmers are not enough. Secondly, the few available have changed the strategies of information sharing from individual farm visits to use of model farm demonstrations. Therefore, the direct influence of government role on the reducing milk losses is not highly felt. However, NGOs have stepped in to fill this gap by employing their own extension workers to work with cooperatives and also sometimes facilitate government extension workers to be involved in the dairy sector.

Today in order for the dairy sector to be successful, these small organizations need the support from the government: policies support to regulate the importation of foreign milk so that the local production can emerge. This national policy can only be possible if the government and international traders are more solidary in recognizing the right to the national sovereignty (Kabanda, 2011). Countries like Zimbabwe and China have set national policies on the use of ICT in the agriculture sector (Kabanda, 2011; Zhang *et al*., 2016). For example according to Zhang *et al.* (2016) with the rapid development of Information and Communication Technologies, data and information are being efficiently generated, stored, analysed disseminated and used to support farmers and farming communities to improve their productivity and sustainability. In Zimbabwe the national policy was put in place in 2007 in order to provide guideline and direction to the implementation of ICT use in all sectors of the economy including agriculture. The incorporation of ICT in the development strategies for agricultural development

has a potential to increase access to markets for agricultural products by increasing income (Government of Zimbabwe, 2012).Agricultural information is a key component in improving smallholder agricultural production and timely markets information, particularly of perishable items (Rashid and Elder, 2009).

4.2.2.2 Sources and types of information used by the peri-urban dairy farmers in Bamako

Information on the animal feed was the highest sought at the cooperatives because during dry seasons feed is very expensive and cooperative members get these feed on subsidies, whereas information on milk quality was the least sought at the cooperative because farmers get training on this issue through the cooperatives and NGOs periodically. The frequency of the type of information that dairy farmers are looking for at the cooperative level is shown in Table 8. Information on feed was the most sought after at 42.07% because farmers who are members of these cooperatives do get subsidies on animal feed and milk exchange for feeds as a form barter trade. Peri-urban dairy farmers in Mali are faced with problems of grazing land availability thereby making the animal feeding more expensive. After feed, the second most sought after information was animal health at 14.85%, problems facing the cooperatives at 13.37% and sanitation at 11.39%. All the cooperatives have extension workers attached to them by several Non-Governmental Organizations (NGOs) that deal with issues of animal health and cooperative problems as shown in Table 8. Whereas the least sought information was on milk quality at 1.98% because dairy farmers have been trained by the cooperatives on clean milk production practices.

Mobile phone was the most used information sharing pathway by the cooperative members to seek information from the cooperatives as shown in Table. Village chief were the least information sharing pathways used by the farmers to seek information from the cooperatives. Mobile phone was also the most common type of information pathway used by dairy farmers to seek all types of information coming from the cooperatives. Farmer to farmer was the information pathway with least use and was only to seek information on feed at 1.14% as shown in Table10.

Peri-urban dairy farmers had different sources of information about dairy production. The most common source was the cooperatives at 80.2% as shown in Figure 9. Throughout the study, mobile phone use in information sharing by the peri-urban dairy farmers was the most common

type of communication channel at 93.4% as shown in Figure 11. Mobile phones have become the cheapest and easily accessible by farmers. The mobile phone uses has added a new dimension to communication between farmers which has enabled them to access extension services, help raise awareness, forecasts of weather conditions, milk prices, higher market participation by farmers and it can significantly reduce communication and information asymmetry that existed between the farmers and the traders (Mugwisi *et al.,* 2014). Similar studies have shown that the use of phones among dairy farmers has linked them to market outlets and other service providers. These findings showed that farmers appreciated the use of phone as easy, fast and convenient way to communicate (Masuki *et al.,* 2009). It can also reduce communication and information cost for rural communities and provides new opportunities for rural farmers to access to information on new agricultural technologies (Aker and Mbiti, 2010). Among the communication channels used, Village Chief was the least type of communication channel used the farmers at 0.6%. Other types of communication channels include farmer to farmer, letters, radio, television and farmer field days.

The dairy cooperative movement in peri-urban system is growing at a very high rate due to the benefits associated it. These benefits include guaranteed market of milk to the farmers, extension services, trainings and provision of subsidized dairy inputs. According to Zhang *et al.* (2016) there are many ways in developing deploying and managing agricultural information services. These services mechanisms can be categorized into three types: Government-led, market driven and self-support. In China the traditional agriculture has been reformed by advanced agricultural informatisation that has contributed to significant improvement in agricultural productivity and sustainability.

4.2.2.3 Common information sharing pathways used in the peri-urban dairy sub-value chain in Bamako

Mobile phone use was the most the common information sharing pathway along the peri-urban dairy sub-value with 93.4% at the farm level and 71.43% at the cooperative level chain are shown in Figure 11. Communication channels are pathways through which information are transmitted to audience or receiver (Olowu, 2001). If there is new technologies or recommendations that need to be disseminated to farmers, extension agents carefully adapt communication sharing strategies and channels to reach out local farmers (Lionberger and Gwin, 1982). Information Communication is catalyst in agricultural development process. It can

facilitate and confirms the desire to change. Different communication channels are used to disseminate agricultural innovations (Yahaya, 2003).

Today in Africa most of the farmers do have mobile phone. In the last decade, the use of mobile phones in African countries has been growing fast, with more than 70% of mobile phone subscription and also having surprisingly a positive impact on the agricultural sector. The mobile phones are making the agricultural information more accessible and convenient to dairy actors. However, the traditional approach of providing agricultural information through extension services is overstretched and under-resourced. Mobile phone has improved farmers' management of inputs and outputs supply by improving communication between farmers and traders also facilitate the provision of inputs to rural areas, by reducing their cost (Suri, 2011). It has facilitated the delivery of other services such as money transfer (known as m-money), a system whereby money transferred to different users via a mobile phone (Foster and Rosenzweig, 2010). It has increased accountability of extension service trough collecting data at farm and agent level. It has increased communication linkages with the research systems by improving communication flow between farmers, extension workers, research centres and vice versa (Dillon, 2011).

Mobile phone applications such as SMS (Short Messaging Service), internet and voice can be used to collect data on farmers' adoption, yields and costs, rather than waiting for annual agricultural surveys (Duflo *et al.,* 2007). A GSM network uses a networking centre to coordinate the sending and receiving of messages. Through SMS based support system farmers can receive automated price and weather information or request information on demand by texting keywords to an SMS server. The server can answered farmers through agricultural experts. However mobile phone has its limitations because the SMS carries only a limited amount of information and requires a basic level of education (Gakuru *et al.,* 2009).

Flow diagram of information sharing strategies network and diffusion in Bamako peri-urban farming system is shown in Figure 8. The peri-urban dairy farmers, milk transporters and cooperatives are the key actors that form the social network in information dissemination and diffusion process. Among these key actors, mobile phone has been the most common type of information sharing pathway used along the dairy sub-value chain. According to Rogers (1995) the exchange of information and its diffusion takes place within a social system. Actors such farmers, cooperatives, transporters and organization are the members of the social system.

Therefore, it can be recommended as the most suitable communication intervention that can be used to reduce milk losses, increase productivity and incomes.

4.2.2.4 Recommended ICT intervention to reduce milk losses and increased income at farm and cooperative levels

According to Richardson (2005) any ICT intervention that improves livelihoods of poor rural families will likely have significant direct and indirect impacts on enhancing agricultural production, marketing and post-harvest activities – which in turn can further contribute to poverty reduction. Mobile application development to connect all the actors with relevant the information sharing will help actors to reduce milk losses and increase production and income throughout the value chain. However, mobile phone application will have an option of choosing local languages on its menu. This will also allow farmers who do not have formal education but have received adult literacy education to relevant information on market price, milk quality, animal health and feeding. This new form of ICT will create a form of interaction between the dairy actors and the source of information at real-time basis. Whereas the traditional forms of information has been used in provision of advisory services but not on real-time basis. According to Goyal (2010), radio and TV programs regularly feature weather and agricultural information in developing countries have provided information on price and quality. In some countries, national ministries of agriculture have attempted to integrate ICTs into information delivery services, specifically by establishing district information centres, with the growth of mobile phone coverage, many of these initiatives have moved away from "traditional" ICTs to mobile telephony, including voice, SMS, and internet-based services (FARA, 2009).

Information sharing through mobile phone is a system that can contribute towards reducing milk post-harvest losses along its value chain. Apart from the field days, workshops and media campaigns, mobile phone applications are becoming more efficient for disseminating information aimed at directly minimizing or eliminating milk losses through information networks. The information network sharing will also act as a comprehensive and accurate electronic data and repository of dairy related statistics (Lore *et al.,* 2005).

An agricultural information system and communication network is an automated or manual system with a group of interacting components such as people, machines, that are organized , transmitted, processed, disseminated , and operated together for a common goal. System

approach is a way of looking and dealing with problem in order to identify and improve the particular system (Spending, 1988). An improved information flow within the agricultural sector is the key component in improving small-scale agricultural production and increased production to remunerative markets, leading to rural livelihoods development such as improved food security, quality, yield and national economy (Asaba *et al.,* 2006). Information and Communication Technologies (ICTs) provide an opportunity for developing countries to harness and utilize information and knowledge to improve productivity including agriculture (Lwoga, 2010).

CHAPTER FIVE
CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

1. Sources of milk losses at the farm and cooperative levels are due to spillage, spoilage and forced consumption. The most frequent milk loss at all levels is spoilage due to the lack information on dairy production and processing especially handling.
2. Mobile phone was the commonest communication channel use by dairy farmers in peri-urban of Bamako. Feeds and health services were the most sought information while the cooperative remained the main source of information for farmers. Lastly, the best suitable pathway of communication intervention among dairy farmers in peri-urban of Bamako was is mobile phone.

5.2 Recommendations

1. To reduce milk losses efforts should be put in good milk handling practices and hygienic measures. Also investment in dairy infrastructures by farmers and cooperative should be promoted.
2. Capacity building of cooperatives and farmers should be enforced by promoting more efficient information sharing strategies. Mobile applications should also be developed to facilitate information flow among dairy farmers and cooperatives.

5.3 Area for further research

This study was only limited to assess the information sharing strategies among dairy farmers in peri-urban area of Bamako, the capital city. Further research should include the entire value chain of the dairy sector not only in per-urban area of Bamako but also the countrywide.

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APPENDICES

Appendix 1. Questionnaire

Questionnaire Code_____

Enumerator

Name_____Signature_____

DATE OF INTERVIEW……. VILLAGE…… LOCATION……

DIVISION…….. DISTRICT……

Household ID #	
Time interview started	
Time interview ended	

Please answer the following questions. (Translate in native language where necessary)

I. FARMER IDENTIFICATION (SOCIO-DEMOGRAPHIC INFORMATION)

Total number of people in the household _____

ID #	Relation to h/h head	Age	Sex	Marital status	Education	Occupation	Income

1. Do you have phone? 1: Yes❒; 0: No❒.
2. Farm size_____
3. Type of farming _____
4. For how long have you been in dairy farming? _____ years.

II. ORGANIZATION FOR FARMERS

2.1 Are you a member of any farmers association? 1: Yes❒; 0: No❒. If yes fill the table below

Organization name	**Cooperative name**	**Villagers group name**	**Association name**

2.2. How often do you meet?

_____

2.3. What issues do you discuss during the meetings?

_____

_____

_____

_____

2.4. What are the communications channels used within your organization? (List the different communication channels) _____

_____

III. INFORMATION

3.1 How do you get information?

3.1.1 Source of information _____

3.1.2 Type of information _____

3.1.3 Type of cost _____

Source of info: Friends, newspaper, Radio, Mobile Phone, TV, Internet, Government, NGO, Cooperative, Others (specify)……

Type of Info: Price, Quality, Market availability, Animal disease, feeding, Others (specify)……

Type of cost: calling, Bying , subscription, Others (specify)……..

3.2 Do you have any information on the existing market price before you sell your milk?

1: Yes❒; 0: No ❒ If Yes, where do you get this information

_____

3.3 Dairy information

3.3.1 Inventory of cattle

Bull	Bull cow	Heifer	Cow	Calves

3.2.2 Different types of breed

Types breed	Number of breed	Cow	Quantity of milk per breed per day	Bull

3.2.2.1 How did you get information on your cattle breed?

3.2.2.2 Do you have any problem with your cattle breed?

_____

_____

_____

3.3 Mortality registered in the course of last 12 months fill the table

Causes of mortality	Types of animals	Number death	Types of breed	Do you communicate with others Yes? No	If no why

3.4 Do you practice insemination? 1: Yes❒; 0: No ❒

3.5 How do you get information on insemination? 1: Extension service; 2: Company 3: other to specify_____

4.Milk production

4.1 Milk production, utilization and losses

Number. of cows	Milk production per day		Current milk production	Quantity of milk for the family	Quantity of milk sold	Price per liter	Milk losses
	Dry season	Rainy season					

4.2 Milk products development and commercialization

Type of the Product	Quantity/year	Who develops the products?	Who sells the products?	Where are the products sold?	Product price

4.2.1 Who is in charge of the selling those products?

_____

Person in charge: 1 head of household, 2 wife, 3 children, 4 employee, 5 others to be specify……

4.3 Milk losses per month

a) Spillage (pouring) 1: Yes □; 0: No □ If yes, how many litres _____
b) Spoilage 1: Yes □; 0: No □ If yes, how many litres _____
c) Forced consumption 1: Yes □; 0: No □ If yes, how many litres _____

4.4 Do you use any milk cooling facility? 1: Yes ❒; 0: No ❒

If Yes describe it

_____

_____

If no, why?

_____

_____

4.5 What are the major Constraints of milk production?

Tick 1: Yes; 0: No

Access to land	
Access to credit for investing in milk production	
Difficult to access inputs	
High cost of input (feeding, seeds)	
Lack of extension services	
High level of disease	
Poor infrastructure	
Lack of information	
Poor organization of breeder	
Theft of animals	
Other1 (to specify) _____	
Other2 (to specify): _____	

4.6 How is the trend of revenue for the last 5 years? 1. Increasing□; 2. Decreasing □; 3. The same □;

4. Difficult to tell □; 5. Somehow □

5.Transport system

How do you transport your milk from farm to market?	To whom are you supplying your milk?	Where do you get your milk?
1.Foot [ ] 2. Bike [ ] 3. Motocycle [ ] 4. Animal cart [ ] 5. Trucks [ ] 6. Other/specify ……	1.Local cooperative [2.Wholesalers [3.Retailers 4.Urban collectors 5.Consumers 6. Processing firm 7. Other/specify ……	1. at the farm level [ ] 2. at the local market [ ] 3. on the main road [ ] 4. At the district market [ ] 5. Others/specify……

5.1 Distance to collect point from farm? 1. Cooperative _____ Km; 2. Local market (if there is) _____ Km ;

3. Local assemblers (if there is) _____Km; 4. The district market _____ Km

VI. BUYERS

Type Buyers	Unit of measurement in litter	Price per unit in CFA	Quantity per litre	Transport cost	Sale price per litter in CFA	Information cost	Time spent to reach buyer

Buyer: Local consumer, Cooperative, processor, farm group, whole seller, others (specify)

Unit of measurement: litre

VII. ANIMAL TREATMENT

Name of Treatment service	Cause of treatment	Price (unit) in CFA	Total price	How do you communicate extension service

VIII. ANIMAL FEEDING SYSTEM

8.1 Do you practice zero grazing? 1: Yes❒; 0: No ❒

8.2 Type of feeding bought

Types	Quantity (kg)	Price per bag	Source of origin

8.3 Type of feeding cultivated

Types of crops	Ha	Fertilizer used	Qty (kg)	Price per bag in CFA

8.4 Do you have difficult to get feeding for animals (process feeding)? 1: Yes ❒; 0: No ❒

If Yes, what are the problems_____

_____

_____

8.5 What period do you have these problems_____

9. What is the motivation behind for the dairy farming?

_____

_____

10. What are the communications constraints in dairy farming you are facing?

_____

Appendix 2: the results of General Linear Model Procedure for milk losses

The GLM Procedure

Dependent Variable: milk losses

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	63768497.00	21256165.67	31.67	<.0001
Error	8	5369825.04	671228.13		
Corrected Total	11	69138322.04			

R-Square	Coeff Var	Root MSE	losses Mean
0.922332	34.04939	819.2851	2406.167

Source	DF	Type I SS	Mean Square	F Value	Pr > F
coop	3	63768497.00	21256165.67	31.67	<.0001

Tukey's Studentized Range (HSD) Test for losses

NOTE: This test controls the Type I experimentwise error rate, but it generally has a higher Type II error rate than REGWQ.

Alpha	0.05
Error Degrees of Freedom	8
Error Mean Square	671228.1
Critical Value of Studentized Range	4.52880
Minimum Significant Difference	2142.2

Means with the same letter are not significantly different.

Tukey Grouping	Mean	N	coop
A	6292.7	3	Kassela
B	1592.0	3	Sanankoroba

B				
B	1490.0	3	Oulessebougou	
B				
B	250.0	3	Tienfala	

Com2

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Farmer to farmer	10	5.5	5.5	5.5
	mobile phone	169	93.4	93.4	98.9
	radio	1	.6	.6	99.4
	village chief	1	.6	.6	100.0
	Total	181	100.0	100.0	

Age group of the respondent

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	<35 Years	52	30.4	31.9	31.9
	36-50 Years	55	32.2	33.7	65.6
	51-62 Years	34	19.9	20.9	86.5
	>63 Years	22	12.9	13.5	100.0
	Total	163	95.3	100.0	
Missing	System	8	4.7		
Total		171	100.0		

Gender of the respondent

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	f	3	1.8	1.8	1.8
	m	168	98.2	98.2	100.0
	Total	171	100.0	100.0	

Farm type category

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	elevage traditional	151	88.3	89.3	89.3
	elevage & verger	5	2.9	3.0	92.3
	elevage intensive	13	7.6	7.7	100.0
	Total	169	98.8	100.0	
Missing	System	2	1.2		
Total		171	100.0		