

**DETERMINATION OF FACTORS AFFECTING EFFICACY OF PUBLIC
EXTENSION SERVICE DISSEMINATION TO DAIRY CATTLE FARMERS
IN THARAKA-NITHI COUNTY, KENYA**

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Requirements for the Award of the Degree of Master of Science in Agricultural
Education and Extension of Chuka University**

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DECLARATION AND RECOMMENDATION


Declaration


This thesis is my original work and has not been presented for the award of degree or diploma in this or any other University or institution.

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Recommendation

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DEDICATION

This research is dedicated to my husband Dr. Eric Mwenda and our daughters, Joygloria, Rehema and Hadassah for their love and support.

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ABSTRACT

Majority of smallholder dairy cattle farmers in Kenya perennially experience extreme shortage of resources. A key contributor to contemporary leaps in agricultural productivity is use of technology. However, there is a lag in adoption of advances in farm technologies and emerging global markets among smallholder dairy cattle farmers. A key determinant of adoption of new technologies is information dissemination. The extension service is the fundamental player in dissemination of information. Understanding the factors determining the efficacy of extension service dissemination will therefore contribute to increasing farm productivity among smallholder farmers. Factors influencing efficacy of extension service dissemination are broadly classified into resource capacities and devolution. In Tharaka-Nithi County, majority of the farmers practice dairy cattle farming. However, little documented information exists regarding effectiveness of delivery of dairy cattle technologies (DCTs) in the County. Therefore, the purpose of this study was to determine factors influencing the efficacy of dissemination of DCTs. This was achieved through a three-way approach; i.e (a) determination of the resources for extension, (b) determination of the perceptions by extension agents on influence of resource availability on efficacy of extension service dissemination and (c) evaluation of the influence of devolution on the efficacy of dissemination of DCTs in the County. A cross-sectional survey design was used for data collection. The target population was 6,800 smallholder dairy cattle farmers and 123 extension agents. A cluster sampling technique was used to select smallholder dairy cattle farmers while all the 123 extension agents were interviewed. A sample size of 365 smallholder dairy cattle farmers was used. The research instruments were structured questionnaires. Piloting was done in Meru County. Reliability of the instruments was determined using Cronbach alpha coefficient whereby a coefficient of above 0.6 was obtained for the three instruments. The Saaty's scaling method for priorities was used to determine extension agents' perceptions on influence of resource availability on efficiency of offering services. Influence of devolution on the efficacy of extension service dissemination was defined by type of services offered, proportion of clients reached, bodies offering extension services and quality of services as perceived by clients. Comparison between proportions for the different aspects being investigated was based on Bernoulli tests. All computations were done with the R statistical program. The aggregate preferences for human resources were 0.318, 0.312 and 0.17 for on-job training, working experience and education respectively. For physical resources, the aggregate preferences were 0.503 for transport, 0.297 for ICT equipment and 0.085 for office space. For financial resources, the preferences were 0.533 for remuneration, 0.164 for travel allowance and 0.145 for capacity building. The proportions of farmers seeking extension services from private and public extension differed significantly for all the services that were considered. Resources for extension were found to be inadequate while devolution had improved extension service dissemination to some extent. The study findings contribute to existing body of knowledge on factors affecting the efficacy of extension service dissemination, necessary interventions, further research and collaboration among stakeholders.

TABLE OF CONTENTS

DECLARATION AND RECOMMENDATION	ii
COPYRIGHT	iii
DEDICATION.....	iv
ACKNOWLEDGEMENTS	v
ABSTRACT.....	vi
LIST OF TABLES	x
LIST OF FIGURES	xi
ABBREVIATIONS AND ACRONYMS.....	xii
CHAPTER ONE: INTRODUCTION.....	1
1.1 Background information	1
1.2 Statement of the Problem	4
1.3 Objectives of the Study	5
1.3.1 Broad Objective	5
1.3.2 Specific Objectives	5
1.4 Research Questions	5
1.5 Significance of the Study	5
1.6 Scope of the Study.....	6
1.7 Limitation of the Study	6
1.8 Assumptions of the study	6
1.9 Definition of Operational Terms	7
CHAPTER TWO: LITERATURE REVIEW.....	9
2.1 The Dairy Cattle Sector in Kenya	9
2.2 Overview of Extension Services	9
2.3 Overview of Extension Services to the Dairy Cattle Sector in Kenya.....	12
2.4 Effectiveness of Agricultural Extension Services in Kenya	15
2.4.1 Public Agricultural Extension Services	15
2.4.2 Pluralistic Agricultural Extension Services	16
2.5 Dissemination of Agricultural Extension Services	16
2.6 Influence of Resource Capacities on Dissemination of Dairy Technologies.....	17
2.6.1 Physical Resources	18

2.6.2 Human Resource.....	20
2.6.3 Financial Resources	21
2.7 Devolution of Extension Services	22
2.7.1 Structure of the Agriculture Sector after Devolution	24
2.8 The Analytical Hierarchy Process Model	25
2.9 Theoretical Framework	26
2.10 Conceptual Framework	27
CHAPTER THREE: METHODOLOGY	29
3.1 Location of the Study	29
3.2 Research Design.....	29
3.3 Target Population	29
3.4 Sampling Procedures and Sample size.....	30
3.5 Research Instrument.....	31
3.5.1 Pilot Study	31
3.5.2 Reliability of the Instrument.....	32
3.5.3 Validity of the Instrument.....	32
3.6 Data Collection.....	32
3.7 Data Analysis	32
3.7.1 Determination of the Human, Financial and Physical Resource Capacities and their Perceived Influence on Dissemination of Dairy Cattle Technologies in Tharaka-Nithi County	32
3.7.2 Influence of Devolution on the Efficacy of Extension Service Dissemination within the Dairy Cattle Sector in Tharaka-Nithi County	34
3.8 Ethical Considerations.....	34
CHAPTER FOUR: RESULTS AND DISCUSSION	36
4.1 Questionnaire Return Rate	36
4.2 Respondents' Demographic Characteristics.....	36
4.2.1 Gender of Farmers and Extension Agents	36
4.2.2 Education Level of Farmers and Extension Agents	38
4.2.3 Working Experience of Extension Agents	39
4.2.4 Type of Cattle Breeds Kept by Farmers	40
4.3 Resource Capacities and Their Influence on Efficacy of Extension Service Dissemination	41

4.3.1 Human Resource.....	41
4.3.2 Physical Resources	49
4.3.3 Financial Resources	54
4.4 Devolution on Efficacy of Extension Service Dissemination	57
4.4.1 Proportion of Farmers Receiving Extension Services	57
CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATIONS.....	67
5.1 Summary	67
5.2 Conclusion.....	68
5.3 Recommendations	69
5.4 Suggestion for Further Research	70
REFERENCES.....	71
APPENDICES	89
Appendix I: Extension Administrator’s Questionnaire.....	89
Appendix II: Field Extension Agent’s Questionnaire	94
Appendix III: Farmer’s Questionnaire	100
Appendix IV: Map of Tharaka-Nithi County.....	104
Appendix V: NACOSTI Permit	105

LIST OF TABLES

Table 1: Distribution of Dairy Farmers in the Study Area	30
Table 2: Distribution of Extension Officers in the Study Area	30
Table 3: Distribution of Sample Size in the Study Area	31
Table 4: Summary of Data Analysis.....	34
Table 5: Questionnaire Return Rate	36
Table 6: Gender of Farmers	36
Table 7: Education Levels of Extension Agents	38
Table 8: Education Level of Farmers	38
Table 9: Working Experience of Extension Agents	39
Table 10: Summary of Breeds Reared by Farmers	40
Table 11: Work Experience and Career Progression of Extension Agents	47
Table 12: Ratio of Physical Resources to Extension Agents.....	50
Table 13: Summary on Facilitation.....	54
Table 14: Available Physical Resources.....	53
Table 15: Summary on Proportion of Farmers Obtaining Extension Services from Public and Private Sources	57
Table 16: Summaries on Reasons why Farmers opt for Public or Private Extension Services (AI, Feed Formulation and Feed Preservation)	61
Table 17: Summaries on Reasons why Farmers Opted for Public or Private Extension services (Treatment, Input Supplies and Vaccination).....	64
Table 18: Summaries on Reasons why Farmers Opt for Public or Private Extension Services (Field Days and Seminars).....	65

LIST OF FIGURES

Figure 1: Structure of the Agriculture Sector at the County Level	24
Figure 2: Represents the Conceptual Framework.	28
Figure 3: 1-9 scale for Pairwise Comparison.	33
Figure 4: Gender of Extension Agents	37
Figure 5: Distribution of Individual Preferences for Human Resources	41
Figure 6: Distribution of Aggregate Preferences for Human Resources by Extension Agents	42
Figure 7: Level of Education of Extension Agents..	45
Figure 8: Individual Preferences for Physical Resources.....	50
Figure 9: Aggregate Preferences for Physical Resources.....	51
Figure 10: Individual Preferences for Financial Resources	55
Figure 11: Aggregate Preferences for Financial Resources.....	55

ABBREVIATIONS AND ACRONYMS

AI	:	Artificial Insemination
DCTs	:	Dairy Cattle Technologies
ERP	:	Extension Recovery Plan
FAO	:	Food and Agriculture Organization
GDP	:	Gross Domestic Product
ICT	:	Information and Communications Technology
NARS	:	National Agricultural Research System
NGOs	:	Non-Governmental Organizations
USAID:		United States Agency for International Development
WHO	:	World Health Organization

CHAPTER ONE

INTRODUCTION

1.1 Background information

Agricultural extension is the application of scientific research and knowledge in agriculture through farmer education (Šūmane et al., 2018). Extension services are geared towards offering technical advice to farmers on proper farming practices and new farming technologies as well as supplying inputs to farmers to support production (Bonye et al., 2012). Access to extension services gives farmers an opportunity to acquire relevant information concerning available services and technologies; thus reducing the farmers' uncertainty about them (Akudugu et al., 2012). They contribute to higher agricultural productivity through giving insight to farmers on production challenges and the required solutions (Zhang & Wu, 2018). Knowledgeable farmers make the right decisions concerning the production challenges as they are better informed (Bonye et al., 2012). Consequently, farmers are aware of and can obtain services and technologies such as credit and insurance, linkage to better markets and distribution networks, artificial insemination and ration formulation (Baumüller, 2012). Therefore, extension services play a critical role in boosting agricultural productivity, increasing food security and promoting the role of agriculture in economic growth (Knuth & Knierim, 2016).

Extension services have play a critical role in developed countries in transforming traditional agriculture into modern practices (Zhang & Wu, 2018). In developing countries, poor extension services have partly contributed to food insecurity (Chauvin et al., 2012). Unreliable and lack of information have led to poor farming practices which results to poor yields for small scale farmers (Elias et al., 2013). Sources of extension services in developing countries can be classified into public and private services. Public services are government-funded and thus offered free to farmers. These services have been reported to be marred by inadequacies reducing their efficacy in positively impacting agricultural productivity (Cohen, 2015). However, public extension service is the most important service as it services the majority of farmers in the developing countries around the globe (Hu et al., 2012). Private extension services on the other hand are offered by private organisation for a fee. These services are in most cases expensive and out of reach for most farmers (Hu et al., 2012). Consequently,

strategies to increase the efficacy of public extension services can greatly impact agricultural productivity especially within smallholder production systems.

Factors influencing the efficacy of extension service can be classified into human, financial and physical resources (Meijer et al., 2015; Altalb et al., 2015; Komba, 2018; Ahmed & Adisa, 2017; Nyasimi et al., 2017). Human resources include the availability of adequate numbers of extension agents, their level of training (both formal and on-job trainings), proper co-ordination and agents' morale. Knowledge levels and skills of the extension agents has a great impact on the clarity and accuracy of the information disseminated on the various innovations (Oladele & Tekena, 2010). Education of the extension agents on the other hand has been found to influence preferences on technologies disseminated (Strong et al., 2014). In addition, regular in-service training for extension agents is necessary to keep them abreast with new technologies (Raidimi & Kabiti, 2019). Therefore, extension agents require technical and process-oriented skills in order to disseminate agricultural information effectively (Suvedi & Kaplowitz, 2016; Tata & McNamara, 2018).

Financial resources influencing the efficacy of extension services relate to adequate budgetary allocation (Kirieieva et al., 2020)). Allocation of financial resources for different extension programs is necessary for increased productivity in agriculture (Suvedi et al., 2017). Motivation in terms of allowances and promotions also go a long way in improving service delivery in extension (Gelan, 2017). Purchase of inputs for demonstration and to support farmers require sufficient and co-ordinated funding (Wossen et al., 2017; Ifenkwe, 2012). Finances are also required for maintenance of extension offices, motorcycles and vehicles (Kising'u & Kising'u, 2016). Training needs of extension agents can also be sufficiently addressed if the required finances are available (Luhmann et al., 2016).

Physical resources for agricultural extension staff include office furniture, computers, internet, teaching aids, display equipment, printing materials, stationery, telephones, vehicles and motorbikes. These resources have been shown to influence the efficacy of agricultural extension services (Adejo et al., 2012). Provision of adequate office space with the required stationery is paramount for successful extension operations (Müller

et al., 2017). An office works as a service center where most of the extension operations are organized as well as a record center for all information on farmers and extension programs (Chen et al., 2015). A space that is not overcrowded and one that has all the necessary amenities improves the extension staff's productivity (Nakamura, 2015). Adequate and comfortable furniture go a long way in providing a conducive environment for improved extension services (Ghimire, 2016). However, in developing countries, extension offices are characterized by lack of fundamental necessities, have inadequate space, and are dilapidated, hence low job satisfaction and sub-optimal extension service delivery (Rajbhandari, 2017).

Smallholder dairy cattle farming is one of the most largely practised agricultural activity in Tharaka-Nithi County. Unfortunately, like other developing agricultural sectors, the smallholder dairy cattle sector is characterised by high levels of inefficiencies resulting in production and economic losses. However, technologies and services exist that have the potential to alleviate most of these inefficiencies but are largely unadopted by farmers (McCord et al., 2015; Kabebe et al., 2017). As an example, fodder production in the region is perennially characterised by excesses during the rain seasons and scarcity during the dry seasons despite the existence of technologies that not only allow conservation but also minimize nutrient losses of preserved fodder such as silage and hay making. Other perennial challenges include parasites and diseases, insufficient water, poor housing, lack of breeding schemes and poor marketing structures (Guadu & Abebaw, 2016; Msuya et al., 2017). One of the reasons why adoption of available technologies is low is due to lack of adequate and effective extension services (Zhang & Wu, 2018). Consequently, farmers are ignorant or lack adequate understanding of how to implement available technologies to aid in solving their problems. Therefore, efficiency, particularly of public extension services is key in adoption of cost-effective dairy technologies (Mugambi et al., 2015).

The efficacy of extension services to smallholder dairy cattle farmers can be improved by addressing the hiccups they face. To this endeavour, the Government of Kenya through the new promulgated 2010 constitution devolved all agricultural services to the County government levels (Muatha et al., 2017). One of the goals for devolving agricultural services was to improve efficiency of extension services by ensuring that

local governments, which better understood the local needs, would allocate the necessary human, financial and physical resources to agricultural services such as extension services. In addition, devolution would enable greater participation of farmers in decision making and also in recognition of the community's right to manage its affairs (Muatha et al. 2017; Cannon & Ali, 2018). Though devolution has potentially great prospects of improving extension services, its impacts have scarcely been studied. Therefore, the study intended to generate information on the influence of physical, financial and human resources under devolved governance, on the efficacy of extension service dissemination in Tharaka-Nithi County.

1.2 Statement of the Problem

Milk production within the smallholder dairy cattle sector in Tharaka-Nithi County has been perennially low. This is attributed to recurrent challenges such as low quality and inadequate quantity of feeds, seasonality in feed production, low genetic potential of animals reared, diseases, parasite infestation and low market prices for products. Technologies have been in existence over the years that can be employed to address these challenges. These include silage and hay making for feed storage and use of reproductive technologies for genetic and fertility improvement, among others. However, the adoption of these technologies at farm level has not been optimal. One of the major reasons for the lag in adoption of technologies among farmers is lack of awareness or inadequate understanding of the value of technologies in alleviating production challenges. This awareness is created by extension services. Low efficacy of extension therefore, has led to inefficient dissemination of technologies consequently leading to low milk productivity of dairy cattle. The Government has over the years provided extension services to address issues contributing to low production of dairy cattle. Recently, government agricultural services were devolved with an aim of increasing efficiency. However, there is paucity of information on how human, financial and physical factors under devolution influence the efficacy of extension service dissemination to dairy cattle farmers in Tharaka-Nithi County.

1.3 Objectives of the Study

1.3.1 Broad Objective

To determine factors affecting efficacy of public extension service dissemination to smallholder dairy cattle farmers.

1.3.2 Specific Objectives

- i To determine the human, financial and physical resource capacities and their perceived influence on dissemination of dairy cattle technologies to smallholder dairy cattle farmers in Tharaka-Nithi County.
- ii To investigate the influence of devolution on the efficacy of extension service dissemination within the smallholder dairy cattle sector in Tharaka-Nithi County.

1.4 Research Questions

- i What is the influence of physical, financial and human resource capacities on dissemination of dairy cattle technologies to smallholder dairy cattle farmers in Tharaka-Nithi County?
- ii What is the influence of devolution on the efficacy of extension service dissemination within the smallholder dairy cattle sector in Tharaka-Nithi County?

1.5 Significance of the Study

The study findings are useful in providing information that will help the extension agents, the County Government and the Government of Kenya in understanding factors affecting efficacy of extension service dissemination to dairy cattle farmers. The findings may enable the extension agents to effectively disseminate information to farmers thus, improving the rate of diffusion and adoption of these technologies which will contribute to the improvement of the dairy sector productivity. The government will be able to formulate necessary policies to foster effective extension service delivery. The findings of the study also added to the existing body of knowledge as well as helping various stakeholders in making necessary interventions in dissemination of information to farmers.

1.6 Scope of the Study

The study was conducted in the upper zone of Tharaka-Nithi County (Chuka, Maara and Igambang'ombe sub-Counties). It focused on the influence of physical, financial and human resources under devolution on efficacy of service delivery to smallholder dairy cattle farmers. The target population was 6,800 smallholder dairy cattle farmers and 123 extension agents in the County. Data was collected from 365 farmers selected using the formula recommended by Cochran (1963) and all the 123 extension agents in the three sub-Counties.

1.7 Limitation of the Study

The limitation to this study was the absence of detailed data from government and private extension agents.

1.8 Assumptions of the study

The study was based on the following assumptions:

- i. Smallholder farmers in the region were willing to participate in the study and that they gave honest answers.
- ii. Agricultural officers in the region provided the required data on extension programs they have been offering and also provided honest responses.

1.9 Definition of Operational Terms

- Agricultural Extension:** It is the application of research findings and knowledge to crop and livestock farming through farmer education. In this study, it is the passage of technological information from researchers through extension agents to smallholder dairy cattle farmers. (Steinke et al., 2020)
- Dairy Farming:** It is the class of agriculture that is involved in the keeping of dairy animals; cattle, goats and camels, for long-term production of milk, which is processed or sold whole. In this study, it refers to the keeping of dairy cattle for the purpose of milk production (Vyas et al., 2020).
- Dairy Technology:** Knowledge and skills that have been developed in research institutions, which are brought to the farmers to enable them improve in all spheres as far as agriculture is concerned. In this study, it refers to knowledge and skills pertaining dairy cattle production, which have been developed through research (Bard et al., 2019)
- Devolution:** It is the transfer of power from a higher level of government administration to a lower one. In this study, it refers to delegation of power from the national to County government (Boex & Smoke, 2020).
- Dissemination:** It is the act of spreading information widely. In this study, it refers to the transfer of agricultural information from the research institutions, through the extension personnel, to the farmers (Ragasa et al., 2016).
- Efficacy:** It is the ability of an extension agent to distribute information in a desired and satisfactory manner. In this study, it refers to the ability of extension agents to transfer information on dairy technologies satisfactorily to smallholder dairy cattle farmers (Mtega & Ngoepe, 2019)
- Extension Services:** Services that offer technical advice to farmers through farmer education. In this study, it refers to services that

offer technical advice to smallholder dairy cattle farmers through farmer education (Steinke et al., 2020)

Resource Availability: Access to the right requirements in terms of skills, finances and time for a given project. In this study, it refers to access to finances, physical structures, and competent and adequate extension agents for dissemination of dairy cattle technologies (Kyalo et al., 2017).

Smallholder Dairy Farmer: A dairy farmer engaged in small scale dairy farming. In this study, it refers to a dairy farmer practicing dairy farming with a small number of dairy cows, usually 5 and below (Kemboi et al., 2020)

CHAPTER TWO

LITERATURE REVIEW

2.1 The Dairy Cattle Sector in Kenya

In Kenya, the dairy cattle sector is the largest sub-sector of agriculture, contributing about 10% of agricultural Gross Domestic Product (GDP) (Brandt et al., 2018). Approximately four million Kenyans derive their livelihoods from dairy farming in form of food, income, and employment (Mugambi et al., 2015). About 80% of dairy farming is practiced by smallholder farmers who produce about 56% of the total milk production in the country (Kimenju et al., 2017). This therefore means that focusing efforts in dairy development towards the smallholder category of farmers has the potential to improve milk self-sufficiency and income levels through improved milk production (Sagwa et al., 2019). Currently, the Kenyan dairy sector is the most rapidly developing sector in East Africa and the second largest dairy producer and consumer in the Sub-Saharan Africa, producing enough milk for both domestic and export markets (Brandt et al., 2018). However, various indicators show that the dairy sector's performance is much lower than its potential. The milk yield per cow per day in the country has invariably remained at an average of 6kg since the early 1980's despite a potential of more than 15kg (Brandt et al., 2018). While the country's per capita milk consumption of 100kg is below the World Health Organization (WHO) recommendation of 200kg (Brandt et al., 2018). The country also exports negligible quantities of long life milk, milk powder and ghee to Asia and North Africa. (Kimenju et al., 2017).

2.2 Overview of Extension Services

The role of agricultural extension is to transfer agricultural technologies and innovations to farmers with an aim of increasing adoption (Ommani, 2011). Extension brings about changes in farmers' attitude, knowledge and skills through farmer education and communication, while at the same time linking farmers with other actors in the agricultural value chain. Extension information can be disseminated to farmers through the mass media, farmer-farmer interactions, Farmer Field Schools (FFSs), demonstrations, workshops and seminars (Murugan & Rain, 2012). Proper and timely access to relevant information is critically important for agricultural and rural development in both developed and developing countries (Agha et al., 2018).

Historically, extension was established in the United States of America as a component of the Land Grant Universities in the late 1800s (Shakerian et al., 2016). In the 1820s, extension underwent some transformations which expanded it to deal with impacts of post-world war amongst farming communities through the co-operative extension approach (Zhou, 2010). Between 1950s and 1980s, public extension was adopted in Latin America in which services were provided by the government to farming communities in order to mitigate the persistent challenges that farmers faced (Baloch & Thapa, 2019). Currently, Latin America provides pluralistic extension with several players that are co-ordinated by the State's Department of Agriculture (Roschinsky et al., 2015). This has improved extension to a great deal by ensuring that farmers obtain demand-driven services from providers that can offer the best depending on their farming challenges (Bonye, 2012).

In many developing countries extension services are also pluralistic. As an example, in South Africa, the National Agricultural Research System (NARS) is based on parastatals and science councils, higher education and development institutions, and the private sector (Bonye, 2012). However, some of its shortcomings are insufficient resources, weak co-ordination and linkages and also limited capacity. The Extension Recovery Plan (ERP) in South Africa was established to improve agricultural development through effective extension and to a great extent is dependent on job satisfaction among extension officers (Eastwood et al., 2017). Post-apartheid extension has faced the problem of low skills and knowledge of extension officers and at the same time delivering services to a more divergent and growing farming community (Bonye, 2012). Lack of accessibility of credit and failure to repay loans are some of the challenges facing resource-poor farmers but the government has been offering financial services to marginalized and resource-constrained farmers. However, even with the introduction of pluralistic extension, public extension is more preferable to smallholder farmers who constitute the greatest percentage of farmers, particularly in the developing countries (Adejo et al., 2012).

In Nigeria, extension service delivery has undergone a drastic transition in the post-independence period (Chauvin et al., 2012; Zhou, 2010). For instance, in the 1970s and 1980s, the practice of agricultural extension was reoriented into Training and Visits (T

& V) system (Musa et al., 2013). The objective of this extension system was to set up a professional extension service to help farmers increase production through creating awareness on new farming technologies that address the challenges faced by farmers in the process of production (Murugan & Rani, 2012). This was to be achieved through creation of dynamic links between farmers, professional workers (through regular in-service trainings), and researchers (Baloch & Thapa, 2019). However, this system was marked with as much deficiencies as the other top-down approaches of extension (Aker, 2011). Identified shortcomings were; the system was too staff-intensive, it focused on agriculture alone neglecting other social and rural development projects, it had poor coordination with other agencies and it did not emphasize on extension methods, management techniques and participation of farmers, which are important in determining the success of extension programs (Musa et al., 2013; Zhou, 2010). Consequently, despite the important role extension services play in agricultural productivity and profitability, their implementation in developing countries has been sub-optimal. This has partly contributed to the low productivity of agriculture since the role of extension cannot be downplayed (Ragasa et al., 2016).

Extension service delivery in Kenya, like many other African countries, has been diverse in terms of quality, target population, coverage, resource utilization, and eventual dissemination of information (Steinke et al., 2020). Provision of extension services in Kenya begun in the early 20th century after introduction by colonialists (Tata & McNamara, 2018). However, its achievements in terms of improvement of agricultural productivity were minimal until in the 1970s when the technology of hybrid maize was successfully disseminated and adopted by farmers (Simiyu, 2014). During the colonial era, Kenya had two systems of extension; one for the settlers and another for the natives (Roghanian et al., 2012). After independence, the national government through the Ministry of Agriculture took over the responsibility of offering extension to farmers (Muatha et al., 2017). Farming Systems Research and Extension (FSR/E) model was introduced in the 1970s (Bebe et al., 2016). This approach concentrated more on small scale farmers and emphasized on farm trials and farmer involvement (Ragasa et al., 2016). As a result, it provided a beneficial linkage between farmers, extension agents and researchers (Simiyu, 2014). All the extension approaches used in the colonial and post-colonial era were bureaucratic, top-down and lacked farmers

participation in the development of extension programs (Aker, 2011). However, there has been a shift from the top-down extension service delivery to a more horizontal, farmer-centered approach that is more participatory and less bureaucratic (Tata & McNamara, 2018). This decentralization of extension included reforms that aimed at introducing extension to other institutions, particularly private institutions, in order to improve farmer participation and decision-making (Roy et al., 2013). The decentralization encouraged pluralistic mode of extension delivery in which the private sector including community-based organizations, NGOs and faith-based organizations were involved thus reaching out to more clients (Komba, 2018).

2.3 Overview of Extension Services to the Dairy Cattle Sector in Kenya

Extension services to dairy farmers are offered by experts in Livestock Production and Veterinary Departments as well as experts in crop production who deal with pasture and fodder production (Sagwa et al., 2019). The role of extension in the dairy sector is to disseminate information on new technologies to farmers through informal education (Roy et al., 2013). There are a number of dairy technologies that farmers can adopt in order to spur productivity. Broadly, they include, reproductive, genetic improvement, disease and parasite control, feed formulation and preservation, milking and milk handling and processing technologies (İnanç & Daşkın, 2015; Roschinsky et al., 2015). Reproductive and genetic improvement technologies include multiple ovulation, artificial insemination (AI), semen sexing and embryo transfer (Moore & Hasler, 2017; Kios et al., 2018; Sagwa et al., 2019). Genetic improvement is the utilization of the genotypes (of exotic cows and their crosses) which are responsible for high milk production (Sharma et al., 2018). Milk production requires specific genes each of which is responsible for a specific action in the process of milk synthesis (Ramírez-Rivera et al., 2019). Sharma et al., (2018) pointed out that these genes are linked to the sex chromosomes thus transmitted during fertilization therefore emphasizing the need for use of superior animals in upgrading the existing herds. Every dairy farmer desires to have a high milk producing herd with high conception rates (Ho & Pryce, 2020) and they can acquire such animals through genetically improving their existing livestock with the aim of improving milk productivity, shortening the calving intervals and improving conception rates (Kimenju et al., 2017). Ho & Pryce (2020) defines artificial insemination as the introduction of semen into the female reproductive tract of a cow

on heat with the aim of causing pregnancy. The efficiency of AI can be improved through increased oestrus detection efficiency and timing the process to ensure that it occurs when the cow is most responsive (Sagwa et al., 2019). In Kenya, AI is currently provided by private extension providers as well as the County governments (Kios et al., 2018). The most convenient and profitable breeding technique is use of timed AI for both high and low producing cows in a herd (İnanç & Daşkın, 2015). For a long time, AI has been regarded as the most important breeding technology for improvement of reproductive performance of livestock (Sagwa et al., 2019).

The technology of Sexing of semen provides about 90% certainty on the gender of the calves giving farmers an opportunity of increased heifer population. This in turn increases milk production and accelerates the upgrading process of livestock (Ho & Pryce, 2020). It is applied by dairy farmers to produce young ones of a desired sex, particularly females, from a given mating with the aim of improving the genetic potential of dairy animals while providing replacement stock from genetically superior cows (McCulloch et al., 2013). However, this technology is expensive and complex with lower rates of pregnancy (Boro et al., 2016). Similarly, Berry et al. (2019) noted that the number of embryos decreases by 30-50% in sexed semen as compared to unsexed semen. This technology is done by flow cytometry or cell sorting machine, an operation that guarantees 90% accuracy without damaging the cells. The principle of cytometry is based on the amount of DNA in the cells (Boro et al., 2016). According to Chebel et al. (2010) the effectiveness of sexing of semen is dependent on a number of factors; skilled labour, high standard preservation and proper management practices. High cost of equipment and maintenance, low sorting efficiency, low pregnancy rates and lack of skilled manpower are some of the factors that jeopardize the efficiency of sexing of semen technology use by farmers (Boro et al., 2016). Genetic and reproductive technologies therefore provide strategies for selecting genetically superior germplasm for improved productivity, determination of sex of calves, and shortening of calving intervals (Berry et al., 2019).

Livestock require adequate feeds containing all the nutrients in the right forms and amounts for optimal productivity (Savenije et al., 2010). Smallholder farmers obtain feeds mainly from cultivated fodder with Napier grass being the leading source of

cultivated fodder crop. By-products are also used as well as maize stovers, dried poultry waste, hay and silage and also locally made feed rations (McCulloch et al., 2013). Savenije et al., (2010) noted that it is important to provide animals with the correct rations to cater for different requirements during the various life stages. According to Akoth (2017) nutrition influences the activity of the immune system and influences productivity of dairy cattle. Savenije et al., (2010) further noted that malnutrition in animals is caused by inadequate feed intake and diseases which reduce the animal's voluntary feed intake with an eventuality of low productivity.

Feed formulation and preservation are integral practices in livestock production. Various methods are available for feed preservation, which can ensure sufficient supply of adequate quantities of quality feeds irrespective of seasonality. These technologies which also reduce wastage during the rainy seasons include solid substrate fermentation, ensiling, hay making and high solid or slurry processes (Wilkinson & Rinne, 2018). Proper feed preservation methods preserve the nutrients in livestock feeds ensuring that dairy cattle benefit maximally from the feeds provided (Tegemeo Institute of Policy Development, 2016). Feed formulation enables farmers to constitute nutritive feed rations by combining available feedstuff, some of which are of low nutritive value (Savenije et al., 2010).

Additionally, technologies for milk handling and processing such as homogenization, pasteurization and chilling ensure production of high-quality milk (Escobar et al., 2011). However, there is a lag in adoption among smallholder dairy cattle farmers especially in the developing world and as a result, productivity of dairy cattle has been perennially low. Returns from smallholder dairy farming is below the threshold with some farmers getting as low as 3.30 Kenya Shillings per a litre of milk as net revenue (Tegemeo Institute of Policy Development, 2016). In Tharaka-Nithi County, Mamo (2013) observed that milk productivity among smallholder farmers was low with a majority of farmers getting less than 10,000 Kenya shillings as their monthly net revenue from dairy farming. As a result, farmers have not been able to reap the benefits of dairying despite the potential that lies within the sector.

2.4 Effectiveness of Agricultural Extension Services in Kenya

2.4.1 Public Agricultural Extension Services

Majority of farmers in the developing world depend on public sector for delivery of extension services (Dlodlo & Kalezhi, 2015). In Kenya, the agricultural extension service delivery has for a long time been driven by the top-down model. In this approach, the Ministry of Agriculture determines the extension programs to be implemented and the content to be taught to farmers without consultation to find out what would work best in solving problems on the ground (Kiptot & Franzel, 2015). Consequently, this approach lacks the element of farmer-participation in the development of technologies and learning processes (Elias et al., 2013; Zhou, 2010). Farmers are only expected to adopt the outcomes of research, majority of which do not address their problems at the grassroots level (Zhang & Wu, 2018). As a result, public agricultural extension services have been sub-optimal in helping alleviate challenges faced by dairy farmers (Roy et al., 2013; Asenso-Okyere & Mekonnen, 2012). This has a huge impact on efficiency of extension service delivery since most farmers in African countries depend on public extension to acquire extension information and technologies. In addition, most public extension services are characterized by limited resources, a situation that has seriously affected its efficiency (Oladele & Tekana, 2010).

Top-down delivery of extension services has hindered the rate of agricultural growth in the past two decades, with a high yield gap between research stations and farmer fields (Babu et al., 2013; Hochman & Horan, 2018). This is due to the failure of the approach to consider the diversity in the needs and priorities of the farmers, which are dictated by the geographical regions, specificity in enterprises and socio-economic factors (Sewell et al., 2017). This has negatively impacted on the effectiveness of extension services as majority of the programs are not responsive to the farmers' needs (Meena et al., 2015; Hu et al., 2012). Smallholder farmers are the most disadvantaged by this approach since their nature i.e., majority are poor, have low levels of education, and lack basic farm implements, is not put into consideration when designing extension programs and innovations (Siyao, 2012). Failure of the top-down public extension has led to the advocacy of pluralistic and demand-driven extension to build on the current trends where farmers have more confidence in the private rather than public extension

(Wambura et al., 2015). However, the challenge of constrained resources amongst the smallholder farmers places them at a disadvantage since majority lack the finances to acquire extension services from private extension (Eastwood et al., 2017).

2.4.2 Pluralistic Agricultural Extension Services

Pluralistic mode of agricultural extension services emerged following the failure of public extension within the Ministry of Agriculture (Rohit et al., 2017). To address gaps in public extension services, various multidisciplinary agencies have stepped up efforts for public-private partnership with the aim of providing a justified opportunity of increasing the rate of access to information among farmers (Husain & Amin, 2017). Pluralistic mode of extension delivery involves different providers of extension, including private and public sectors, individuals, farmer-based organizations, and non-profit making organizations (Majokweni, 2018). It advocates for farmers to demand and access extension services given by providers who can best deliver them (Diesel & Miná Dias, 2016). The private sector is composed of institutions like input suppliers, media houses, finance institutions, marketing organizations, and agro-chemical companies (Kaegi, 2015; Eastwood et al., 2017). For the success of pluralistic extension to be achieved proper co-ordination is necessary to avoid duplication of programs by the service providers and exploitation of farmers by agencies that are in business (Oladele & Tekana, 2010).

2.5 Dissemination of Agricultural Extension Services

Farmers in the majority of African countries depend on public sector for extension services since they are affordable to them (Dlodlo & Kalezhi, 2015). In Kenya, the public agricultural extension service has for decades been driven by the top-down model. In this approach, the Ministry of Agriculture determines the extension programs to be implemented and the content to be taught to farmers without consulting them (Kiptot & Franzel, 2015). This has resulted to lack of participation by farmers thus their input to development of customized solutions to their problems has been ignored (Elias et al., 2013; Zhou, 2010). Farmers are expected to co-operate and participate in learning of new technologies, majority of which don't address their challenges (Zhang & Wu, 2018). As a result, public agricultural extension services have been sub-optimal in

helping alleviate challenges faced by smallholder farmers specifically in the dairy sector (Roy et al., 2013; Asenso-Okyere & Mekonnen, 2012).

Majority of the NGOs cover smaller geographical areas enabling them to have better concentration in terms of physical and financial resources to implement extension programs (Asadullah & Ara, 2016). However, most NGOs have the challenge of inadequate and well-trained extension personnel and therefore, they depend on the government extension agents (Karkee & Comfort, 2016). Private sector on the other hand offers services that promote their products while producer organizations offer advisory services in situations where they benefit from large scale production of livestock and crops (Faure et al., 2017). Marketing organizations come in handy to advise farmers on the production of high-quality products as demanded by the markets for which they promote (Kshetri, 2017). Input suppliers provide livestock feeds, feed supplements, pasture seeds, fertilizers, herbicides and animal drugs (Rohit et al., 2017).

Finance institutions offer loans to farmers and advice farmers accordingly on how to invest the money for maximum profits while reducing the risk of defaulters (Abankwah et al., 2016). Even so, the full potential of pluralistic extension services is yet to be harnessed despite the increase in the number of actors offering services (Raidimi & Kabiti, 2017). In addition, pluralistic mode of extension has been found to mostly favor well-off farmers who deal with high-value agricultural commodities at the expense of the rural smallholder farmers (Klerkx et al., 2016).

2.6 Influence of Resource Capacities on Dissemination of Dairy Technologies

Factors influencing the effectiveness of extension services include availability of quality human, adequate financial and physical resources and proper governance (Meijer et al., 2015; Altalb et al., 2015; Komba, 2018; Ahmed & Adisa, 2017; Nyasimi et al., 2017). The poor delivery of extension services in developing countries is attributed to inadequate financial and physical resources, lack of training materials, and poor quality human resource (Kadiyala et al., 2016; Masangano & Mthinda, 2012).

2.6.1 Physical Resources

Physical resources for agricultural extension staff include office furniture, computers, internet, teaching aids, display equipment, printing materials, stationery, telephones, vehicles and motorbikes (Adejo et al., 2012). These resources have been shown to influence the efficacy of agricultural extension services. Provision of adequate office space with the required stationery is paramount for successful extension operations (Müller et al., 2017). An office works as a service center where most of the extension operations are organized as well as a record center for all information on farmers and extension programs (Chen et al., 2015). A space that is not overcrowded and one that has all the necessary amenities creates a conducive environment for working which improves the extension staff's productivity (Nakamura, 2015). Adequate and comfortable furniture go a long way in providing a conducive environment for improved extension services (Ghimire, 2016). However, the results of a study by Takahashi et al, (2019) concluded that the absence of an extension office does not have a serious impact on effectiveness of extension since farmers are taught on the farms. In most developing countries, extension offices lack the fundamental necessities and necessary stationery, have inadequate space, and are dilapidated hence, low job satisfaction and extension service delivery (Rajbhandari, 2017).

The world has become a global village and the use of computers and internet cannot be over-emphasized (Bello et al., 2018). The use of computers and the internet has become a common element in extension, especially with the recent technological developments (Tzounis et al., 2017). Downloading and printing of materials can easily be done from the offices without the need to go to cyber cafés (Wackenhut, 2018). The internet is used for browsing the web, sending and receiving e-mails, and accessing social networking applications by extension agents (Lin et al., 2017). Availability of these services to extension agents enables them to access global information on new technologies as soon as the said technologies are developed (Siegel, 2017). The internet also comes in handy when the extension agents require information to enable them give farmers feedback on complex questions (Minet et al., 2017). At the click of the button, an extension agent gets the information to empower farmers with the necessary guidance (Vijayasekar, 2018).

Additionally, physical mobility is critical as extension agents have to meet with the farmers at their places of work for information sharing (Føre, 2018). Majority of the farmers are in rural areas. Therefore, the need for reliable transport for the extension personnel cannot be overlooked (Vincent, 2018). Some of the roads are impassable requiring the use of four-wheeled vehicles especially during the rainy seasons (Dingen & Cook, 2018). Reliable and convenient means of transport enable the extension agents to make the most of their time by allowing better contact with the farmers. This highly contributes to improved extension service delivery (Mitcheam-Eatmon, 2020). Vehicles and motorbikes require regular servicing to avoid constant breakdown which leads to wastage of time and in some instances aborted meetings (Ortmann, 2017). The latter may lead to erosion of confidence in extension agents which may, in the long run, lower farmer turnout in meetings (Ortmann, 2017). Some studies have shown that some of the government vehicles meant for extension have been lying in parking lots in very poor states for a long time (Ou et al., 2019). Fore (2018) noted that extension is an informal mode of education carried out on the farms thus, a reliable transport system is vital in improving the agents frequency of visits with the farmers. Physical resources are needed to carry out extension activities effectively (Bonye et al., 2012).

In developing countries, the ratio of vehicles and motorcycles for extension is usually high, resulting to minimal contact between farmers and the extension personnel (Ragasa et al., 2016). Extension is more beneficial to farmers when carried out practically on the farms thus reliable transport for extension personnel is a pre-requisite for effective dissemination (Deichmann et al., 2016). Most of the rural roads are in poor states, some almost impassable and as a result the rate of depreciation of the vehicles and motorcycles is higher which affects the mobility of extension agents (Jost et al., 2016). The challenge is compounded by inadequate finances to cater for repair and maintenance of the means of transport as well as replacing those that are completely unserviceable (Singh & Shishodia, 2016). Inadequacy and unreliability of transport for extension creates a gap that that results to failure of the developed technologies from reaching the farmers (Ragasa et al., 2016). For instance, in dairy farming, productivity has remained low yet there are many dairy technologies that are yet to reach the farmers due to transport challenges that affect extension personnel (Føre, 2018) Consequently, the availability of physical infrastructure improves the extension worker's motivation,

confidence, satisfaction, and welfare hence, quality extension services and improved area of coverage (Barau & Afrad, 2017).

2.6.2 Human Resource

Effective dissemination of technologies can be achieved if the extension agent possesses relevant technical competency, economic competency, and ability to conduct simple field experiments on innovations and analyze the results objectively (Wossen et al., 2017; Ifenkwe, 2012). Relevant technical competency has been a critical area in extension as far as service delivery to the rural poor is concerned (Ngaka & Zwane, 2018). Competent extension agents possess the right knowledge, skills, attitudes, and behavior which enable them to effectively disseminate information to farmers (Listiana et al., 2019). Therefore, competencies serve as the basis for extension to develop the required programs that can improve the rate of adoption of technologies by farmers (Suvedi et al., 2017; Cohen, 2015; Johnson et al., 2017; Safrit & Owen, 2010).

Knowledgeable extension agents are more customer-driven, focused on cost-effective approaches, and are flexible in meeting the ever-changing needs of the farmers (Man et al., 2016). Competency identification and assessment is vital in order to determine the kind of skills and knowledge relevant for extension agents to effectively play their roles (Conner et al., 2013). Competencies of extension agents are determined through the academic trainings offered through formal as well as informal education (Ghimire et al., 2017; Listiana et al., 2019; Prager & Creaney, 2017; Khan et al., 2016). According to Oladele et al. (2010) extension agents who had opportunities for further education deliver better extension services.

Regular trainings of extension agents through seminars and workshops keep them abreast with the new technologies which improve efficiency of transfer of information to farmers (Dimelu, 2016). The training needs of extension agents change from time to time and this calls for assessment of training needs before developing the training programs (Thomas & Laseinde, 2015; Chaudhry, 2016; Shakerian et al., 2016; Siphesihle & Lelethu, 2020). The review of the extension curricula is vital in ensuring that the training is timely, demand-driven, and responsive to the dynamic agricultural sector (Raidimi & Kabiti, 2019). Effective extension service delivery also emphasizes

the need for extension agents to acquire relevant communication skills; oral, written, computer, ICT infrastructure, and internet skills (Miriti, 2016).

The quality of the human resource can be quantified in terms of number of personnel in relation to the number of farmers to be served and their knowledge level in contemporary advances in their fields of specialization. Shortage of trained extension workers is detrimental to effectiveness of information delivery (Lakai et al., 2012). In most developing countries, the ratio of farmers to extension agents is alarmingly high (Nyambi, 2012). Lopokoiyit et al. (2012) observed that in Kenya the ratio of extension agents to farmers is 1:1000 against the FAO recommendation of 1:400. Inadequate personnel in extension derails the timeliness of decision-making as each agent has to serve many farmers hence ineffective service delivery (Ngaka & Zwane, 2018).

2.6.3 Financial Resources

The role of finances in agriculture cannot be over-emphasized. Adequate funding contributes immensely to the success of the agricultural sector, particularly in agricultural extension. The national government has a mandate to allocate adequate financial resources to the County governments for public goods and services to be efficiently delivered to the farmers (Khaunya & Wawire, 2015). The Maputo Declaration of 2003 recommends at least a 10% annual national budget allocation for agriculture (Declaration, 2003). Finances are required for hiring of extension personnel, purchase of equipment and to meet short and long-term operational costs (Cohen & Reynolds, 2015). Funding of regular training of extension personnel through on-job training keeps them abreast with new technological developments and equips them with the necessary skills that are required in the field (Solomon, 2015). Allocation of financial resources for different research programs is necessary for development of more farmer-oriented programs in agriculture (Suvedi et al., 2017). Motivation in terms of allowances and promotions also go a long way in improving service delivery in extension (Gelan, 2017).

Shortcomings in the financing of research have contributed to disappointing performance in agriculture in the developing world (Sovacool et al., 2017). Financing in extension does not only deal with the amount of money allocated but also the design

of funds flow, funds control and how the funds are used in extension programs and activities (Clark et al., 2018). However, inadequate funding has led to laying down of some extension personnel in the recent past (Auta & Dafwang, 2010). Poor funding has also led to inefficient mobility and lack of the necessary teaching and learning resources in extension service provision (Hamisu, 2017; Ragasa et al., 2016). Politicization of extension services has affected budgetary allocation in agriculture and financial control, subsequently, affecting the performance of extension negatively (Isgren, 2018). Additionally, inadequate budgetary allocations and poor remuneration of extension agents has contributed to failure of extension service delivery (Adejo et al., 2012). This leads to poor performance due to low job satisfaction (Bonye et al., 2012; Hellin, 2012).

2.7 Devolution of Extension Services

Devolution is the delegation of power and governance from a national government to a local level (Blunkett et al., 2016). The main aim of devolution is to ensure that citizens benefit from increased efficiency, timeliness, and relevance of services by taking governance closer to the people (Kugonza & Mukobi, 2015). Devolution has been found to encourage some degree of autonomy in the lower units of governance, allowing them to make decisions that encourage domesticated policies addressing the needs of the people (MacKinnon, 2015).

However, the motivation for devolution varies from region, for example, in former Soviet Union, it formed part of the political transformation from a centralized system of governance to a more decentralized one where participation in decision-making was enhanced in all the parties involved (Ngundo & Chitere, 2015). In South Africa, it was a response to ethnic disunity and regional conflicts (Kyle & Resnick, 2016). Devolution brought an institutional agenda that brought divided groups in lower governance levels thus serving as a path to national unity (Blunkett et al., 2016). In Uganda, the main objective was to bring services closer to the citizens through devolving power from the central government to the local government authorities (Kyalo et al., 2017).

In Kenya, the era of devolution was ushered in by the promulgation of the new constitution in 2010, after a series of constitutional review debates (Ngigi & Busolo, 2019). An expected outcome of devolution was increased unity amongst the leaders

which would enable formulation of policies that address the needs of the local people relatively better (Muhumed et al., 2019). The 2007/2008 post-election violence left a scar in the economy of Kenya and the social cohesion amongst communities ((Ngundo & Chitere, 2015). Therefore, devolution was recommended as a remedy for the failures in the political governance (Ngundo & Chitere, 2015).

This led to devolution of the agricultural sector to the County government level (Muhumed et al., 2019). Consequently, the provision of agricultural extension services was placed at the County level, with the counties being the primary centers for service delivery and economic expansion (Kyalo et al., 2017). Devolution strengthens the functions of the County government and empowers the leaders with more authority and accountability to the service users as well as transparency of the service providers (agricultural extension agents) at the grass root level (Ashraf et al., 2017). However, for the devolved governance system to be relevant to agricultural extension leaders need to be accountable and stakeholders must participate fully in the matters influencing County affairs (Muatha et al., 2017; Mulae, 2016).

Devolution empowers the farmers to communicate their feedback and demands on the extension service delivery to a level of government that is not too distant from them (Cheyne, 2015; Muhumed et al., 2019). Farmer participation opens avenues for feedback on the quality of services enabling program planners to make improvements where necessary (Feola et al., 2015). As observed by Spronk (2016) there has been meaningful increase in public investment in agriculture due to devolved agricultural extension services. However, financial and constitutional constraints have contributed to the failure of the devolved functions (agricultural extension) to meet the expectations as far as service delivery is concerned (Kyalo et al., 2017). Underfunding has dwindled service delivery and staffing of extension officers (Kyle & Resnick, 2016). The share of funding budgeted for agriculture has improved minimally while agricultural expenditure has declined in comparison to other devolved sectors of the government (Ngundo & Chitere, 2015). However, despite the challenges that devolution has experienced, its success stories are evident. Farmers undoubtedly appreciate the improved access to public goods and services as well as improved participation in decision-making particularly in agricultural extension ((Feola et al., 2015).

2.7.1 Structure of the Agriculture Sector after Devolution

Figure 1 shows the administrative structure of the Ministry of Agriculture at the County governments' level.

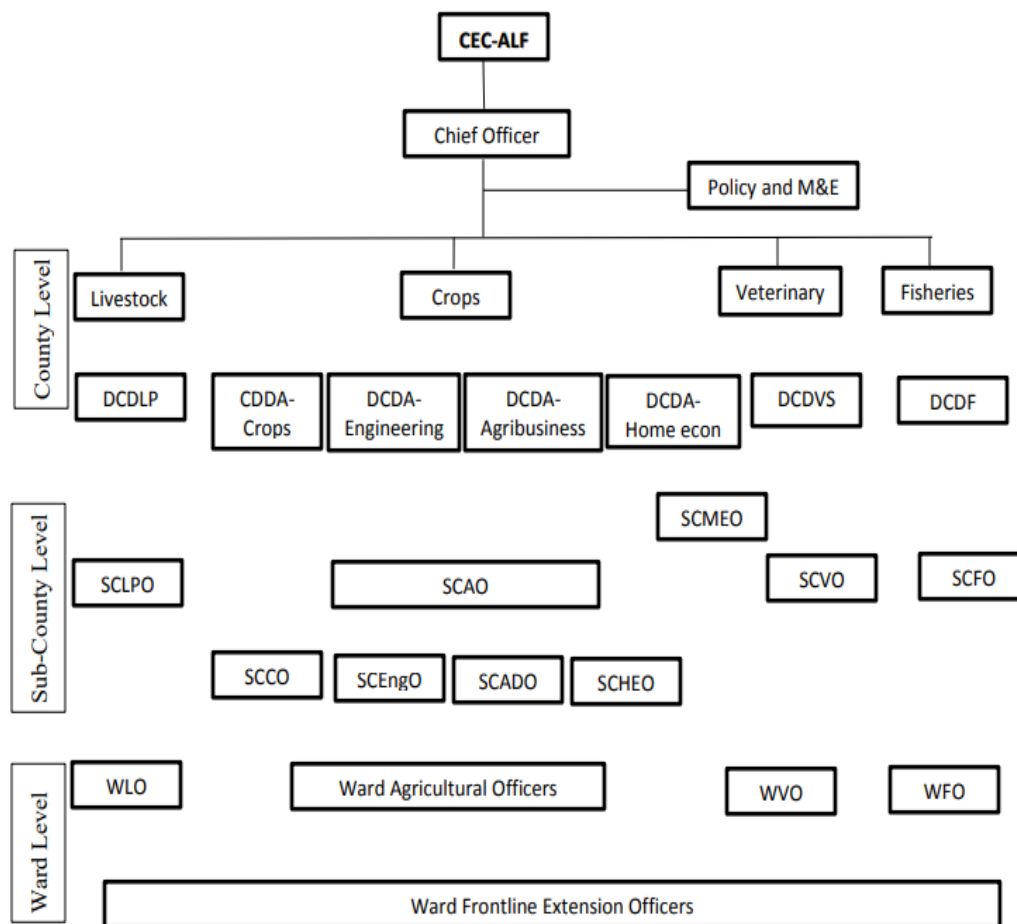


Figure 1: Structure of the Agriculture Sector at the County Level

The Ministry of Agricultural has four directorates i.e. Agriculture, Veterinary services, Livestock Production and Fisheries. Majority of the Counties have four directorates, although some may have co-operatives as the fifth one. The livestock directorate is headed by a county Director of Livestock Production (CDLP), agriculture is headed by a County Director of Agriculture (CDA), and veterinary directorate is headed by a County Director of Veterinary Services (CDVS) while the County Director of Fisheries (CDF) is in charge of the fisheries directorate. There is also a director in charge of monitoring and evaluation. Agriculture as a directory has several specialized divisions headed by deputy directors. At the sub-County level, there are four or five sub-county officers, depending on the number of directorates in the County. The Sub-County

Livestock Production Officer (SCLPO) is in charge of livestock production, the Sub-County Agricultural Officer (SCAO) heads the agriculture department. The sub-County Veterinary Officer (SCVO) is in charge of the veterinary services while the Sub-County Fisheries Officer heads the fisheries department. There is also a Sub-County Monitoring and Evaluation Officer (SCMEO) in charge of policies, monitoring and evaluation. At the sub-County level also, agriculture has four subject matter divisions headed by sub-county officers. These are; crops division headed by a Sub-County Crops Officer (SCCO), engineering division headed by a Sub-County Engineering Officer (SCEO), agribusiness development headed by a Sub-County Agribusiness Development Officer (SCADO) and home economics division headed by a Sub-County Home Economics officer (SCHEO). At the ward level, there are ward level officers in charge of the field extension agents at the location level.

2.8 The Analytical Hierarchy Process Model

The traditional top-down approach to planning and implementation of agricultural extension services is not only non-inclusive in determining the focus areas but also in determining the basis for allocation of funds. Non-inclusivity in determining focus areas for extension tends to alienate the extension agents from the farmers when the focus areas targeted does not meet the farmers' needs. On the other hand, allocation and distribution of human, physical and financial resources is mostly determined by the planned activities. In top-down approach decisions are mostly done by senior government officials with minimal involvement of low cadre officials who have the mandate to do the actual dissemination of services to farmers. However, lower cadre agents best understand the challenges facing dissemination of extension services as they experience them directly. This information, which is rarely captured, can greatly increase efficiency in resource allocation thus increase efficiency of the service.

In this study a multi-criteria decision-making approach was used to determine impacts of resource allocation on efficacy of extension services. Multi-criteria decision making approaches are based on expert knowledge to decide on the relative importance of multiple elements influencing the outcome of a decision-making process. Such criteria are used for situations where direct measures on the multiple elements affecting the outcome of a process are not feasible. However, the non-measurable experiences by

experts can be captured and logically weighted to determine the relative importance of each element and consequently, rank them appropriately in the decision-making process (Saaty, 1990).

The Analytical Hierarchy Process (AHP) is a popular multi-criteria decision-making process developed by Thomas Saaty (Saaty, 1977). The methodology involves use of pairwise comparisons of elements in a decision-making process to arrive at the best decision (Saaty, 1987). The problem in question is first represented in a hierarchy consisting of the objective, criteria and sub-criteria (Saaty, 2008). The perceived importance of each element among the experts is transformed from a qualitative to a quantitative scale using the numerals 1 – 9. Each numeral indicates the comparative importance between any two elements. The value 1 indicates that the two elements being compared are of equal importance, 3 indicates that one of the elements is moderately more important than the other, 5 indicates that one element is strongly preferred to the other, 7 indicates very strong preference of one element over the other while 9 indicates that one element is extremely more important than the other. Values 2, 4, 6, and 8 indicate intermediate scores (Saaty, 1987). The resulting pairwise matrices are then transformed into priority vectors, and then ranking of the alternatives is done in order of preference (Saaty & Tran, 2007).

2.9 Theoretical Framework

This study was guided by Roger's diffusion theory. Diffusion is the process through which an innovation is transferred through various channels over time among members in a social system (Rogers, 2010). Diffusion of innovations theory underscores the need for a sequential process before the adoption of an idea or technology by members of a particular society. It also considers diffusion as an essential social process, in which perceived information about a new idea or innovation is communicated (Dedehayir et al., 2017). The adopter's perceptions of the innovation affect the levels of adoption. Relative advantage, triability, and simplicity of application are attributes that affect the levels of adoption of an innovation (Richardson, 2009).

The innovation decision stages through which a new technology is adopted by an individual or a community are knowledge, persuasion, decision, implementation, and

confirmation stages (Dedehayir et al., 2017). The variables that explain diffusion include the adopters' characteristics, social and political influence as well as the attributes of the innovation itself (Dearing & Cox 2018). Innovations are not communicated in a haphazard manner. Communication of innovations takes place from the source to end users through communication channels (Nguyen, 2015; Ishida et al., 2018). A source in this case can be a person or an institution from which the message originates and the end user is the farmer who will make use of the innovation (Mann & Sahni, 2012). Reception of information may be through interpersonal communication where face-to-face mode is applied or through mass media channels like radios, television, and print media.

Additionally, there are five clusters of adopters of an innovation which include innovators, early adopters, early majority, late majority, and laggards (Wonglimpiyarat & Yuberk, 2005). Across these clusters, adoption of innovation is affected by the participants' communication behavior, information sources, personality characteristics, and socio-economic conditions such as age, gender, educational level, and income (Rogers, 2010). This theory is considered the most suitable in analyzing the dissemination and adoption of an innovation (Sahin, 2006). Therefore, this theory guided this study in describing the factors that affect efficacy of extension service dissemination to smallholder dairy cattle farmers. It also guided the study in investigating the influence of devolution on the efficacy of extension service dissemination within the dairy cattle sector in Tharaka-Nithi County.

2.10 Conceptual Framework

A conceptual framework is an analytical tool showing the relationship between the independent and the dependent variables (Simiyu, 2014). Efficacy of extension service dissemination is the dependent variable while the independent variable is factors affecting efficacy of extension service dissemination. Resource capacities included; availability of human, financial, and physical resources while devolution of extension services were assessed in terms of in-service training of extension agents and farmer training. Dairy technologies were assessed in terms of feeding, reproductive, genetic improvement, disease and parasite control, and milking and milk handling technologies applied by the dairy farmers. Intervening variable will include government policy

which is presumably among the factors that influence the dissemination of dairy technologies. Government policies promote extension programs through budgetary allocation for farmer training, extension personnel training and giving of subsidies to farmers to improve agricultural production. Therefore, resource capacities and devolution may affect dissemination of dairy technologies either singly or in conjunction with the intervening variable.

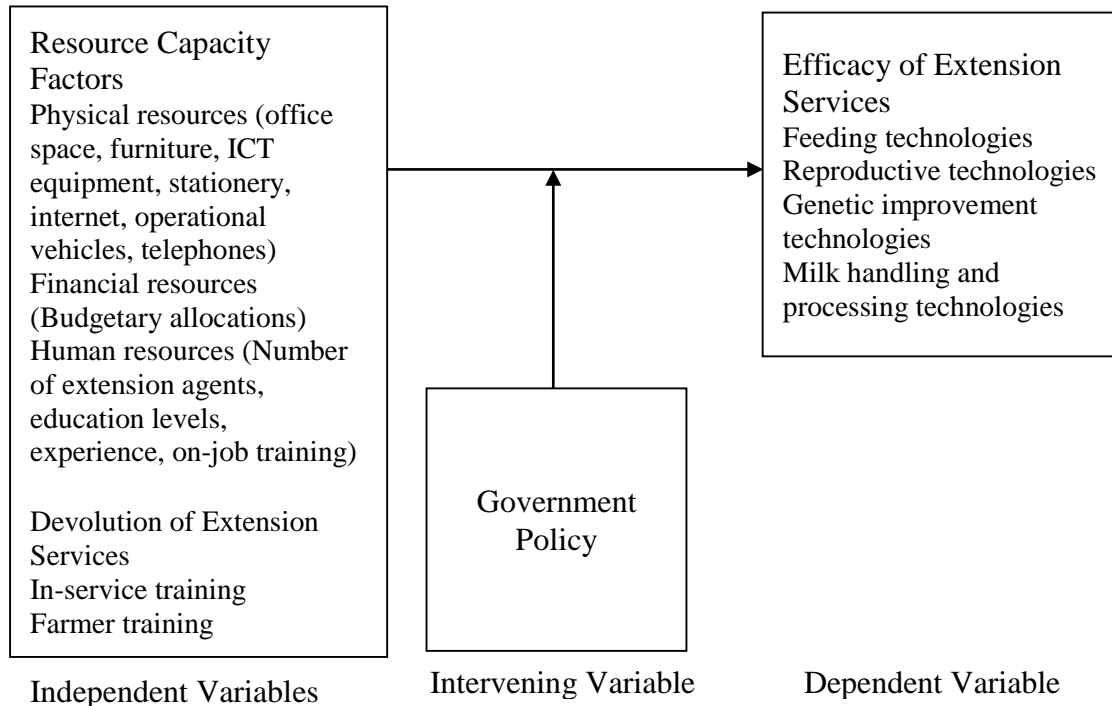


Figure 2: Conceptual Framework.

CHAPTER THREE

METHODOLOGY

3.1 Location of the Study

The study was carried out in Tharaka-Nithi County since dairy production is a viable venture due to the favorable climatic conditions in the area. The County lies on a longitude of 37.7238E, latitude of 0.2965S and an altitude of about 1,500m above sea level. The average temperature experienced in the area is between 16 °C and 27 °C. Tharaka-Nithi County receives an annual rainfall of between 500 millimeters and 1,400 millimeters per annum. According to Jaetzold et al. (2016) cited in Mucheru-Muna (2007), most parts of the County are characterized by humid nitisol, deep, and fertile soils. The main agro-ecological zones in the county include; upper midland (UM3 and UM4), lower midland (LM4 and LM5) and intermediate lowland (IL5 and IL6).

3.2 Research Design

The study adopted a cross-sectional survey design. The design is useful when the researcher intends to collect data at just one point in time (Fraenkel et al., 2015). It also entails the description of certain characteristics about the particular population of interest. Therefore, the design was deemed suitable since the study is aimed at describing the influence of human, physical and financial resources and devolution, and dissemination of dairy technologies among smallholder dairy cattle farmers.

3.3 Target Population

The target populations consisted of 6,800 smallholder dairy cattle farmers and 123 extension agents drawn from the upper zone of Tharaka-Nithi County (Chuka, Maara, and Igambang'ombe sub-Counties) since this is where dairy cattle farming is practiced. The farmer population was divided into clusters; Chuka, Maara, and Igambang'ombe sub-Counties to determine whether there are any underlying differences within the sub-counties. All the extension agents from the Departments of Agriculture, Livestock Production, and Veterinary from the three sub-Counties were also interviewed. Table 1 and 2 show the distribution of dairy farmers and extension agents respectively, within the sub-Counties.

Table 1: Distribution of Dairy Farmers in the Study Area

Sub-county	Population
Chuka	2,700
Maara	3,500
Igambang'ombe	600
Total	6,800

Source: County Extension Department

Table 2: Distribution of Extension Officers in the Study Area

Department	Chuka	Maara	Igambang'ombe	Total
Livestock production	2	4	2	8
Veterinary	15	20	2	37
Agriculture	30	36	12	78
Total	47	60	16	123

Source: County Extension Department

3.4 Sampling Procedures and Sample size

The study adopted a cluster random sampling technique in which the farmer population was divided into clusters; Chuka, Maara, and Igambang'ombe sub-Counties. In this study, farmers were selected randomly from each of the clusters to attain the desired sample size. Additionally, 123 extension agents were interviewed. The sample size for dairy farmers was determined as follows (Cochran, 1963)

$$n_0 = (Z^2pq)/e^2 \dots\dots\dots 1$$

Where, n_0 is the sample size, Z^2 is the square of the z-score for the desired confidence level, p is the proportion of the attribute present in the study, $q = 1 - p$, and e is the desired precision. The sample size was calculated so as to attain 95% confidence level with $\pm 5\%$ precision. In addition, p was set to 0.5 so as to obtain maximum variability. For a population of 6800 farmers (less than 10,000), the following formula was used;

$$n_0 = \frac{n_0}{1 + (n_0 - \frac{1}{N})} \dots\dots\dots 2$$

Where,

n_0 = Sample size

N = Population size

Thus, the working sample size was 365 farmers. The distribution of sample size is shown in Table 4.

Table 3: Distribution of Sample Size in the Study Area

Sub-county	Population	Proportion	Sub-Sample
Chuka	2,700	$(2700/6800) = 0.3970$	$(0.3970 * 364.42) = 145$
Maara	3,500	$(3500/6800) = 0.5147$	$(0.5147 * 362.42) = 188$
Igambang'ombe	600	$(600/6800) = 0.0882$	$(0.0882 * 364.42) = 32$
Total	6,800	0.9999	365

3.5 Research Instrument

The study used structured questionnaires to collect data from dairy cattle farmers and extension agents. There were three questionnaires; questionnaire one (1) for extension administrators collected information on influence of human, financial and physical resources on efficacy of extension service dissemination comprising of: section A; demographic information, and section B; resource capacities and dissemination of DCTs. Questionnaire two (2) for administrators and field extension agents collected information on influence of human, financial and physical resources on efficacy of extension service dissemination with: section A; extension agent's demographic information, and section B; Saaty's scale; collected information on resource capacities and dissemination of DCTs. Finally, questionnaire three (3) for farmers collected information on influence of devolution on the efficacy of extension service dissemination, comprising of: section A; farmer demographic information, section B; Saaty's scale collected information on quality of extension services for specified dairy cattle technologies.

3.5.1 Pilot Study

A pilot study was carried out prior to data collection. According to Hazzi and Maldaon, (2015) a proportion of 10% of the intended sample size is adequate for piloting. Questionnaires were administered to 50 respondents comprising of 13 extension agents and 37 dairy cattle farmers in Imenti North Sub-County of Meru County. Meru County share similar socio-economic characteristics as those in the study area.

3.5.2 Reliability of the Instrument

A test for reliability was carried out using the pilot study data. A Cronbach Alpha coefficient was computed to estimate the internal consistency of the questionnaire items. All the questionnaire items yielded an alpha value of above 0.6. Consistency was assumed when a reliability coefficient of above 0.6 was achieved (Palos-Sanchez, 2018; Gugiu & Gugiu, 2018). Therefore, items that yielded a lower coefficient were revised.

3.5.3 Validity of the Instrument

In this study, content validity was ensured by cross-checking of instrument items against the objectives of the study. Supervisors and other scholars from the Department of Agricultural Economics, Agribusiness Management, and Agricultural Education and Extension helped in the improvement of the instruments' construct validity. A pilot study also helped in improving the accuracy and clarity of the instrument items.

3.6 Data Collection

Nine enumerators were recruited and trained on the administration of the questionnaires. Enumerators were obtained from the study area to help clarify research questions to farmers who could not read and write. The questionnaires were administered at the respondents' places of work to allow room for triangulation of the information provided where necessary. The instruments were filled in presence of the enumerators to allow clarification and translation of the questionnaire contents when needed.

3.7 Data Analysis

3.7.1 Determination of the Human, Financial and Physical Resource Capacities and their Perceived Influence on Dissemination of Dairy Cattle Technologies in Tharaka-Nithi County

Firstly, was to determine the human, financial and physical resources available for extension as follows: (a) human capacities were defined as number of employees, their level of education, number of on-job trainings and working experience, (b) financial resources comprised of capitation for extension services i.e., monies to cater for transportation, holding of field days and seminars, allowances and funds for internal capacity building for extension employees and, (c) physical resources included available office space and furniture, computers, printers, telephones, ICT equipment

and, vehicles and motor bikes for extension services. In addition, data was collected on the quantity of extension services offered, which was defined based on the number of field days held and number of farmers contacted in the last financial year. Collected data was then summarized against the population of dairy cattle farmers in the County. Available resources per number of clients (i.e., dairy farmers) was then compared against international standards.

The extension agents' perceptions on the influence of human, financial and physical resources on dissemination of extension services was determined using a pairwise comparison criterion. The Saaty's scaling criteria (Saaty, 1977) was used to rank the importance of the resources on efficiency of offering extension services. Individual perceptions on relative importance of resources was based on the 1-9 Saaty's scale of intensities. A value of 1 indicates "equal importance" between a pair of resources and 9 indicates "extreme importance" of one resource over the other as shown on Figure 3. Intermediate intensities are indicated by values 2 to 8.

On-job trainings									Level of education								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

Figure 3: 1-9 scale for Pairwise Comparison.

A score of 1 indicates equal importance of the two resources under consideration. A score of 9 indicates that one resource is extremely important compared to the other.

Individual perceptions on importance of resources was compiled in a matrix A consisting of intensities and their reciprocals. Let a_{ij} represent the intensity of resource i over resource j . The reciprocal a_{ji} is computed as $\frac{1}{a_{ij}}$. Aggregate perceptions on overall ranking of resource importance is determined by recovering the principal eigenvector (w) of the positive pairwise comparison matrix A by solving the system (Saaty, 1990).

$$(A - 1)w = 0 \dots\dots\dots 3$$

where n is the number of resources and I is an identity matrix. All computations were done using the AHP package (R Core Team, 2018).

3.7.2 Influence of Devolution on the Efficacy of Extension Service Dissemination within the Dairy Cattle Sector in Tharaka-Nithi County

The influence of devolution on extension service dissemination was described by determining the following aspects relating to extension: a) proportion of farmers receiving extension services, b) main players in offering services, c) the extension services being offered, d) the proportion of the dairy farmers being served by the different players and e) farmers' perception on the quality of services from the different players. Comparison between proportions for the different aspects being investigated was based on Bernoulli tests. The strength of the differences between categories within an aspect was evaluated using odds ratios. All computations were done with the R statistical program (R Core Team, 2018). The summary of data analysis is shown on Table 4.

Table 4: Summary of Data Analysis

Research Questions	Independent Variables	Dependent Variable	Statistics
What is the influence of human, financial and physical resource capacities on dissemination of dairy cattle technologies to smallholder farmers in Tharaka-Nithi County?	Resources (Human, physical, and financial)	Dissemination of dairy technologies	AHP process
What is the influence of devolution on the efficacy of extension service dissemination within the dairy cattle sector in Tharaka-Nithi County?	Devolution of extension services	Efficacy of extension services	Bernoulli tests

3.8 Ethical Considerations

The research proposal was submitted to the Ethics Committee of Chuka University for approval. The researcher also acquired an introductory letter from Chuka University to apply for research permit from the National Council of Science and Technology and Innovation (NACOSTI). The permit was submitted to Tharaka-Nithi County

administration for clearance to carry on with the study. The study ensured equity, dignity and respect to all respondents. The study upheld the respondent's confidentiality throughout the research period. Respondents were assured that the information they provided would be treated with utmost confidentiality and that it would be used for the purpose of the research only. Anonymity of the questionnaires was also exercised. The study also ensured voluntary participation of farmers in the exercise.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Questionnaire Return Rate

A sample of 365 farmers and 123 extension agents participated in the study. Table 5 shows the percentage of questionnaires that were administered, completed, and collected.

Table 5: Questionnaire Return Rate

Respondents	Numbers	Percent (%)
Extension agents	111	90.2
Farmers	365	100.0
Total	476	

Questionnaire return rate for farmers was 100% while that of extension agents was 90.2%. The response return rate was adequate for the study. A response rate of at least 90% is essential for data analysis, discussion, and conclusion (Frippiat et al., 2010).

4.2 Respondents' Demographic Characteristics

Previous studies have shown that gender, working experience and educational level influence the efficacy of extension service dissemination.

4.2.1 Gender of Farmers and Extension Agents

Table 6 shows gender distribution among farmers who participated in the study.

Table 6: Gender of Farmers

Gender	Freq. (f)	Percentage (%)
Male	207	56.7
Female	158	43.3
Total	365	100.0

Males were the majority accounting for 56.7% of the total number of respondents while that of females accounted for 43.3%. This shows that the variation in gender was not significant in the study area. The explanation for male dominance is that, males are considered the heads of households therefore, majority of them participated in the study. The findings are corroborated by previous studies (Wodon & De La Briere, 2018). However, other studies have shown that gender has no significant influence on

the effectiveness of extension service delivery (Thomas & Laseinde, 2015). Figure 4 indicates the distribution of extension agents by gender.

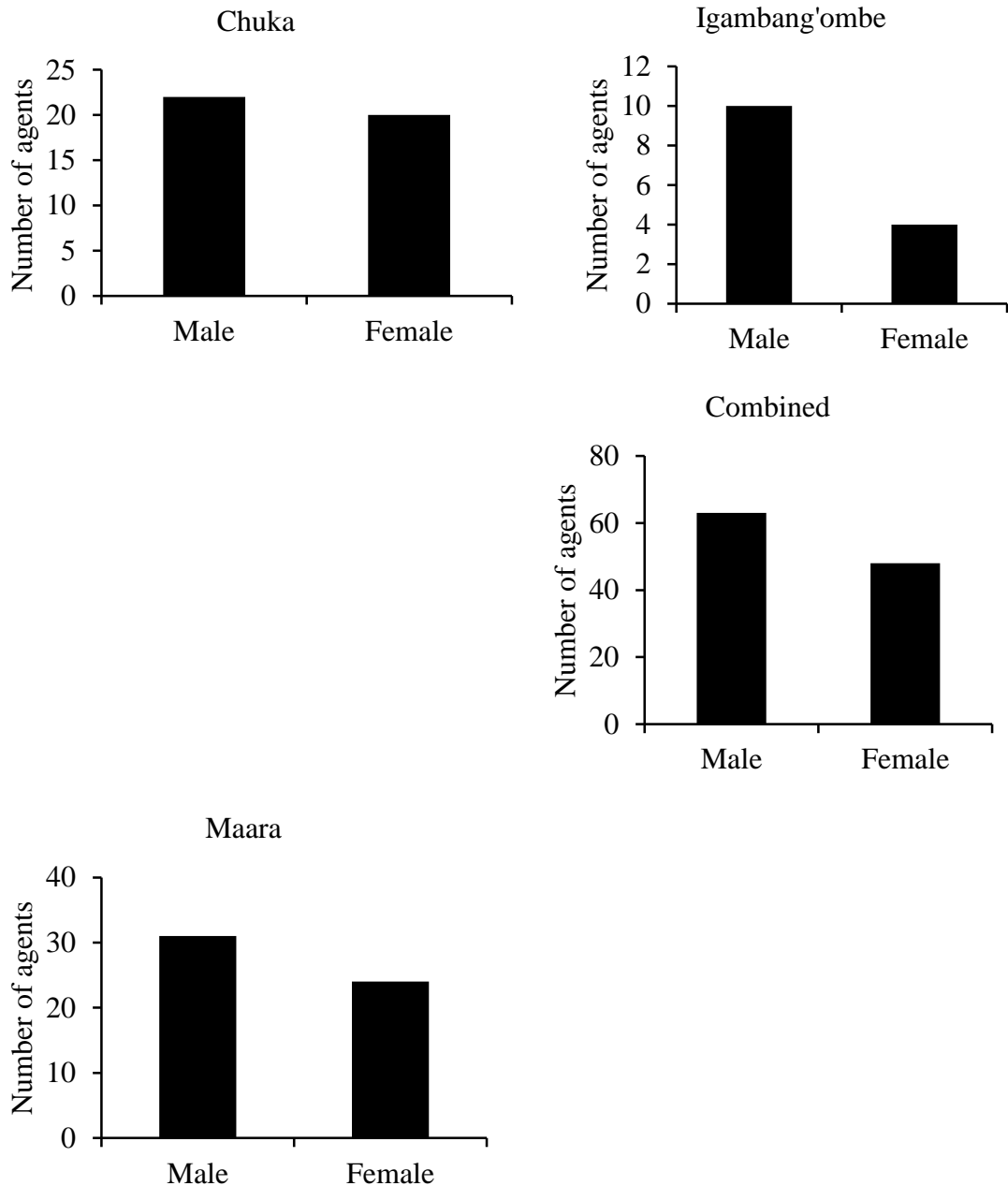


Figure 4: Gender of Extension Agents

Generally, there were more male extension agents as compared to female ones, that is, 63% males and 47% females. However, the difference was not significant. Maara and Igambang'ombe sub-Counties had a fair balance between male and female agents at 95 males and 83 females and, 19 males and 14 females, respectively. Chuka sub-County

was poorest with a proportion of 61 female and 93 male agents. The difference between gender distributions was insignificant in the 3 sub-Counties. Other studies have shown that gender has no significant influence on the effectiveness of extension service delivery (Thomas & Laseinde, 2015).

4.2.2 Education Level of Farmers and Extension Agents

As a preliminary, the study further sought to investigate the educational levels of currently active extension agents and farmers in the County. Table 7 presents the education levels for extension agents.

Table 7: Education Levels of Extension Agents

Education Level	Freq. (f)	Percentage (%)
Post-graduate	5	4.50
Degree	27	24.3
Diploma	36	32.4
Certificate	43	38.7
Total	111	100.0

Majority of the agents had certificate level (38.7%), followed by diploma (32.4%) level training. Degree and post-graduate holders were 24.3% and 4.5%, respectively. All the extension agents in the study area had post-secondary education giving them the minimum entry qualification to disseminate information to dairy farmers (Gao, et al., 2020). Numerous studies have indicated that educational level influences the productivity of extension service (Lundström & Lindblom, 2018; Msuya et al., 2017).

Table 8: Education Level of Farmers

Education Level	Chuka		Sub-county Igambang'ombe		Maara	
	Male	Female	Male	Female	Male	Female
University	9	2	-	-	3	3
College	5	2	-	-	13	4
Polytechnic	4	-	2	2	3	11
Secondary	36	22	5	3	36	16
Primary	34	29	10	4	37	36
None	5	6	2	5	3	13

A proportion of 9.3% of farmers did not have any formal education. Majority of farmers in the study area had a fairly low educational level; 41.1% had only acquired primary

education. Those who had attained secondary level of education were 32.3% while Polytechnic level was 6.0%. College and University levels had 6.6% and 4.7%, respectively. The low levels of education could be an impediment in understanding and applying new technologies in dairy farming. This is because education plays an important role in interpretation of the information passed to farmers by the extension personnel (Zamasiya et al., 2017).

Misinterpretation of information from agents can result in low productivity. However, Raidimi and Kabiti (2019) argues that understanding of disseminated technologies is not dependent on formal education since there are several other ways of informal education through which farmers can get enlightened. Farmer Field Schools carry out demonstrations on selected farms under the guidance and supervision of the agents to enable farmers to learn by practicing (van den Berg et al., 2020). Any challenges cropping up from the processes are addressed by the agents for the benefit of the farmers who duplicate the solutions on their own farms (Tomlinson & Rhiney, 2018). Workshops and seminars offer short courses on new technologies with the aim of training some farmers who act as contact farmers to transfer information to the larger community of farmers (Aldosari et al., 2019). Farmers also learn from each other in their day-to-day interactions (Nakano et al., 2018).

4.2.3 Working Experience of Extension Agents

Table 9 shows the working experience of extension agents in years.

Table 9: Working Experience of Extension Agents

Years of Experience	Freq. (f)	Percentage (%)
1 – 5	22	19.8
6 – 10	26	23.4
10 – 20	34	30.6
21 – 30	15	13.5
>30	14	12.6
Total	111	100.0

A majority of extension agents had a work experience of 10-20 years (30.6%). The highest and lowest levels of work experience were >30 years and 1-5 years which took up to 12.6% and 19.8% of agents, respectively. The other groups of agents had a work experience of 6-10 years (23.4%) and 21-30 years (13.5%). The findings implied that

extension agents had the pre-requisite work experience needed for effective service delivery in their areas of assignment. Work experience is an important ingredient for extension agents in their world of work as it is viewed as a proxy to accumulated knowledge and information. Therefore, extension agents with more experience are better equipped to pass on knowledge and information to farmers (Lundström & Lindblom, 2018).

4.2.4 Type of Cattle Breeds Kept by Farmers

Table 10 indicates the cattle breeds and their crosses, kept by farmers.

Table 10: Summary of Breeds Reared by Farmers

Breed	Percentage (%)
Friesian	69.0
Ayrshire	7.6
Guernsey	1.5
Jersey	3.1
Friesian * Ayrshire	13.0
Friesian * Guernsey	1.5
Friesian * Jersey	3.4

The Holstein Friesian was the most popular dairy cattle breed. The breed was reared by 69% of the farms sampled. Most farmers kept this breed due to the various benefits attributed to it (Ajak et al., 2020). The breed is a high producer of milk and early maturing. It was also noted that the breed was not affected by high altitude and low altitude climate with slightly different vegetation species. The other breeds reared were Ayrshire, Guernsey and Jersey, which were reared in 7.6%, 1.5% and 3.1% of the farms, respectively. It was worth noting that the ‘breeds’ in question were actually not pure rather upgraded versions of the local cattle, exhibiting more characteristics of the pure breed that was used in the upgrading process (Zhang et al., 2020).

4.3 Resource Capacities and Their Influence on Efficacy of Extension Service Dissemination

4.3.1 Human Resource

Figure 5 shows the summary in boxplots for individual preferences for education, experience and on-job training.

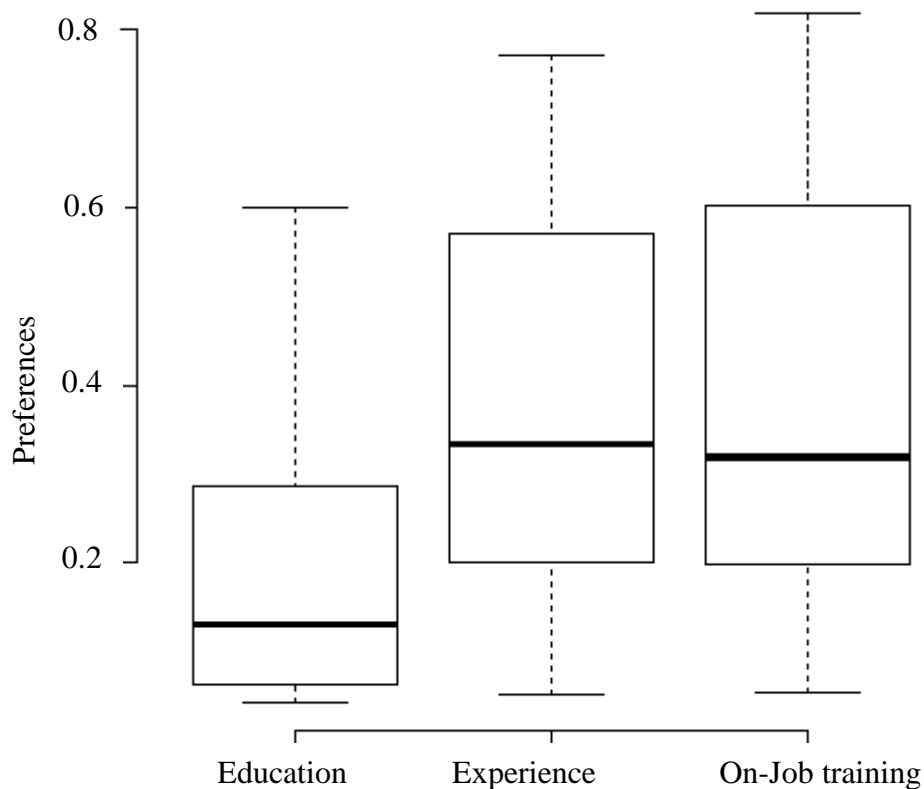


Figure 5: Distribution of Individual Preferences for Human Resources

On-job training was the most limiting human resource identified by the agents, with a median of 0.508, followed by working experience with a median of 0.506. Education was ranked third with a median of 0.085. This implies that emphasis should be put on provision of adequate in-service training for extension workers. More often, increasing

on-job training for workers enables them to increase their knowledge and skills hence, effective service delivery (Ortiz-Crespo et al., 2021).

Individual preferences were aggregated to group preferences using the principal eigenvalues to get the overall ranking of the importance of resources to dissemination of extension services (Saaty, 2008). The individual preferences had a lot of variations which were dealt with by computing the aggregate preferences.

Figure 6 indicates the distribution of aggregate preferences from extension agents on human resources.

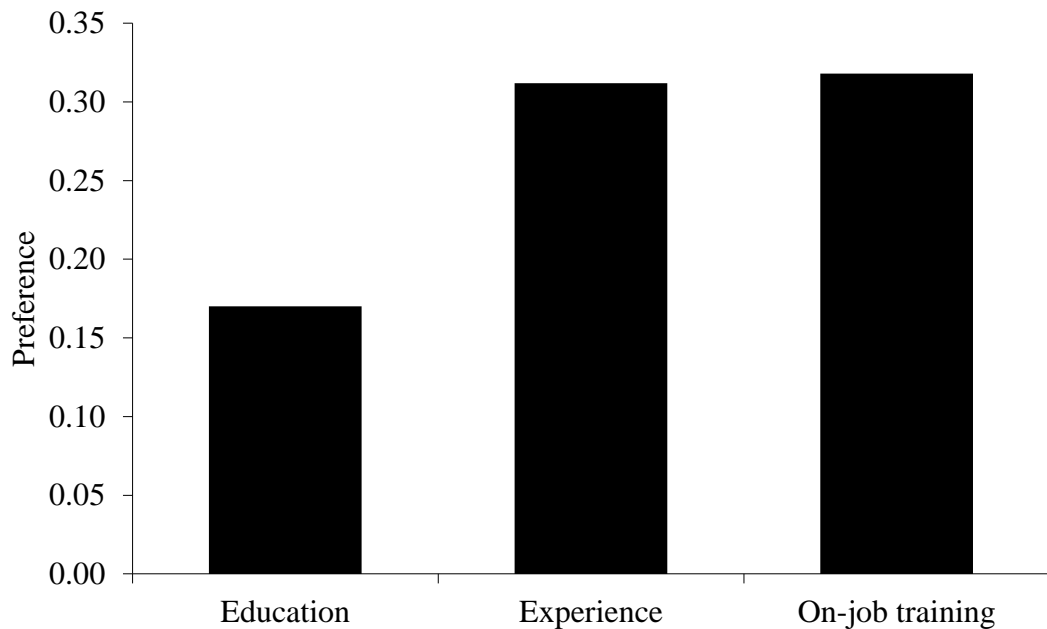
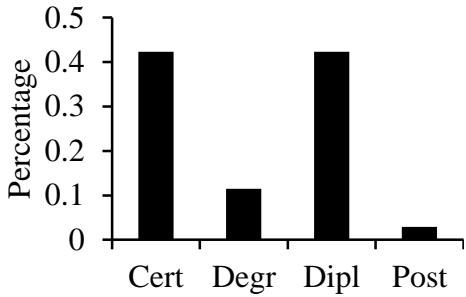


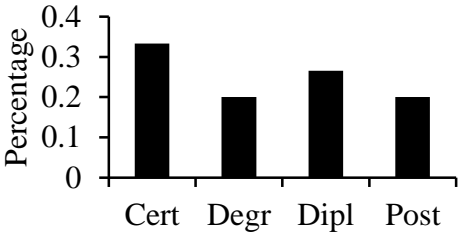
Figure 6: Distribution of Aggregate Preferences for Human Resources by Extension Agents

On-job training was the most important human resource affecting the delivery of extension services with an aggregate rank of 0.318 (Figure 6). It was followed closely by work experience (0.312). Education level was ranked third with an aggregate preference of 0.170.

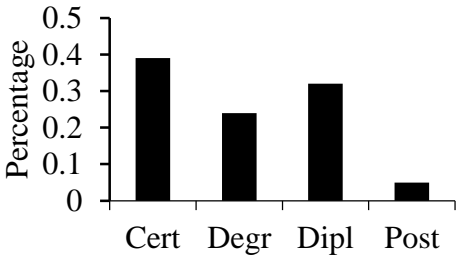
Distribution of education levels against 6-11 years experience



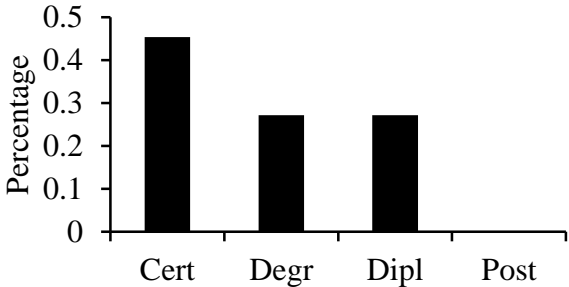
Distribution of education levels against 21-30 years experience



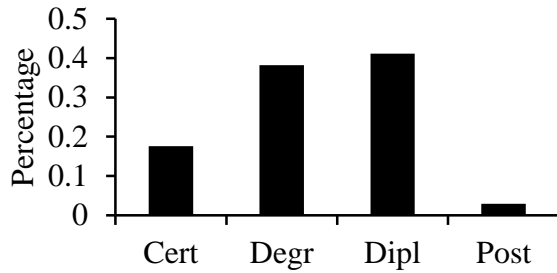
Distribution of agents according to their education levels



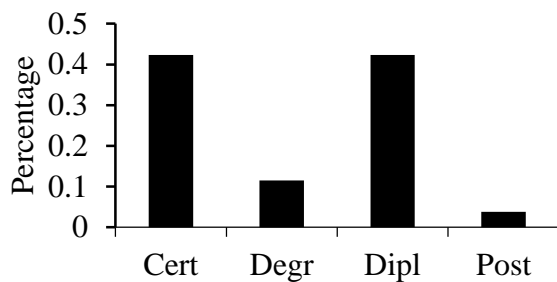
Distribution of education levels against 1-5 years experience



Distribution of education levels against 11-20 years experience



Distribution of education levels against >30 years experience



Cert = certificate, Dipl = diploma, Degr = degree and Post = post-graduate levels of education

Figure 7: Level of Education of Extension Agents.

Figure 7 indicates that the largest proportion of agents had the lowest level of education (39%-Certificate) while diploma holders were 32%. Degree and postgraduate levels had 24% and 5%, respectively. A proportion of 71% of the agents had acquired diploma and certificate levels. Only 29% had degree and post-graduate levels of education. This indicates an impediment to effective service delivery since formal education increases the knowledge and change of mind-set of extension agents as well as helping them through career development and progression (Raidimi & Kabiti, 2019).

Various studies have reported a direct relationship between the level of education and effectiveness of service delivery (Meek et al., 2019; Chen et al., 2015; Dimelu, 2016). An agent's education level has a direct effect on their ability to understand new knowledge and technologies and to effectively pass the same to clients (Alotaibi et al., 2019; Bachewe et al., 2019). Extension agents with higher education qualifications quickly master and apply new technologies received, compared to those with low education background. The largest proportion of agents in the current study had low levels of education, which negatively impacts the efficacy of dissemination of extension

services in the County. The situation is further compounded by the minimal on-job training for the agents. However, the low aggregate preference (0.171) of extension agents on education indicates that they did not perceive the entry level of education to have a great impact since they were already through with school and their only opportunity to further their studies was through on-job training.

The findings of Klerkx, (2020) agree with the results that once extension personnel secure jobs they seize the opportunities for in-service training giving it more preference to further education in the institutions of higher learning. Experience is another important avenue for gaining knowledge and skills making the idea of further education less popular with the agents. This is in agreement with Sennuga et al. (2020) who felt that experience of the agents over time endowed them with knowledge and skills concerning the real situations on the ground. They further argued that knowledge from formal education still needed hands-on and practical experience for the farmers to reap the full benefit of extension. However, the findings of the current study contradict Zeweld et al. (2022) who concluded that formal education in terms of foundation or further education had an impact that is irreplaceable by experience regardless of its length. Therefore, low levels of education in the study area negatively affected the efficacy of extension service delivery to the smallholder dairy farmers. As a consequence, milk production was low since dairy technologies could not reach the farmers efficiently.

The study findings indicate that all the extension agents had post-secondary education (Figure 7). This implies that all extension agents had the minimum entry qualifications to enable them disseminate information to farmers effectively. The findings are in line with those of Alotaibi et al, (2019) that extension agents with post-secondary education have what it takes to deliver to farmers. However, various studies have reported a direct relationship between the level of education and effectiveness of service delivery (Sennuga et al., 2020; Meek et al., 2019; Dimelu, 2016). In addition, Klerkx (2020) envisaged that the value of formal education cannot be downplayed since it completely changes the reasoning capacity of extension personnel thus affecting their manner of decision-making. This, as a consequence improves their ability to disseminate information on dairy technologies. This indicates that an agent's education level

therefore, has a direct effect on their ability to understand new knowledge and technologies and to effectively transfer the same to farmers.

Further, results show that there was very slow career progression with more than 24% of the agents reporting to having never been promoted at all. In addition, approximately 71% of agents with over 10 years of experience had not been promoted in the previous 6 - 12 years. Career progression is critical to efficacy of extension service as it immensely contributes to the morale among the agents (Klerkx, 2020). Promotions and salary increments are determined by the level of education, experience and availability of funds to cater for higher salaries. In this study, most of the agents had only the entry level of education i.e., certificate holders and with minimal in-service training. This may be the biggest hindrance to their career progression. Another possible explanation to the slow progression is lack of funds for in-service training which could give the agents an opportunity for career development and progression. The slow progression therefore, is an indication of a lowly motivated staff-base, which adversely affects the efficacy of service delivery. However, majority of the agents in the current study (80.1%) had over 6 years in service. This is favourable to the efficacy of extension service as experience increases an agent’s level of knowledge and skills of extension personnel (Zeweld et al., 2020). Table 11 indicates the working experience and career progression of extension agents, in reference to the year 2021, in the study area.

Table 11: Work Experience and Career Progression of Extension Agents

Years of service	Number of years since last promoted (reference year is 2021)												
	Never	1	2	3	4	5	6	7	8	9	10	11	12
1-5	21	1											
6-10	5	15	3	3									
10-20	1	8	4				10			8		2	1
21-30		4								8		1	2
Over 30		1					4			5		4	

Career progression among agents was pathetically slow in the County. Almost all (21 out of 22) of the extension agents in the 0-5 years of work experience category were yet to be promoted. For the 6-10 category, 19% of the agents had never been promoted

at all and another 11.5% had three years since last promotion. In the 10-20 and above 20 years' experience categories 64.7% and 82.8% of the agents had more than 5 years since last promotion, respectively. Majority of the extension agents (89 out of 111) had served for 6 years and above. Therefore, the agents had acquired the required experience in the field of extension. This could be taken to conclude that the extension agents in Tharaka-Nithi County had a vast knowledge derived from work experience necessary for extension service dissemination. This is because experience has a great impact in convincing farmers about materials and information presented thus, extension agents with longer work experience had more trust from farmers than those with little experience (Zamasiya et al., 2017). Experience and career progression are critical on the efficacy of extension service as it immensely contributes to mastery of ideas and handling of situations, and morale among the agents (Klerkx, 2020). Farmers have more confidence in extension agents who are more experienced thus boosting their level of participation and understanding of the technologies that are being transferred (Mtega & Ngoepe, 2019). In the current study, there was very slow career progression with more than 27 agents reporting to having not been promoted at all. Further, approximately 71% of agents with over 10 years of experience had not been promoted for the previous 6-12 years despite having acquired the necessary experience in the field of extension.

Generally, promotions are determined by education level, experience, and availability of funds to cater for higher wages. Experience gives extension agents the capacity needed to carry out their duties properly since it gives them knowledge to know what literally works in the field (Phillipson et al., 2016). Most of the agents had only the entry level of education, that is, certificate holders and with no indications of on-job training. This may have been the biggest hindrance to their career progression. Additionally, the slow progression could have been due to lack of funds to cater for higher fees for trainings. Further, the slow progression was an indication of a lowly motivated staff-base, which adversely affected the efficacy of the service delivery.

In this study, on-job training was ranked as the most important human resource with an aggregate preference of 0.318 (Figure 6). Upgrading and strengthening of professional competencies and skills through competency-based programs better equips agents with knowledge and skills thus increasing the effectiveness of extension service delivery

(Zamasiya et al., 2017). A highly trained agent is able to guide farmers to make the best decisions on the production process to achieve the set goals (Ashraf et al., 2020). This, coupled with the fact that most extension agents had just the entry level academic qualification, indicates the agents feeling of inadequacy as far as knowledge and skills are concerned. With the current situation where agriculture is witnessing rapid adoption of scientific approaches, having a poorly trained extension workforce with minimal on-job training is of concern to the efficiency of dissemination of extension services.

On-job training enables the upgrading and strengthening of professional competencies and skills through competency-based programs that impart necessary knowledge to extension agents, hence, enabling the agents to address the needs of the farmers more effectively (Mudzanani, 2019). However, there was minimal on-job training in the County. This may have been as a result of inadequate funds to cater for the training costs. Training needs of extension agents need to be addressed from time-to-time in order to fill the gap between ‘what is’ and ‘what should be’ (Zamasiya et al., 2017). An empowered extension staff is able to guide farmers to make the best decisions on the production process to achieve the set goals (Kwapong et al., 2020). Additionally, farming challenges are dynamic thus, on-job training is paramount to keep the extension agents abreast with the new technologies that can address the challenges adequately. On-job training seems to be the factor limiting the efficiency of the extension agents in dissemination of services to farmers. Therefore, the county government of Tharaka-Nithi needs to allocate more resources towards the in-service training of the extension agents.

4.3.2 Physical Resources

Individual preferences on the relative importance for physical resources by the agents were summarized using boxplots. Figure 8 represents the median and interquartile range for individual preferences for the three physical resources (office space, means of transport and ICT equipment).

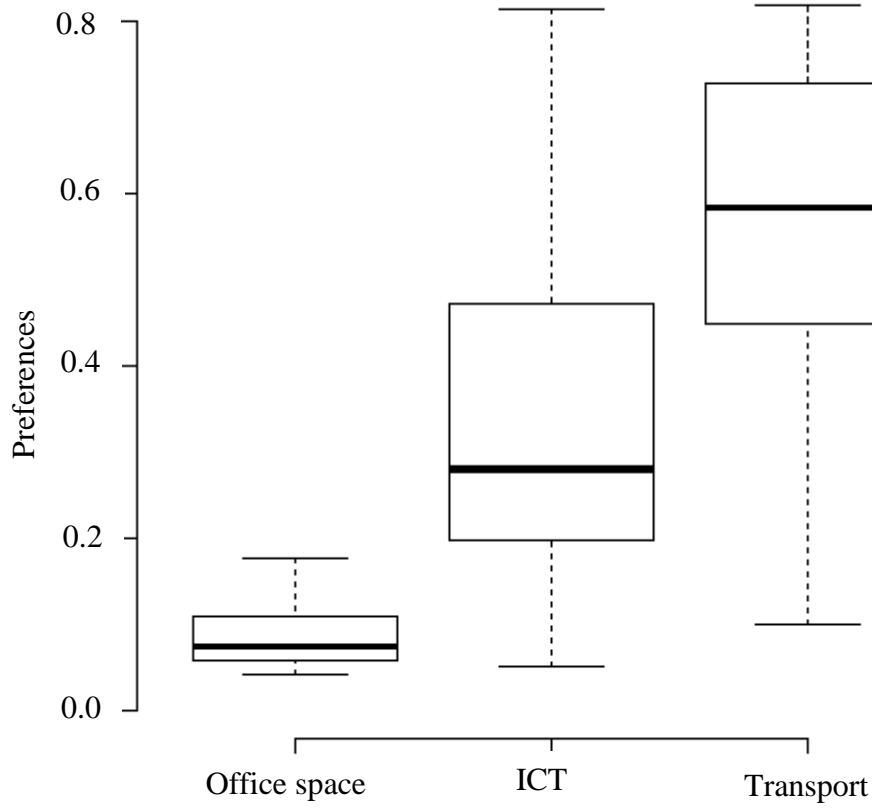


Figure 8: Individual Preferences for Physical Resources

The most limiting physical resource was means of transport with a weight of 0.503. This was followed by ICT resources (0.297). Office space was the least limiting with a weight of 0.085.

Table 12 indicates the numbers of available physical resources (vehicles, motorbikes, computers and printers) against the population of extension agents, and their ratios, in the study area.

Table 12: Ratio of Physical Resources to Extension Agents

Resource	Freq. (f)	Agents	Ratio
Vehicles	4	123	1:30.8
Motorbikes	25	123	1:4.9
Computers	8	123	1:15.4
Printers	8	123	1:15.4

There was a marked shortage of physical resources within the County extension department. For transport facilities, the ratio of vehicles to the number of agents was 1:30.8 while that for motorcycles to agents was 1:4.9. For ICT facilities on the other hand, the ratios for computers and printers to the number of agents were 1:15.4 each. Igambang’ombe sub-county did not have access to internet. All the departments in the 3 sub-Counties had adequate office space with the required furniture (a seat and a desk) necessary for effective office operations and extension services. Figure 9 indicates the aggregate preferences for physical resources.

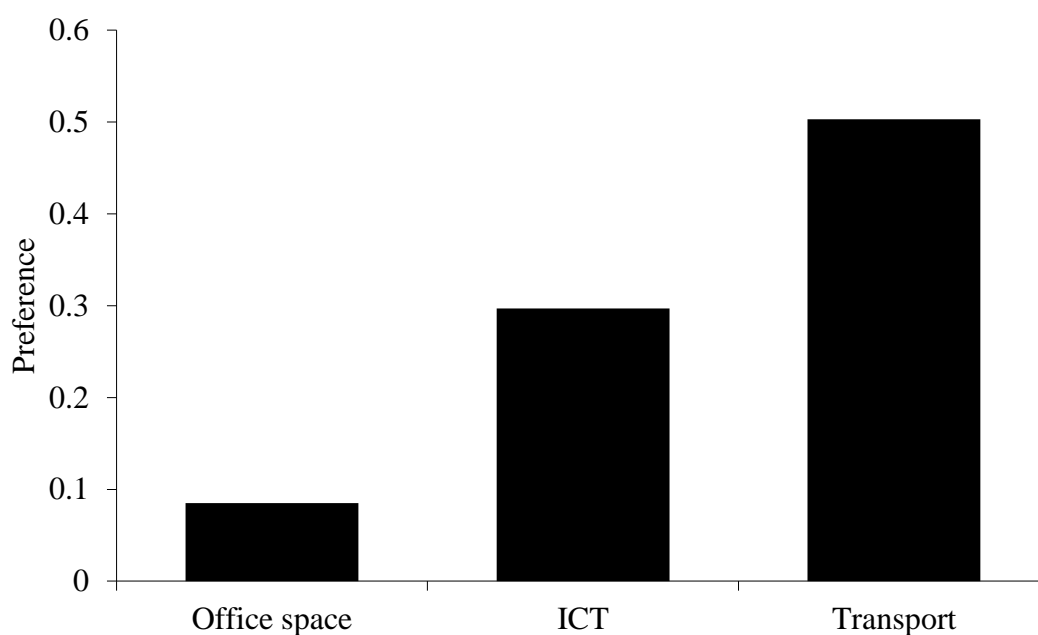


Figure 9: Aggregate Preferences for Physical Resources

Farm visits by agents for meetings and demonstrations are highly dependent on availability and reliability of the means of transport. The high ratios of the vehicles and motorcycles to extension agents (Table 12) is a pointer to a serious challenge in the transport logistics. Shortages in means of transport may have been due to inadequacy of funds to buy more vehicles and motorbikes. It was also noted that some of the transport facilities had remained in the parking lots for years due to lack of funds for servicing. Furthermore, vehicles that had been completely unserviceable had not been replaced at all, leaving Chuka and Maara sub-Counties with one vehicle each for extension operations. This implied that mobility of extension agents in the county was

seriously affected. As a result, new technologies that were developed remained with the agents since there was a challenge in transport.

More emphasis should be put on the need for reliable transport since extension is an informal mode of education involving farmers that cannot be carried out in the confines of a classroom (Fore et al., 2018). Greater benefit of extension education is achieved when learning takes place on the farms through ‘seeing and doing’ by the farmers. Therefore, the observed shortage in transportation results in reduced agent-farmer contact, adversely impacting the efficacy of extension. This could have been the reason why technologies innovated by research institutions years back were yet to reach the dairy farmers in the County. Inadequate mobility also reduces the number of follow-up visits, implying that for any new technology disseminated subsequent meetings to lay emphasis on the same were unlikely or limited. Therefore, the need for reliable transport contributes to the efficacy of information dissemination to farmers since majority of the farmers were in the rural areas where dairy farming is practiced (Vincent, 2018).

Information Communication Technology (ICT) equipment was ranked as the second most limiting physical resource. Table 12 indicated that Igambang’ombe did not have any WiFi connectivity. In addition, even in offices with connectivity, the internet was reported to be unreliable due to frequent and long outages. Other offices located away from the central agricultural offices, for instance, zonal offices were reported to lack WiFi access. The challenge of accessing information via the internet was further compounded by the fact that the monthly facilitation for purchase of data bundles on personal devices which included laptops and mobile phones, was insufficient. The status of internet availability and reliability negatively affected the ability of the agents to acquire up-to-date information to share with the farmers. Therefore, agents relied mostly on physical means of getting information on new technologies.

With the world having become a global village due to advances in technology, the extension agents in the County without internet connectivity were seriously disadvantaged as they lack means to acquire and transfer new and relevant quality of information. The agents noted that one of the benefits of internet in extension is fast information sharing. Updates on new technologies can be shared via the internet

through contact farmers who can later share with the others (Thomas & Laseinde, 2015; De Clercq, 2018). In addition, use of ICT in extension links extension agents with the researchers and the end users of the technologies without physical meetings (Vincent, 2018).

Thus, inadequate ICT equipment affected the ability of the agents to obtain and share information therefore negatively impacting on extension service delivery in this era of technological advancement. It was clear that majority of the older extension agents shied away from using ICT in extension as compared to the younger ones (Thomas & Laseinde, 2015). Hence, there was need to tap into new technologies in ICT as the world is increasingly becoming a global village thus, the use of ICT cannot be over-emphasized. Therefore, the County government of Tharaka-Nithi needs to improve on the availability of ICT equipment for extension to improve on information dissemination to farmers.

Table 13: Available Physical Resources

Sub-county	Agents	Vehicles	Motorcycles	Computers	Printers	*WiFi access points
Chuka	51	1	9	4	3	3
Igambang'ombe	9	2	2	1	2	0
Maara	55	1	14	3	3	2

* Were reported to be unreliable due to frequent and long outages

Office space was ranked third with an aggregate preference of 0.085 in the category of physical resources (Figure 9). Extension agents perceived that information sharing with the farmers was not significantly affected by the presence or absence of an extension office. Dissemination of technologies could comfortably be done devoid of a physical office since the farmers' place of learning was the farm. The extension workers indicated that office space was necessary but had less impact on effective dissemination of extension services in the County. The finding was in tandem with that of Chen et al. (2015) that an extension office is important, it acts as a centre for organisation of extension operations as well as a record centre for all information about farmers and extension programs. Comparatively therefore, ICT equipment and transport had greater impact on efficacy of extension in the study area. Extension offices should therefore be spacious enough and equipped with other amenities to create an enabling environment

for the agents to maximize their potential in extension (Bello et al., 2018). However, it was found out that extension offices were in existence but some were dilapidated with inadequate furniture. Some offices were congested with a large number of agents sharing small offices. This could have been one of the demotivating factors to the agents, indirectly affecting their work morale. Consequently, the efficacy of extension delivery is negatively influenced. These findings were corroborated by a study of Altalb et al. (2015).

As indicated in Table 14, the facilitation for fueling of vehicles and motorcycles was adequate and reliable for all the departments in the County. Adequacy is determined by the distance to be covered by the agents during meetings and demonstrations with farmers (Kwapong et al., 2020). Monthly airtime facilitation for communicating with farmers was available but insufficient. Expenses for mail and parcel postage were not catered for by the County government. For internet, the offices that had access to WiFi had direct connection of internet on their personal devices. However, internet was unreliable at times. For Igambang’ombe sub-County which did not have access to WiFi, monthly facilitation for data bundles was available, but inadequate. Extension agents noted that the inadequacy of these resources affected their performance adversely.

Table 14: Summary on Facilitation

Sub-county	Fuel	Calling Farmers*	Postage	Internet (on Personal Devices)*
Chuka	Yes	Yes	No	Yes
Igambang’ombe	Yes	Yes	No	Yes
Maara	Yes	Yes	No	Yes

* Facilitation was inadequate

4.3.3 Financial Resources

Figure 10 presents individual preferences for financial resources. Remuneration was ranked as the most important financial resource, with travel allowance and capacity building having approximately equal importance with medians of 1.64 and 1.45, respectively. The boxplots indicate that there was variation among the agents on the perceptions and the importance of the various resources on dissemination of extension services.

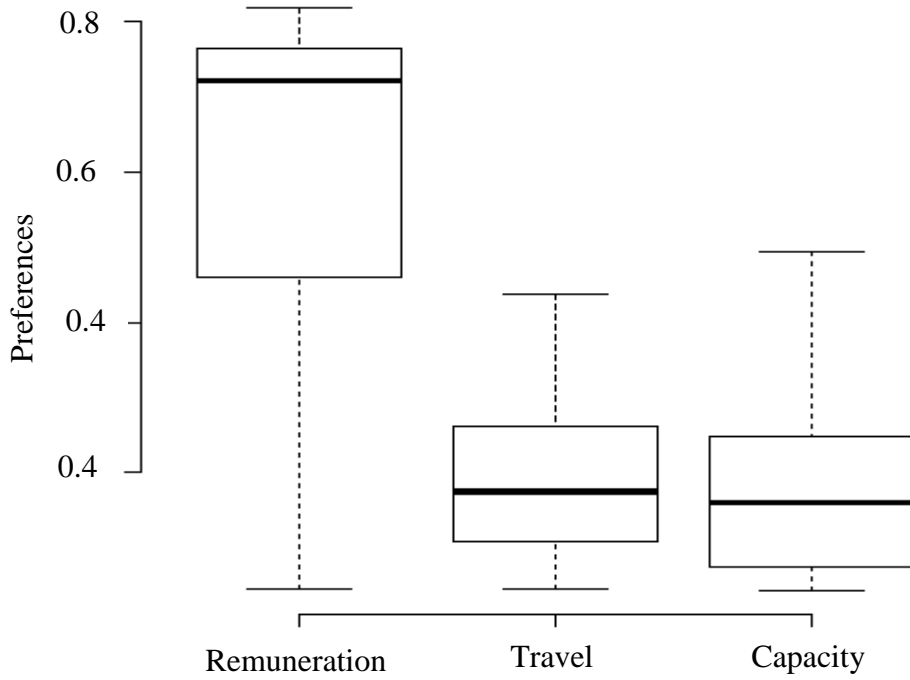


Figure 10: Individual Preferences for Financial Resources

Figure 11 presents aggregate group preferences for financial resource (remuneration, travel allowance and finances for on-job training) as given by the extension agents.

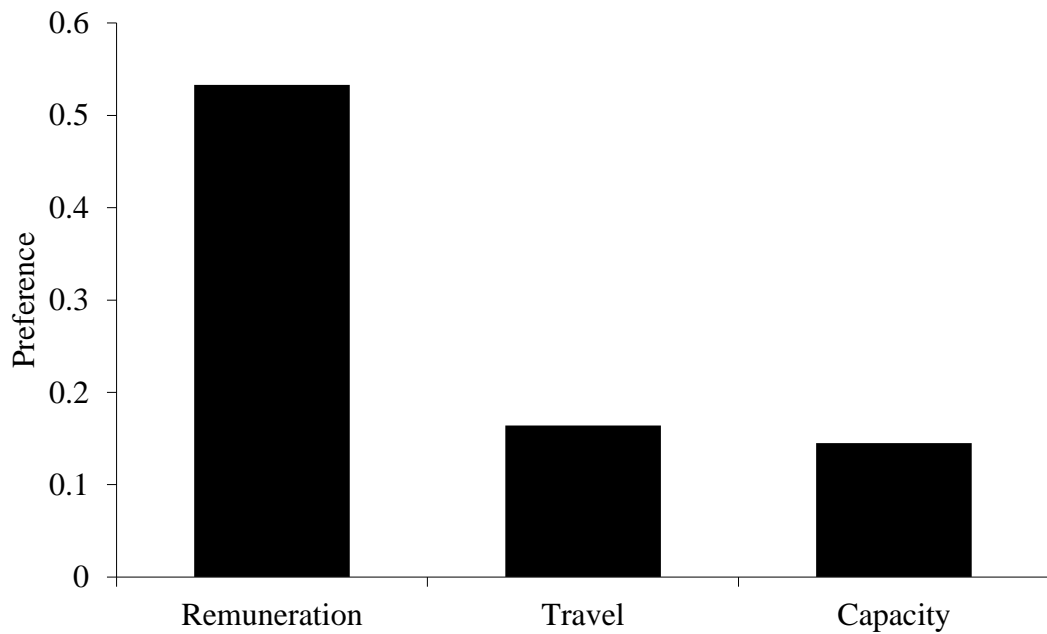


Figure 11: Aggregate Preferences for Financial Resources

Remuneration was ranked first with an aggregate preference of 0.523. This implies that the influence of remuneration on effective delivery of information by extension agents was great. The more the remuneration, the greater the motivation in extension agents to perform their duties. The findings were in tandem with those of Liu (2018) who acknowledged that higher remuneration made extension agents happy, proud, and encouraged to perform their duties. Remuneration is in most cases determined by the level of education, experience and on-job training. Since majority of the agents were certificate and diploma holders, their remuneration was, most likely low. Further, with the observed slow rate of progression even agents with many years of service were most likely earning low salaries. Therefore, it is not surprising that remuneration was the most limiting factor to effective dissemination of technologies to dairy farmers in the County.

Travel allowance, with a much lower aggregate preference of 0.164 was the second factor after remuneration. Travel allowances are important in enabling agents meet the farmers on their farms to disseminate new technologies. Travel subsistence includes all expenses incurred by extension agents relating to transport costs for farm visits (Berhane, 2018). Travel and accommodation expenses were necessary to enable extension agents reach the farmers in the rural areas as well as during in-service seminars and workshop (Namyanya et al., 2022). The study findings indicated a serious inadequacy of travel allowances which affected the frequency of meeting with the farmers. Travelling to attend seminars and workshops required allowances. This implied that due to inadequate allowances, training sessions were not attended as expected. Further, the shortage of sufficient and reliable means of transport complicated the challenge more.

Finances for capacity building was ranked third with an aggregate preference of 0.145. Knowledgeable extension agents are more customer-driven, focused on cost-effective approaches, and flexible in meeting the ever-changing needs of the farmers (Man et al., 2016). The minimal on-job training recorded could have been influenced, to some extent, by shortage of financial resources. Capacity building for both extension agents and farmers is an expensive venture which requires adequate financing. The challenge

of finances could have led to the minimizing of these training sessions, making the agents to be disadvantaged on matters upgrading their knowledge. On the other hand, the low levels of education for the agents could have contributed to serious inefficiency in information transfer to dairy farmers (Liu, 2018).

Equipping of the extension agents with the current knowledge through capacity building has been shown to enable extension agents to meet the demands and expectations of farmers (Elias et al., 2013). Therefore, the 10% of the national budgetary allocation recommended by the Maputo Declaration (2003) should be set aside and part of it used for training of extension agents and to cater for other logistics in extension. This would go a long way in addressing the challenges that extension faces due to financial constraints. For instance, ensuring availability of enough budgetary allocation for capacity building of both extension agents and farmers. Unfortunately, in Tharaka-Nithi County, the accomplishment is far-fetched.

4.4 Devolution on Efficacy of Extension Service Dissemination

Objective 2 of the study intended to investigate the influence of devolution on the efficacy of extension service dissemination within the dairy cattle sector in Tharaka-Nithi County. This was done by defining the type of services offered, proportion of clients reached, bodies offering extension services and quality of services as perceived by the farmers. The confidence level for the study was set at 95%. Binomial test was done using binom test. () function in R. The null hypothesis for the binomial test stated that ‘the proportion of farmers sourcing for public extension was equal to the proportion sourcing for private extension’. Literature has illustrated that the advent of devolution has a far-reaching impact on the County functionaries and organizations.

4.4.1 Proportion of Farmers Receiving Extension Services

Popularity among farmers for public and private services differed for the different services. Table 15 shows the proportion of farmers obtaining extension services from public and private extension.

Table 15: Summary on Proportion of Farmers Obtaining Extension Services from Public and Private Sources

Services	Source of services			Bernoulli test for proportions obtaining services from public and private sources (ignoring 'both')
	Public	Private	Both	p-value
AI	125	180	60	0.002
Feed preservation services	107	204	48	0.000
Feed formulation training	77	243	44	0.000
Field days & seminars	218	114	33	0.000
Input supplies	0	365	0	0.000
Health services (treatment)	0	365	0	0.000
Vaccination	327	31	7	0.000

Private AI services were significantly more popular with farmers compared to public AI services (Table 15). The p -value was 0.002. Additionally, 107 farmers sought feed preservation services from public extension providers while 204 farmers received the same services from private extension providers. This translated to a p -value of 0.000. For field days and seminars, a proportion of 218 farmers had a preference for public extension while 114 preferred private extension. The p -value was 0.000. All the farmers in the study area received input supply services from private extension, with a p -value of 0.000. Likewise, health services were sought by all the farmers from private extension with a p -value of 0.000. For vaccination, a majority of farmers sought the services from public extension (327) while 31 farmers preferred private extension for the same services. The p -value was 0.000.

There is a myriad benefit that dairy farmers can enjoy from AI. For instance, AI increases the yielding capacity of dairy cows by introducing improved genes for milk productivity as well as reducing transmission of reproductive diseases in livestock (Drake et al., 2020). The utility of AI as a service is to a great extent determined by the quality of extension services that enlighten farmers on the existence and benefits of the technology (Abdalla et al., 2020). Artificial Insemination, just like other extension services can be offered by private or public extension (Omontese et al., 2020). The farmers' preference for the source of the services is dependent on various factors, ranging from affordability, to convenience and availability of the services (Bandai et al., 2020). The proportion of farmers seeking AI services from private extension was significantly higher (180 farmers) than the proportion seeking the same services from

public extension (125 farmers). The p -value was 0.002 which was statistically significant at 95% confidence level.

Public AI services were reported to be less available and convenient and this made the private services to come in handy. Although the latter were quite expensive, it was noted that besides affordability, farmers considered other factors like convenience and availability of the services. Thus, although the quality of semen could have been the same, more farmers opted for private AI services despite the high cost. Devolution of extension services was meant to improve services by making them more affordable to the farmers especially the resource-constrained smallholder farmers (Birch, 2018). This objective was yet to be achieved in the study area as far as AI services were concerned thus contradicting the findings of Birch, (2018) as well as Bulut and Abdow, (2018). Artificial Insemination is an upgrading tool used in improvement of indigenous livestock, therefore smallholder dairy farmers in the County were yet to reap the full benefits of public AI services for higher milk productivity (Vyas et al., 2020).

The proportion of farmers who sought feed formulation services from public extension was substantially below the proportion that sought the same services from private extension. The p -value was 0.000, which was statistically significant. As a result, the null hypothesis was rejected. Feed formulation training services had a proportion of 77 farmers obtaining the services from public extension while 243 farmers obtained the same services from private extension. The proportion for private extension was statistically significant, with a p -value of 0.000, which was less than 0.05 thus, the null hypothesis was rejected. Devolution of extension services may not have had a substantial influence on feed formulation services in Tharaka-Nithi County. For farmers to have a preference for private extension, it could mean that the quality of services as far as feed formulation and preservation was concerned had serious shortcomings.

As it is, not all smallholder farmers could afford these services and as a result new technologies on feed preservation could not be disseminated to the farmers who lacked the resources to pay for the services. This could be one of the reasons for feed shortage in the study area especially during the dry seasons which as a consequence affected the productivity of dairy cattle. Majority of the smallholder dairy farmers did not preserve

feeds in form of hay and silage resulting into shortages that affected productivity of their livestock, an observation held by Ntakyo et al (2020). Devolution was meant to make services affordable to the farmers, especially the smallholder category that was resource-poor (Kyambo et al., 2021). There was no budgetary allocation to cater for feed preservation and formulation services for farmers, the services could only be enjoyed by the few farmers who had the financial muscle to pay for them.

From the findings in Table 15, none of the farmers sourced for input supplies from private extension. The p -value was 0.000 which was statistically significant. The null hypothesis was therefore rejected. The results in Table 17 show that convenience and availability were the reasons why farmers preferred private extension for input supplies. Local agrovets and farmer co-operatives came in handy as suppliers of inputs. Livestock feeds and feed supplements, drugs, tools and equipment were obtained solely from private extension. The prices were unaffordable to some farmers and this had a negative impact on milk production. Devolution of services to the Counties was yet to factor in the supply of inputs to farmers at subsidized prices. The resource-constrained farmers could not afford the commercial feeds and feed supplements and as a result, they relied only on the local feeds produced on their farms. The local feeds are, in most cases not balanced and as a consequence, the productivity of milk was affected. Feeding is a very crucial component of livestock management which if taken lightly affects livestock productivity to a great extent (Kemboi et al., 2020). Although devolution of agricultural services in Tharaka-Nithi County has been reported to have improved some services, there were some other crucial ones that had been completely neglected. This, coupled with the challenge of feed preservation may have had a serious impact on the overall productivity of dairy cattle in the County.

Majority of the farmers sought vaccination services from public extension while only 26 farmers relied on private extension for the same services. The p -value was 0.000 indicating a statistical significance thus the null hypothesis was rejected. Table 15 indicates that the reason for the preference was availability (p -value=0.000) and convenience (p -value=0.000). The null hypothesis was thus rejected since the p -values were less than 0.05. For the majority of farmers to seek vaccination services from public extension, it implies the quality of the services was good. The results in table 4 indicate

that the cost of the services was fair thus it attracted the farmers whose greatest proportion in the study area were smallholder. Disease surveillance and vaccination campaigns were launched as a way of protecting livestock from disease outbreaks. This was one of the positive contributions of devolution in the sector of agriculture in the County.

Farmers reported to have their livestock vaccinated since government subsidy made it affordable to them. The resource-poor farmers, who were the majority, had their livestock vaccinated at a small fee. Diseases that could have killed livestock were successfully controlled through vaccination. Additionally, mass vaccination was economical for the livestock department since it factored in all the livestock in the locality, following a programmed schedule. The influence of devolution on routine vaccination of livestock in the study area cannot be overlooked. Outbreaks of viral and other diseases in livestock are becoming rare by the day. Health of livestock is paramount for productivity and profitability of livestock to be achieved. Occurrences of mass death of livestock due to viral diseases had been curbed through vaccination and this is partly attributed to the fact that with devolution, solutions to farmers' problems are sought according to the challenges on the ground.

Table 16 indicates the reasons for the farmers' preference for public or private extension. The reasons were broadly categorized into availability, convenience and affordability of the services.

Table 16: Summaries on Reasons why farmers opt for Public or Private Extension Services (AI, Feed Formulation and Feed Preservation)

Reason	AI			Feed formulation			Feed preservation		
	Public	Private	p-value	Public	Private	p-value	Public	Private	p-value
Availability	24	98	0.000	33	151	0.000	35	110	0.000
Convenience	6	76	0.000	9	87	0.000	32	88	0.000
Cost-effective	95	6	0.000	29	5	0.000	2	-	-

It is evident that 24 and 98 farmers preferred public and private AI services respectively, due to availability of the services. Fewer farmers (6) went for public AI services due to the convenience of the services while 76 preferred private AI services because of

convenience. Cost-effectiveness of AI services from public extension attracted 95 farmers. For feed formulation services, public extension attracted 33, 9 and 29 farmers due to availability, convenience and cost-effectiveness of the services, respectively. On the other hand, 151, 87 and 5 farmers sought feed formulation services from private extension due to the availability, convenience and cost-effectiveness of the services, respectively. Feed preservation services were more popular with private extension. Availability (110 farmers) and convenience (88 farmers) were the reasons favoring private extension. A proportion of 35, 32 and 2 farmers cited availability, convenience and cost-effectiveness, respectively as the reasons why they preferred public to private feed preservation services. Cost-effectiveness did not feature in private extension while only 2 farmers were attracted by the affordability of public feed preservation services.

Private AI services were more popular with the farmers in the study area. A proportion of 98 out of the 180 farmers who had preferred private AI services quoted availability as the reason while 76 out of 180 cited conveniences. The *p*-value for both availability and convenience were 0.000 which were statistically significant. Therefore, despite the fee that came along with private AI services, convenience and availability of the services attracted the farmers. The services were available any time they were required. The fact that the providers could offer them at odd hours and also during the weekends increased their preference by the farmers. In cases where demand-driven services are offered, farmers mostly go for private AI services whose timing is more convenient leading to greater chances of conception (Marques et al., 2020). However, the results differ with the findings Bandai et al., of (2020) that the chances of conception in AI are dependent on accuracy of oestrus observation by the farmer, regardless of the source of the service. The proportion that preferred private AI services due to its affordability was quite small (6 farmers). The charges of the semen and the cost of insemination could have been exorbitant since the practitioners were in private businesses.

There is therefore need for the government to co-ordinate and regulate pluralistic service provision to avoid exploitation of farmers (Phali, 2020). A majority of farmers who preferred public AI services cited affordability. Since the study targeted smallholder dairy farmers, who are mostly resource-challenged, the subsidy AI program in the County came in handy. The results are in tandem with the findings of Bebe et al.

(2002) that the availability of subsidized AI services in developing countries gives smallholder farmers, who would otherwise not have afforded the services, an opportunity to introduce better genes for milk productivity into their dairy herds. The p -value for availability and convenience of public AI services were 0.000 for both reasons, thus significant in the study. These proportions were much smaller compared to the proportions for private AI services. The quality of public extension services in some cases is compromised due their nature bureaucratic nature (Gao & Yu 2020). The implication here is that devolution of extension services could have improved AI services from public extension to some extent, making a reasonable proportion of farmers to prefer it. Since majority of the farmers in the County are small-holder farmers with limited resources, the fair prices of AI from public extension could have been the motivating factor. However, the services were reported to lack convenience, that is, farmers could not obtain the services whenever they needed them. The daily working schedules of the extension personnel did not allow farmers to obtain the services during odd hours of the day and also during weekends. This was worsened by the fact that extension agents were inadequate to effectively offer services to the farmers in the County AI services were also reported to be unavailable for instance the services may be required when the semen was out of stock.

Availability is one of the reasons influencing the quality of extension services (Kassem et al., 2020). There was a significantly higher proportion of farmers who sought private feed formulation services due to availability of the services as compared to public services. A proportion of 33 farmers were attracted by availability of public feed formulation services while 151 farmers sought the same services from private extension due to the same reason. The p -value was 0.000, which was statistically significant since the confidence level for the study was set at 0.05. The null hypothesis was therefore rejected.

For feed preservation services, private extension was more popular. The proportion of farmers who opted for private services due to availability (110 farmers) was significantly higher than that which preferred public extension for the same reason (35 farmers). The p -value for availability was 0.000, which was less than the level of confidence set for the study (0.05), therefore the null hypothesis was rejected. Only 2 farmers felt that public feed preservation services were affordable. This proportion was

not significant and p -value was not applicable. Thus there was no statistical significance. As a result, the alternative hypothesis rejected.

Table 17 indicates the reasons for extension service preference for treatment, input supplies and vaccination.

Table 17: Summaries on reasons why farmers opted for public or private extension services (Treatment, Input Supplies and Vaccination)

Reason	Treatment			Input supplies			Vaccination		
	Public	Private	p-value	Public	Private	p-value	Public	Private	p-value
Availability	0	162	-	0	177	-	52	12	0.000
convenience	0	203	-	0	186	-	26	14	0.040
Cost-effective	0	-	-	0	2	-	249	5	-

All the 365 acquired treatment services from private extension. From Table 17, it was apparent that public services were not popular with health services since none of the farmers sought services from them. Availability (162 farmers) and convenience (203 farmers) were the reasons for the farmers' preferences. Likewise, input supply services were obtained from private extension by all the farmers, with a proportion 177, 186 and 2 quoting availability, convenience and cost-effectiveness, respectively. Vaccination services were more popular with public extension with 52 farmers citing availability (p -value = 0.000), 26 farmers were attracted by the convenience of the services (p -value = 0.040) and 249 farmers attracted by the cost-effectiveness of the services.

Private treatment services were wholly preferred by all the farmers. A proportion of 162 farmers sited availability while 203 farmers sought the services due to their convenience. Affordability of the services was not a big deal to the farmers. They were ready to pay the price for convenience.

Devolution of extension services may not have achieved subsidy in treatment of livestock therefore farmers could only obtain them from private extension. Demand-driven services are offered to farmers as and when they need them and this comes with some price (Tesfaye et al., 2019). Veterinary doctors and para-vets offered the services which sometimes were too costly for the farmers to afford. Devolution therefore, had little, if any, positive influence on health services in the study area. Treatment of

livestock is key if productivity has to be achieved (Ng'asike, 2020). Poor health of livestock due to prevalent diseases may have contributed to low productivity of dairy cattle in the study area. Table 18 summarizes the reasons for preference of public and private extension for field days and seminars.

Table 18: Summaries on Reasons why Farmers Opt for Public or Private Extension Services (Field Days and Seminars)

Reason	Field days & seminars		p-value
	Public	Private	
Availability	72	49	0.023
Convenience	91	61	0.009
Cost-effective	55	4	0.000

A proportion of 72, 91 and 55 farmers preferred public extension for field days and seminars while giving availability, convenience and cost-effectiveness respectively, as the reasons. Private extension was less popular with 49, 61 and 4 farmers (availability, convenience and cost-effectiveness respectively) noted as the incentives for the preferences. The *p*-values were 0.023, 0.009 and 0.000 for availability, convenience and cost-effectiveness respectively.

The proportions of farmers who chose field days and seminars because of the availability of the services were 72 (public services) and 49 (private services). Public extension was more favorable to the farmers. The null hypothesis was rejected since the *p*-value was 0.023, which was below the set level of confidence of 0.05. Public field days and seminars were more available than private services. With the advent of devolution, availability of farmer training through field days and seminars had improved. The services could be obtained readily whenever required. The results of the study therefore concur with the findings of Ngigi, and Busolo (2019) that one of the benefits of devolution was to bring services closer to the people at the grass root levels by making them available to farmers of all cadres especially the resource-challenged smallholder farmers. The proportion of farmers who favored public extension due to convenience of the services was significantly higher (91 farmers) than those who opted for private extension for the same reason (49). The *p*-value was 0.009 thus the null hypothesis was not rejected since the confidence level for the study was set at 0.05. Convenience of farmers training had also improved with the introduction of devolution

in the County. The proportion of farmers that preferred public extension in farmer training was 55 as compared to 4 who opted for private extension due to the affordability of the services. Public extension services were more popular to the farmers since they were offered for free by the County government in the study area. The findings are in tandem with the results of Spencer et al. (2018), public extension services that are funded by the government are more attractive to smallholder farmers who may not afford to pay for extension services from private extension. However, they contradict those of Takahashi et al. (2020) that although public extension goods and services are offered to farmers at a subsidized fee, the challenges of public extension deter farmers from obtaining them despite their cost-effectiveness.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

This study sought to determine the factors influencing efficacy of extension service dissemination to dairy cattle farmers in Tharaka-Nithi County. The subsection presents the summary of the study based on the objectives of the study. The first objective sought to determine the human, financial and physical resource capacities and their influence on the efficacy of extension service dissemination to dairy cattle farmers in Tharaka-Nithi County. Physical resources which the study considered included office space, ICT equipment and means of transport. The study found out that means of transport was the most limiting factor to effective dissemination of extension services, with an aggregate preference of 0.503. ICT equipment was ranked second (aggregate preference = 0.297) while office space had an aggregate preference of 0.085. There was a marked inadequacy of extension resources. The mobility of extension agents in the county was adversely affected by the insufficient means of transport since the meeting places or farmers and extension agents was on the farm. The study also showed that extension agents lacked adequate ICT equipment necessary for effective dissemination of information to dairy farmers.

The human factors that were considered were on-job training, education level and work experience. On-job training was perceived as the most important human resource (aggregate preference = 0.318) followed by working experience (aggregate preference = 0.312). Level of education was ranked third with an aggregate preference of 0.17. Low education levels of extension agents affected their ability to disseminate services to farmers. The problem was compounded by the minimal on-job training recoded in the study area. Education is one of the factors influencing promotion and career progression as well as remuneration of extension agents. Therefore, this may have affected the remuneration of the agents consequently leading to a poorly motivated work force. The results show that despite the agents having acquired the relevant work experience, there was very slow career progression with more than 24% of the agents reporting to having never been promoted at all. In addition, approximately 71% of agents with over 10 years of experience had not been promoted for the previous 6 - 12 years in service.

Financial resources considered in the study included remuneration, travel allowance and finances for capacity building. Remuneration was perceived to influence the efficacy of information dissemination more than the other factors (aggregate preference = 0.533). Travel allowance came second in order of preferences by the agents with an aggregate preference of 0.164. Agents perceived financial allocation for capacity building as having the least impact on their effectiveness to disseminate extension services to farmers (aggregate preference = 0.145). Remuneration was determined by levels of education of extension agents, working experience and on-job training. Travel allowances were vital in facilitating the agents to meet the farmers for information sharing. Agents felt that facilitation for capacity building had a comparatively lesser influence on their ability to effectively offer services to farmers, thus they ranked it in the third position.

The second objective sought to investigate the influence of devolution on the efficacy of extension service dissemination within the dairy cattle sector in Tharaka-Nithi County. The study found out that majority of the farmers sought for extension services from private extension. AI, feed preservation, feed formulation and health services had a *p*-value of 0.000 each. Farmers who sought for extension services from public extension were attracted by convenience and cost-effectiveness of the services with a *p*-value of 0.000 (field days and seminars), 0.000 (vaccination). The results indicated that cost-effectiveness was a significant reason for acquiring extension services from public extension, *p*-value = 0.000. Private services were offered at a fee since the providers were in business. Farmers noted that services from private extension were convenient as they could be acquired any time they were needed. Availability of the services was also cited as a reason for the preference.

5.2 Conclusion

Provision of successful extension services to smallholder farmers across the world is influenced by availability of adequate physical, financial and human resources. Human, financial and physical resource capacities and their perceived influence on dissemination of dairy cattle technologies was determined and was found to be alarmingly inadequate in Tharaka-Nithi County. This could have been contributed by the low budgetary allocation for agriculture from the national as well as the County

government. Education levels of extension agents were generally low with minimal on-job training recorded. Despite a majority of the agents having the necessary working experience, career progression was quite slow. The ratio of physical resources to extension agents was quite high. Means of transport was noted to be a serious factor in achieving effective extension. Farm visits and follow-up meetings are seriously affected by inadequate and unreliable transport. ICT equipment affected the success of extension agents in acquiring and sharing of information. This implies that for effective dissemination of information to take place, there is need for the national and county governments to invest in adequate and reliable resources for extension. Office space was adequate in all the extension departments in the study area.

The influence of devolution on the efficacy of extension service dissemination within the dairy cattle sector was investigated and found to have positive impact as far as effectiveness of extension service dissemination was concerned. Public extension was popular in some services like vaccination, feed preservation and field days and seminars. However, the benefits of devolution are yet to be harnessed fully in the field of extension. Some services were popular with private extension, for instance health service, input supplies, AI and feed preservation services. If the challenges affecting devolution are addressed appropriately, especially by the County government, extension would be of more benefits to the farmers.

5.3 Recommendations

- i. Recruitment more extension agents as a measure of improving the efficacy of extension services to dairy farmers. This way agent to farmer ratio will be improved which will improve the effectiveness of information dissemination.
- ii. Efforts should be made by the government to ensure there is enough means of transport and ICT equipment in order to increase the frequency of farm visits and improve information acquisition and sharing.
- iii. On-job training of extension agents should be encouraged to keep the extension agents abreast with information that can be shared with the farmers. This is because challenges in agriculture are dynamic thus the knowledge base of the agents should be improved continuously.

- iv. Challenges affecting devolution need to be appropriately addressed by the County government to allow farmers to benefit more from the potential that lies in devolution.

5.4 Suggestion for Further Research

- i. Further study should be conducted in other Counties in Kenya to establish the availability of resources for extension and to determine the influence of devolution on the quality of extension services. This will help in establishment of appropriate solutions to address the challenges of extension in the country in order to improve extension service dissemination in the country.

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APPENDICES

Appendix I: Extension Administrator's Questionnaire.

Influence of resource capacities on dissemination of dairy cattle technologies in Tharaka-Nithi County.

Introduction

This questionnaire is intended to collect data regarding the influence of resource capacities on dissemination of dairy cattle technologies to dairy cattle farmers in Tharaka-Nithi County, Kenya. Data collected will be used for academic purpose only. Therefore, you are kindly asked to give your responses for the questions below. This information will be kept confidential.

Instructions: Tick (✓) appropriately in the space(s) provided.

SECTION A: Extension Service Administrator's Demographic information

1. Please indicate your sub-county.
Chuka [] Igambang'ombe [] Maara []
2. Please indicate your gender.
Male [] Female []
3. What is your highest academic qualification?
Postgraduate [] Degree [] Diploma [] Certificate []
4. Please indicate your working experience in years.
1-5 years [] 6-10 [] 11-20 [] 21-30 [] >30 []

SECTION B: Influence of Resource Capacities on Dissemination of Dairy cattle Technologies

a. Human resources

5. What is the total number of extension agents in your sub-county?.....
6. State the year you were lastly promoted.....
7. How many on-job training sessions did you organize in the last one year? (2019)
.....
8. Please give an estimate of the number of extension agents that benefited from the on-job trainings in the year 2019 in your sub-county
.....

9. Please tick the areas that were addressed by the on-job trainings

- Feed and feed formulation
- Artificial Insemination
- Silage and hay making
- Milk handling practices
- Disease surveillance, treatment and vaccination
- ICT compliance
- Marketing of livestock products
- Other areas (specify)

.....

.....

.....

.....

.....

b. Physical resources

10. How many means of transport are in working condition for extension in your sub-County?

Motorbikes.....

Vehicles

11. How many computers are available and in working condition in your sub-county office?.....

12. How many extension agents rely on the above computers for service delivery in the sub-County?.....

13. Please indicate the number of broken resources in your sub-County office stating the duration they have been out of order and the reasons why they have not been repaired

Resource	Number	Duration	Reason(s) – Tick where applicable		
			Lack of funds	No longer required	Unrepairable
Printers					
Motorbikes					
Vehicles					
Desks					
Projectors					
Computers					
Photocopiers					

14. Do you have access to printing and photocopying services in the office?

Yes [] No []

If not, where do you get the services from?

.....

Do you receive facilitation from the government for printing and photocopying services obtained away from the office?

Yes [] No []

15. Indicate the teaching aids that are accessible in your office for service delivery (tick where applicable).

Posters

Pamphlets

Magazines

Video clips

Booklets

Others

(Specify).....

.....

.....

.....

c. Financial resources

16. Please indicate the annual estimate of budgetary allocation for extension service delivery in KES.

.....

17. Of the annual budgetary allocation above, please state the estimated percentage allocation for the following extension departments.

Livestock production.....

Veterinary.....

Agriculture.....

Fisheries.....

18. How would you rate the funding for on-job training in your sub-county?

Very satisfactory []

Satisfactory []

Fairly satisfactory []

Not satisfactory []

19. Is there a budgetary provision for fueling of vehicles and motorbikes?

Yes [] No []

20. Do you get facilitation for the following services?

Service	Yes	No
Making calls to farmers		
Postal services		
Internet services		

21. How would you rate the above facilitation?

Very adequate []

Adequate []

Fairly adequate []

Inadequate []

22. Do you have access to internet services in your office?

Yes [] No []

If yes, indicate it's source.

Personal [] Government-provided []

23. How would you rate the reliability of internet in your office?

Very reliable []

Reliable []

Fairly reliable []

Not reliable []

24. From the list below, please indicate the services that are funded and show the nature of funding.

Service	Fully funded	Partly funded	Not funded
Artificial Insemination			
Disease surveillance and treatment			
Semen Sexing			
Deworming			
vaccination			
Embryo Transfer			
Input supplies/subsidies			

25. What are the activities that are not funded yet you feel they are fundamental in improving your effectiveness in service delivery?

.....
.....
.....
.....
.....

THANK YOU.

Appendix II: Field Extension Agent’s Questionnaire

Perceived influence of Human, Financial, and Physical Resources on Extension Services (Saaty’s scale).

Introduction

This questionnaire is intended to collect data regarding efficacy of extension agents and dissemination of information to dairy cattle farmers in Tharaka-Nithi County, Kenya. Data collected will be used for academic purpose only. Therefore, you are kindly asked to give your responses for the questions below. This information will be kept confidential.

Instructions: Tick (√) appropriately in the space(s) provided.

Section A: Field Extension Agent’s Demographic Information

1. Sub-County

Chuka [] Igambang’ombe [] Maara []

2. Gender Male[] Female[]

3. Kindly, indicate your highest education qualification.

Certificate [] Diploma [] Degree [] Post-graduate []

4. Please indicate your working experience in years.

1-5 years [] 6-10 [] 11-20 [] 21-30 [] >30 []

Section B: Resource Capacities and Dissemination of Dairy Cattle Technologies (DCTs).

Comparing each of the two factors shown below, which one do you feel has greater influence in your ability to deliver quality extension services to dairy cattle farmers. Tick where appropriate: A value of 1= indicates “equal importance” between the two factors, 9 = indicates the ticked factor has “absolute importance” compared to the other factor, values 2-8 indicate intermediate levels; the level of importance increase from 2 (small) to 8 (large).

i. Physical Resources

1. Office Space and ICT Equipment

Office space								ICT equipment								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

2. Office Space and Means of Transport

Office space									Means of transport								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

3. ICT Equipment and Means of transport

ICT equipment									Means of transport								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

ii. Human Resources

4. Level of Education and Work Experience of Extension Agents

Educational level									Work experience								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

5. Level of Education and On-Job Training

Educational level									On-job training								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

6. Work Experience and On-job Training

Work experience									On-job training								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

iii. Financial Resources

7. Remuneration and Travel subsistence

Remuneration									Travel subsistence								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

8. Remuneration and Monies for Capacity Building

Remuneration									Monies for capacity building								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

9. Travel Subsistence and Monies for Capacity Building

Travel subsistence										Monies for capacity building							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

Comparison between Physical and Human Resources

10. Office Space and Level of Education

Office space										Level of education							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

11. Office Space and Work Experience

Office space										Work experience							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

12. Office Space and On-job Training

Office space										On-job training							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

13. ICT Equipment and Level of Education

ICT equipment										Level of education							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

14. ICT Equipment and Work Experience

ICT equipment										Work experience							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

15. ICT Equipment and On-job Training

ICT equipment										On-job training							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

16. Means of Transport and Level of Education

Means of transport										Level of education							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

17. Means of Transport and Work Experience

Means of transport										Work experience								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9		

18. Means of Transport and On-job Training

Means of transport										On-job training								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9		

Comparison between Physical and Financial Resources

19. Office Space and Remuneration

Office space										Remuneration								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9		

20. Office Space and Travel Subsistence

Office space										Travel subsistence								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9		

21. Office Space and Monies for Capacity Building

Office space										Monies for capacity building								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9		

22. Travel Subsistence and Remuneration

Travel subsistence										Remuneration								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9		

23. ICT Equipment and Travel Subsistence

ICT equipment										Travel subsistence								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9		

24. ICT Equipment and Monies for Capacity Building

ICT equipment									Monies for capacity building							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

25. ICT Space and Remuneration

Office space									Remuneration							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

26. Office Space and Travel Subsistence

Office space									Travel subsistence							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

27. Office Space and Monies for Capacity Building

Office space									Monies for capacity building							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Comparison between Human and Financial Resources

28. Level of Education and Remuneration

Level of education									Remuneration							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

29. Level of Education and Travel Subsistence

Level of education									Travel subsistence							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

30. Level of Education and Monies for Capacity Building

Level of education									Monies for capacity building							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

31. Work Experience and Remuneration

Work experience									Remuneration							
-----------------	--	--	--	--	--	--	--	--	--------------	--	--	--	--	--	--	--

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

32. Work Experience and Travel Subsistence

Work experience										Travel subsistence							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

33. Work Experience and Monies for Capacity Building

Work experience										Monies for capacity building							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

34. On-job Training and Remuneration

On-job training										Remuneration							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

35. On-job Training and Travel Subsistence

On-job training										Travel subsistence							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

36. On-job Training and Monies for Capacity Building

On-job training										Monies for capacity building							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

Thank You.

Appendix III: Farmer's Questionnaire

Influence of devolution on efficacy of extension service dissemination within the dairy cattle sector in Tharaka-Nithi County.

Introduction

This questionnaire is intended to collect data regarding the influence of devolution on efficacy of extension service dissemination within the dairy cattle sector in Tharaka-Nithi County, Kenya. This research will be used for academic purpose only. Therefore, you are kindly asked to give your responses for the questions in the questionnaire. This information will be kept confidential.

Instructions: Tick (√) appropriately in the space(s) provided.

Section A: Farmer Demographic information

1. Sub-County:

Chuka [] Igambang'ombe [] Maara []

2. Location

.....

3. Gender:

Male [] Female []

4. Highest education level:

None []

Primary []

Secondary []

Polytechnic []

College []

University []

5. Number of dairy cattle

1-2 [] 3-4 [] 5> []

6. How many of the above animals are;

a) Milking.....

b) In-calf.....

c) Calves.....

7. Which breed are your dairy cows?

Friesian []

Jersey []

Guernsey []

Ayrshire []

8. Please indicate the size of your farm in acres.

1 and below [] 2 – 5 [] 6 – 10 [] Above 11 []

9. Did you receive any extension services in the year 2019?

Yes [] No []

If yes, please indicate the kind of extension service received, source of the service and the reason why you preferred the source(s).

Service	Private extension	Public extension	Both	Reason
Artificial Insemination				
Embryo Transfer				
Treatment				
Vaccination				
Semen Sexing				
Feed formulation services				
Input supplies e.g. animal feeds				
Field days and seminars				
Feed preservation services				

10. What is your average daily milk production in litres?

<5 litres [] 6-10 [] 11-15 [] >15 []

11. Indicate other agricultural activities you engage in apart from dairy farming.

Animal Production

Pig farming []

Poultry farming []

Bee keeping []

Beef rearing []

Crop Production

Coffee production []

Tea production []

Maize []

Beans []

Sunflower []

Green grams []

Vegetables []

Fruits []

Macadamia []

Others

(Specify).....

.....

.....

Section B (Saaty's scale- to collect information on quality of extension services for specified dairy technologies).

12. Comparing the two service providers (Public and Private), which one do you feel has better services as far as the listed dairy technologies are concerned? Tick where appropriate: A value of 1 indicates "same quality" between the two service providers, 9 indicates that one service provider has "absolutely high quality services" compared to the other, values 2 - 8 indicate intermediate levels; the quality of services offered increase from 2 (small) to 8 (large).

i. Artificial Insemination

Private extension									Public extension							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

ii. Vaccination of animals

Private extension									Public extension							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

iii. Treatment of sick animals

Private extension									Public extension							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

iv. Field Days

Private extension									Public extension							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

v. Feed formulation technologies

a. Mixed rations

Private extension									Public extension								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

b. Feed additives

Private extension									Public extension								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

vi. Feed preservation

Private extension									Public extension								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

vii. Fodder production

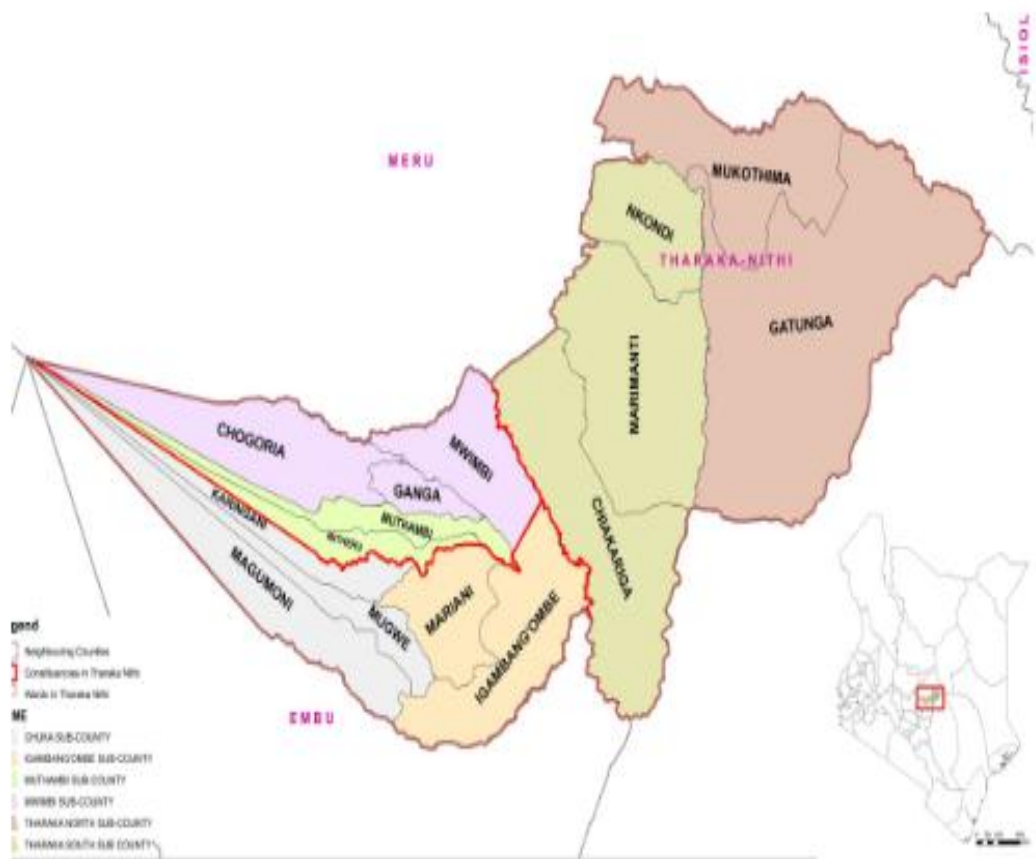
Private extension									Public extension								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

viii Milking, Milk handling and processing technologies

Private extension									Public extension								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

Thank You.

Appendix IV: Map of Tharaka-Nithi County




Appendix V: NACOSTI Permit

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Ref No: **643749** Date of Issue: **28/July/2021**

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