DIFFUSION OF INFORMATION AND COMMUNICATION TECHNOLOGIES IN COMMUNICATION OF AGRICULTURAL INFORMATION AMONG AGRICULTURAL RESEARCHERS AND EXTENSION WORKERS IN KENYA.

BY

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DECLARATION

I declare that this study "Diffusion of Information and Communication Technologies among agricultural researchers and extension workers in Kenya" except where specifically indicated in the text, is my own original work and has not been presented for the award of any degree at any other university. All the information used has been acknowledged both in the text and in the references.

.... 29th - April - 2004 ....

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DEDICATION

This dissertation is dedicated to my beloved wife Peninah, whose sacrifice, patience, understanding and encouragement were instrumental to its completion.

To our children, Kipkemoi, Chebet and Cherop who always raised my inspiration during the most difficult periods of my study.

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ABSTRACT

The purpose of this study was to investigate the diffusion of Information and Communication Technologies (ICTs) in the communication of agricultural information among agricultural researchers and extension workers in Kenya. In particular, the study focused on the public agricultural sector and covered the Kenya Agricultural Research Institute (KARI) and the Ministry of Agriculture and Rural Development (MoARD).

A survey research method, comprising a self-completed questionnaire and a structured interview schedule was utilized to gather data from the respondents. This was supplemented by observation and document review. The questionnaire was used to solicit information from agricultural researchers and extension workers, while the face to face interview was used to obtain information from the key informants of the study. The agricultural researchers were drawn from the 21 KARI research centres distributed in all the eight provinces of Kenya and strategically spread to cater for different agro-ecological zones and socio-economic systems. The extension workers, on the other hand, were drawn from the Uasin Gishu and Baringo Districts, while the Key informants of the study were drawn from all the institutions surveyed.

A total of 356 respondents comprising 159 agricultural researchers, 138 extension workers and 59 key informants participated in this study. The completed questionnaires were reviewed to determine their usability. Two questionnaires were discarded because they were incomplete. A total of 295 questionnaires (159 agricultural researchers and 136 extension workers) and 59 recorded interviews were usable. This brought the total number of respondents to 354.

It was observed that KARI and MoARD had adopted a wide variety of ICT tools and services in an effort to facilitate information sharing and exchange among agricultural researchers, extension workers, farmers and other actors involved in research and extension. These ranged from modern ICT based on digital information that included computers, the Internet and email, electronic sources, scanners, digital cameras among others. Traditional ICTs based largely on analogue information waves included radio

cassettes, tape recorders, television, video cameras, VCR, telephone, fax (analogue and digital) among others. It was further established that the Agricultural Information Centre (AIC) had a modern radio studio equipped with professional sound recording equipment and editing suites amongst a variety of other video production facilities. The wide range of ICT models adopted addressed the different kinds of information needs and communication problems encountered by agricultural researchers, extension workers and farmers.

The agricultural researchers and extension workers had a critical need for information that was specific to the nature of their work. In addition, they needed information on agricultural policies and meteorology. The information needs of the two categories of respondents were met through the use of print and electronic sources. Agricultural researchers obtained useful information from the Internet and CD-ROM databases with TEEAL database having the most useful information, while the Kenya Agricultural Research Database (KARD) provided useful information on local content. In contrast, the extension workers were disadvantaged as the majority lacked skills and physical access to ICTs. Their information needs were, therefore, met through the use of printed sources of information, and by attendance of meetings, workshops and seminars.

Most of the respondents used ICTs to communicate among themselves and also with actors involved in research and extension. The Internet and email was used for consultation purposes, for communicating agricultural information, for research purposes and for collaborative projects with other colleagues. Radio, television and video were used in disseminating agricultural information to the farming community. Mobile phones were found to be a convenient means of communicating short messages. It was observed that use of ICTs had increased the respondents' work productivity and creativity.

Information literacy programmes were taking place in the institutions surveyed although at different levels of intensity and continuity. Through the programme most of the respondents had improved their skills on the use of computers, Internet, email and electronic sources. The programmes were better coordinated and managed at KARI than the Ministry of agriculture.

Although ICTs had facilitated communication of agricultural information among actors involved in research and extension, it was yet to improve the linkage between agricultural researchers and extension workers. For ICTs to be leveraged in the agricultural sector, it was observed that the agricultural researchers and extension workers should work more closely as their activities are interrelated. Each group should play their roles in the multi-faceted process of transmitting new knowledge of farm technology to farmers and getting their feedback.

An attempt had been made to formulate institutional ICT policies to guide the diffusion of ICTs at KARI and the Ministry of Agriculture. Implementation of these policies had been hampered by the lack of adequate funds, poor infrastructure and lack of commitment by some of the policy makers. The policies had also failed to address the over-reliance of donor funded projects, capacity building and skill development and to bring institutional changes. It was observed that the Kenya Government had formulated policies to guide liberalization, privatization and tariff reform. These policies had been implemented to a greater extent and had paved the way for the involvement of the private sector in the development of the various sectors of economy in the country. The government was also in the process of formulating a comprehensive national ICT policy to provide guidelines in the ICT sector.

Despite the efforts to expand and modernize ICTs in the agricultural sector, its growth had been hampered by a number of constraints and challenges. Among them include inadequate funding; poor infrastructure; inadequate skill development; lack of comprehensive national and institutional ICT policies; lack of monitoring and evaluation system; inadequate provision of ICTs tools and services; poor maintenance, and over-reliance of donor funded projects leading to a low level of sustainability. To address these problems requires the intervention and interaction of all the stakeholders in the agricultural and ICT sector and also involvement of the government. The study recommends the following: improvement of telecommunication infrastructure and rural electrification; formulation of comprehensive institutional and national ICT policies; alternative sources of finance; employment of more IT personnel; comprehensive strategies on ICT skills development; reduction of taxes on ICT tools and services; development of responsive content; development of monitoring and evaluation mechanisms for ICT projects; improvement of communication between agricultural researchers and extension workers; and adoption of FAO Virtual Extension, Research and Communication Network (VERCON) system to improve the linkage among and between actors involved in research and extension.

It is concluded that despite the constraints and challenges encountered in the application and use of ICTs in the agricultural sector, a wide variety of ICTs had been adopted to facilitate information sharing and exchange among agricultural researchers and extension workers. The application and use of these ICTs have a greater role to play in the context of the changing paradigms in agricultural research and extension, where linear information flows are being replaced by pluralistic information flows.

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ACRONYMS AND ABBREVIATIONS

AGRICOLA	Agricultural Online Access
AGRIS	International Information System for the Agricultural Sciences and Technology
AIC	Agricultural Information Centre
AIRC	Agricultural Information Resource Centre
AHITI	Animal Health and Industry Training Institute
ATIRI	Agricultural Technology Information Response Initiative
CABI	Commonwealth Agricultural Bureaux International
CD-ROM	Compact Disk Read Only Memory
CGIAR	Centres for Consultative Group on International Agriculture Research
CTA	The Technical Centre of Agriculture and Rural Cooperation
DVD	Digital Video Disc or Digital Versatile disk
FAO	United Nations Food and Agricultural Organization
ICIPE	International Centre for Insect Physiology and Ecology
ICRAF	World Agroforestry Centre
ICTs	Information and Communication Technologies
IPGRI	International Plant Genetic Research Institute
ITU	International Telecommunication Union
KARI	Kenya Agricultural Research Institute
KEFRI	Kenya Forestry Research Institute
KEPHIS	Kenya Plant Health Inspectorate Service
KETRI	Kenya Trypanosomiasis Research Institute
MoARD	Ministry of Agriculture and Rural Development
NAEP	National Agricultural Extension Policy

TEEAL	The Essential Electronic Agricultural Library
T&V	Training and Visits System of Extension
UNDP	United Nations Development Programme

GLOSSARY OF CONCEPTS

Agricultural information: published and unpublished knowledge in all aspects of agriculture.

Agricultural researchers: scientists working in agricultural research institutes such as the Kenya Agricultural Research Institute.

Agricultural Information Sub-systems: these comprises agricultural research system. extension service, farming systems and library and information services.

Communication: a process by which participants create and share information with one another in order to reach a mutual understanding.

Diffusion: from the word diffuse which means to spread out widely to reach a large area. A communication process by which a new idea or an innovation spreads among the members of a social system (or among defined social group).

Extension workers: personnel in the agricultural sector providing extension service. Their role is to disseminate agricultural knowledge and provide a link between agricultural researchers and farmers.

Information and Communication Technologies (ICTs): electronic means of capturing, processing, storing and communicating information. They are based on digital information and comprise computer hardware, software, communication links and networks. They also include intermediate technology, based largely on analogue information held as electro-magnetic waves such as radio, television, telephone and fax.

Innovation: an idea, practice, or object that is perceived as new by an individual or other unit of adoption.

Information Technology (IT) personnel: one who is working in information technology or computer section charged with responsibility of maintaining ICTs facilities.

Librarians: one who is responsible for acquiring. processing. organizing information resources and disseminating information to meet the needs of users.

Paradigm: is a scientific approach to some phenomena that provides model problems and solutions to a community of scholars. Recognition of a new paradigm such as that of

CHAPTER ONE

INTRODUCTION AND BACKGROUND OF THE STUDY

1.1 Conceptual setting

The majority of sub-Saharan African countries rely heavily on the agricultural sector as the mainstream for economic growth, employment creation and foreign exchange generation. In most of these countries, the agricultural sector employs about 70% of the labour force, accounts for 25% of their Gross Domestic Product (GDP) and 60% of their export earning (Economic Commission for Africa 1998:1, Aina 1999:96, Adimorah 1995:154, Kiplangat 2001:82). The sector is also the major contributor to national food security and a stimulant to the growth of off-farm employment.

According to a report by The Technical Centre for Tropical Agriculture and Rural Cooperation (CTA 2002:1), a number of sub-Saharan African countries are experiencing a slow agricultural development which, has not grown as fast as the population. The Report attributes this to a number of constraints that include inappropriate national agricultural policies, lack of adequate information provision, low adoption rate of appropriate technologies, and ineffective institutional frameworks. Aina (1999:97) has singled out inadequate information provision to policy makers, agricultural researchers, extension workers and farmers as a major hindrance to agricultural development. This view is supported by other studies and literature which identifies lack of relevant, reliable and comprehensive information as a major contributor to low agricultural productivity in most sub-Saharan African countries (Arokoyo 2003:1, Oryokot 2003:9, Ojiambo 1989:2, Economic Commission for Africa1998: 1).

Aina (1999:97) observes that in the absence of timely and relevant information, agricultural researchers, extension workers and farmers often find it difficult to make the right decisions. He is of the view that any factor that will improve agricultural production will occupy a prominent position in the hierarchy of priorities in Africa. Inadequate information support to all stakeholders in agricultural production is attributed to ineffective agricultural information systems (Richardson 2003:9, Ojiambo 1995:116, Munyua 2000:2).

There is need, therefore, to develop an effective and efficient agricultural knowledge and information system that provides relevant information to all actors involved in agricultural research and extension. Such a system can also facilitate the flow of agricultural information among the stakeholders.

Ojiambo (1995:110) asserts that agricultural technology transfer depends on a holistic agricultural information system that comprises a research subsystem, the extension subsystem, farmer's subsystem and information subsystem. He further observes that the flow of agricultural information among the subsystems can be efficient, if there is a good linkage and clear definition of responsibility for each of the subsystems. He is of the view that the role of research is to generate innovations, while extension service is responsible for disseminating these innovations to the farmers who are the end users. On the other hand, the farmers utilise this information and provide feedback on problems encountered in adopting agricultural technologies. Ndungu, Nkonge, and Rees (2000:2) add that farmers are also generators of indigenous knowledge. The libraries and information services constitute an information support system with the important role of acquiring, processing, repackaging and disseminating information to users. Without a clear delineation of functions of each of the subsystems there is a possibility of an overlap of functions affecting the flow of agricultural information (Arnon 1989:781).

The three subsystems of research, extension and farmers must work closely together. They must understand each other's problems. The research group must understand the dissemination methods used by extension workers, while the extension service must relate similarly to the farmers (Anholt & Zijp 2002:4). The ultimate goal of a good linkage between the three subsystems is for purposes of the effective flow of information. Extensive review of literature about agricultural development shows that there is a direct relationship between research and utilization of research findings (Toffelson 1999:5, Aina 1995:4, Evenson 1997:4, Ojiambo 1995:111, Crowder and Anderson 1996:1). Without a close link and feedback from the field, research becomes excessively academic and unrelated to farmers real problems.

1.1.1 Communication of agricultural information among agricultural researchers and extension workers

In recent years many countries in sub-Saharan Africa including Kenya have experienced decentralization of government structures and privatization of agricultural extension services which has increased the number of actors in the agricultural innovation process (CTA 2003:2). The linear information flows that dominated the traditional model of technology transfer from formal research system to the farmers by way of government-owned extension system are being replaced by pluralistic information flows between farmers as the demanders of service, and various providers of these services (Lightfoot 2003:2). This has profound implications on the information products and services required by the various actors, and on the capacities and skills that these actors need in order to bridge the communication gap for information sharing and exchange between the different actors in agricultural knowledge and information system (CTA 2003:2). Despite the changing paradigms in research and extension, agricultural researchers and extension workers remain the key actors in the provision of agricultural information and require a good linkage.

Crowder and Anderson (1996:1) point out that the weak linkages between agricultural research and extension systems have affected communication of agricultural information. Consequently causing major "bottlenecks" in national agricultural technology systems and limiting their effectiveness in contributing to agricultural development. They observe that structurally, research and extension are often compartmentalised in separate institutions, or even ministries, and have a history of functional specialization, which hampers the establishment of linkages. In many cases therefore, just as extension is often not well linked with knowledge bases, research is equally oblivious to the needs of farmers (Owino 1999:23). Kaniki (1995:21) observes that research has generally fielded better-educated staff and has tended to treat extension staff as inferiors rather than equals in a multiple faceted process. Crowder and Anderson (1996:2) further observe that extension and research have generally adopted a top-down discipline oriented approach rather than a farmer centred management approach. While extension and research have unique and different needs, their destinies are closely intertwined.

Crowder and Anderson (1996:2) advocate an integration of researchers, extension workers, educators, input suppliers and farmers in the agricultural innovation process. They observe that the common denominator among the participants is joining in agricultural knowledge and information system that draws on both modern science and the farmer's indigenous knowledge. This, they say, will improve a two-way flow of agricultural information and avoid the traditional "trickle down" flows of information from research to extension and from extension to farmers. This approach will shift attention to feedback and upward communication from farmers and to facilitate research-extension-farmer interaction. The agricultural researchers will be kept constantly aware of the technical, social, and economic problems encountered by the extension agents in their contacts with farmers (Anholt and Zijp 2002:2). The time lag between research findings and their adoption can also be reduced.

Anholt and Zijp (2002:4) underscore the potential of mass media and other forms of Information and Communication Technologies (ICTs) in supporting technology transfer among researchers, extension workers and farmers They observe that ICTs, have been used successfully in some developing countries such as Peru, Honduras, Indonesia, and Jordan to bridge the gap in research and extension. This, they say, provides clear evidence of ICTs potential in communication of agricultural information. CTA (2003:3) cautions that the potential of ICTs for improving information flows between and among actors involved in agricultural research and extension will vary greatly between different countries and regions. This is supported by Adeya (2001:5) who observes that sub-Saharan African countries are not homogenous in nature. Although there are some common factors, each country encounters unique social-economic problems and different level of infrastructure development.

1.1.2 Potential role of Information and Communication Technologies

The rapid development and use of Information and Communication Technologies (ICTs) has a direct and dramatic impact on all aspects of life. The traditional distinctions among media, publishing, telecommunication, computing and information services are becoming blurred, and new paradigms for creation, dissemination and exploitation of knowledge have evolved (UNESCO 1996:1). Ajayi (2002:2) remarks that, unprecedented capabilities of ICTs to process, store, refine and disseminate data, information and knowledge in a variety of ways across geographical boundaries has dramatically changed the ways in which individuals, governments, the public and private sectors operated all over the world. The emergence and convergence of ICTs, he concludes, has remained at the centre of global socio-economic transformation. Heeks (1999:2) asserts that hundreds of billions of dollars per year are spent on ICTs, reflecting a powerful global belief in the transformatory potential of these technologies. He points out that ICTs are proving to be formidable tools in addressing various development issues in a rapid and cost effective manner.

The terms Information Technology (IT) and Information Communication Technologies (ICTs) have been used interchangeably in many studies. Foster in Adeya (2001:3) defines IT as the group of technologies that are revolutionarizing the handling of information and embody a convergence of interest between electronics, computing and communication. The author is of the view that the concepts of ICTs and IT designate the information-processing interaction between providers and users of information and also development and application of information processing systems. Heeks (1999:2) has defined ICTs as electronic means of capturing, processing, storing, and communicating information. He categorised ICTs to include:

- Digital information held as 1s and 0s and comprises computer hardware, software and networks.
- Intermediate technology based largely on analogue information waves such as radio, television, and telephone.

The present study has adopted the use of the broader term 'ICTs'. Thus, the two categories of ICTs as identified by Heeks (1999) are the main focus of the study.

Heeks (1999) further states that in building up a model of ICTs, two separate elements are identified, the technology itself and information on which it operates. He observes that for processing of information to take place human intervention is necessary. ICTs comprehend technologies that can process different kinds of information (voice, video, audio, text, and data) and facilitate different forms of communications among humans and information systems, and among information systems (Chowdhurry 2000:3). These technologies can further be divided into capturing, storing, processing, sharing, display and protecting (Ngenge 2002:1).

Chowdhury (2000:4) has identified a cluster of ICTs to include world wide web, distributing computing, web enabled call centres, digital communications technologies (mobile telephones, satellites, wireless local loops, web enabled digital radio), speech recognition technologies, satellite imaging, geographical information systems and global positioning systems. There are also a plethora of vehicles and media for disseminating ICT applications, ranging from locally networked computers, the Internet, dial in services, cable satellite and other wireless modes, CD-ROM, DVD, and other information storage and delivery technologies (Economic Commission for Africa 2001:2). A combination of these technologies is breaking down organizational, national and international barriers.

ICTs are powerful enablers of development goals because of their unique characteristics of improving communication and exchange of information and strengthening and creating new economic and social networks (Accenture, Markle and UNDP 2001:1). ICTs foster the dissemination of information and knowledge by separating content from its physical location. This flow of information is largely impervious to geographic boundaries allowing remote communities to become integrated into global networks and making information, knowledge and culture accessible to anyone (Ajayi 2002:2).

ICTs power to store, retrieve, sort, filter and share information seamlessly can lead to substantial efficiency gains in production, distribution and markets. The increase in efficiency and subsequent reduction of costs brought by ICTs is leading to creation of new products, services and distribution channels within traditional industries as well as innovative business model (Accenture, Markle and UNDP 2001:1). ICTs, therefore, offer immense opprtunities to all societies and individuals for alternative, truly universal and often cheaper ways of accessing and disseminating information.

While ICTs have the potential to allow developing countries to participate more fully in the global economy, the danger is that countries that fail to use the technology to their advantage will fall further behind countries that do widening the gap between richer and poorer nations (Ajayi 2002:5). Zongo (2001:6) suggests that, the advancement of ICTs in Africa is both an opportunity to overcome inherent and historical disabilities in the economies of the region, and a challenge to ensure that these countries do not get left even further behind the developed world. He observes that ICTs present an opportunity to those who can respond to the new paradigm and a threat to those who cannot. He cautions that although the immediate returns of investment in ICTs may not be readily apparent, the long term positive impacts to social and economic development cannot be ignored.

Hodday in Pigato (2001:5) is of the view that ICTs represent a window of opportunity for developing countries to progress from a situation of 'zero' or limited technology to widespread adoption of sophisticated technologies, without going through the stages of technological adaptation and learning experienced in developed countries. In Africa this optimistic view is promoted by the African Information Society Initiative (AISI), which in 1996 proposed a 15-year program to provide connectivity and electronic access to information for all citizens of Africa (Zongo 2001:5, Ajayi 2002:8). The program is to be achieved through partnership arrangements between national governments and wide range of international development organizations. It recognizes that ICTs can bring wide ranging efficiency gains through free flow of information, improved delivery of public services and development of indigenous resource capacity to handle ICTs (Zongo 2001:5, Amoako 1996:6). Subsequently, many countries in Africa, Kenya included, have started the design and implementation of their National Information and Communication

Infrastructure (NICI). The NICI has its roots in the vision of AISI. The NICI provides the framework within which ICTs are mainstreamed into the national planning process in order to facilitate the achievement of national and sectoral development priorities and objectives (Soltane 2002:3). Several ICTs related projects are also taking place in most African countries and are initiated by international development agencies such as IDRC, World Bank, USAID, ITU (Jensen 1998:3 1999, Zongo 2001:18, Pigato 2001:45). However, most of the African countries are facing numerous challenges that hinder effective adoption of ICTs.

Adam and Wood (1999:307) in their research on impacts of ICTs in sub-Saharan Africa, established among others, the under-utilisation of existing technology due to the lack of awareness, underdeveloped legal framework for information sharing, infrastructure problems, poor connectivity to global networks, maintenance problems, weak research and development and high taxes. These problems and challenges affect most countries in sub-Saharan Africa including Kenya. There is need for sub-Saharan African countries to overcome some of these challenges if they are to harness meaningful digital dividends. Zongo (2001:14) identifies some of the areas to be addressed as including policies related to universal access and connectivity, frequency management and monitoring, technology standards, Internet and broadcasting and regional integration policies. Achievements of these initiatives will very much depend on concerted efforts by the governments, private sector and the donor community.

1.1.3 Information Communication Technologies and Agriculture

The potential role of ICTs to transform development is now receiving greatest attention world-wide and is being integrated into every sector of the economy (Ajayi 2002:1, Heeks 1999:3). Agricultural research and extension, which depends to a large extent on information exchange between and among farmers, on one hand, and a broad range of actors, on the other hand, has been identified as one area in which ICTs have had a particular significant impact (CTA 2003:2). They have presented a new dimension to agriculture, enabling effective and efficient transfer and access to scientific, technical and market information which were previously difficult and often expensive to obtain (Aina

1998:97).

Zijp in Kiplang'at (1999:117) observes that ICTs offer tremendous capabilities to the agricultural sector in terms of vast information storage, fast and inexpensive communication channels, links between different media, easy and enjoyable use at comparatively low and steadily declining costs. These capabilities can facilitate the flow of agricultural information among agricultural researchers, extension workers and farmers. ICTs have the potential of ensuring that knowledge and information on important technologies and practices reaches the farmer (Godake 2001:85, Munyua 2000:1). Munyua (2000:2) adds that knowledge and information are the basic ingredients of food security and are essential in facilitating rural development and bringing social and economic change.

Chowdhury (2001:15) recognizes that ICTs have brought many challenges as well as opportunities to the agricultural sector. He points out that application of ICTs has enabled precision agriculture (farming) to be practised in the developed world. He observes that this mode of agriculture uses technologies and techniques such as geographic information systems (GIS), grid soil sampling, spatially matched variable rate fertilizer use, and yield maps controlled by global positioning systems (GPS) to adjust inputs to specific conditions within each area of a field. He argues that ICTs have made great contribution to sustainable development of agriculture and have even greater impetus for future agricultural development.

Conventional communication channels that include radio, video and television have been used successfully in Africa to communicate agricultural information, but these have been monologue and have not allowed for much interaction with users (Munyua 2000:2). Investment in new ICTs such as the Internet and email can complement conventional delivery systems. Several initiatives are now being undertaken to see how conventional communication channels can be integrated with new ICTs in communication of agricultural information. An example of these initiatives includes a project by the

International Service for National Agricultural Research (ISNAR) on Linking Agricultural Research and Rural Radio (Odame and Kassim 2002). Partners in this project include FAO, University of Guelph, Canada, and Developing Countries Farm Radio Network (DCFRIN). The project involved two types of partner organizations-national agricultural research centres and rural radio stations conducting farm broadcasting in local languages. African countries participating include Ghana, Cameroon, Uganda and Mali. The main focus of the project is on innovation on rural radio in using digital technology and integration with new ICTs (Atibila and Odame 2003) .Similar projects are taking place in Africa, Pacific and Caribbean countries (ACP) initiated by The Technical Centre for Tropical Agriculture and Rural Cooperation (CTA) based in Wageningen, the Netherlands.

Integration of the mobile phone and the Internet also offer tremendous capabilities in communicating agricultural information. An example of such a project is Manobi developed in Senegal to provide multi-channel business information to farmers, exporters, fishermen, middlemen and women (Annerose 2003:3). The project provides a true convergence between the mobile network and Internet to provide access and exchange business and strategic data. A similar project called DrumNet has been developed in Kenya to provide marketing and financial information services to agricultural entrepreneurs in the rural areas through simple, stand alone facilities called info-kiosks (Groh 2003:3). Each info-kiosk is equipped with a computer with dial-up connection to the Internet and a mobile phone (GSM) to link up with the central hub stationed in capital city Nairobi. The project has proved beneficial to farmers who can now sell their produce without passing through middlemen (Groh 2003:3). These projects exemplify integration of variety of ICTs to enhance communication of agricultural information among actors involved in research and extension.

Other areas where ICTs could play a catalytic role in increasing agricultural development include:

- Decision making process – Sound decision making is dependent upon availability of comprehensive, timely and up-to-date information. E-mail and the Internet could be used to transmit agricultural information to researchers and extension workers.
- Market outlook – Farmers with the help of extension workers could promote their products and handle simple transactions such as orders over the web while payment transactions for the goods can be handled off-line (O'Farrell 1999:4)
- Different forms of ICTs and media combinations may, however, be used in different cases. This includes use of the radio, television, audiocassettes, tele-conferencing, computer programmes, CD-ROM and the Internet (Munyua 2000:2).
- Creating employment – through the establishment of multipurpose telecentres, ICTs can create employment opportunities by engaging tele-centres managers, subject matter specialists, information managers, translators, information technology technicians (Oryokot 2003:2).

The present study is based on the premise that there is great potential for ICTs in the agricultural sector in Kenya. This will depend very much on the creation of an enabling environment that can promote adoption and diffusion of ICTs in the agricultural sector in Kenya. ICTs have the potential of strengthening the weak linkages among agricultural researchers, extension workers, and farmers and also with other actors such as NGOs, CBOs, agro-chemical industries, stockist and traders. Thus facilitating communication of agricultural information and enabling efficient transfer of new technologies to farmers who may utilise this knowledge for better agricultural productivity.

1.2 Contextual Setting

Kenya's economy is heavily dependent on the agricultural sector that also provides the basis for the development of the other sectors (Kenya, Republic of. National Development Plan 2002:23). Its direct contribution to Gross Domestic Product (GDP) is 25% and indirectly contributes a further 27% through linkages with agro-based and associated industries (KARI 2002:1). The sector employs about 75% of the total labour force, generates 60% of export earnings, and provides 75% of industrial raw materials and 45% of Government revenue (KARI 2002:1). About 80% of Kenya's population live in the rural areas and are engaged in agricultural activities. The majority of this population are smallholder farmers who account for 75% of the total agricultural output in the country (KARI 2002:1). In addition to its role in the national economy, the agricultural sector is also key to the livelihood of many Kenyans in food security and nutritional balance (KARI 2000:6). It suffices to say, therefore, that agriculture remains the engine of the national economy and its performance in any one year impacts heavily on nearly all other sectors.

Although there has been a significant investment in agricultural research and extension in the country, unfortunately like in most sub-Saharan African countries, there is declining agricultural production, rising poverty levels and increased natural resource degradation (Kenya, Republic of, Economic Survey 2000:75). In the decade following independence (1963-1972) agricultural growth in Kenya accelerated to an average of 4.6 per cent per annum. During the 1980's and early 1990's, the average annual growth fell to 2.2 per cent. In the period 1990 to the year 2000 the average annual growth rate fell to negative 1.4 per cent. The decline subsequently affected the Gross Domestic Product (GDP) in the agricultural sector which declined from 37% in the 1970s to 25% in 1998 (Kenya, Republic of, Ministry of Agriculture 1998:2). The factors that have hampered agriculture's full potential in the country include decreasing farm sizes, inadequate use of appropriate technology due to lack of information, unreliable rainfall, poor marketing infrastructure, limited access to credit and market information, high costs of farm inputs, and poor Early Warning Systems (Kenya, Republic of, National Development Plan 2002:23).

The decline has been a major concern to the Kenyan Government as the agricultural sector is the backbone of the economy. One of the major reasons adduced for the low agricultural productivity in the country is the lack of adequate information support to all the stakeholders in agricultural production. Factors that may have contributed to inadequate information support include the lack of appropriate agricultural information systems and services, the lack of appreciation of the role of timely and relevant information, and ineffective linkages among agricultural researchers, extension workers, farmers and other actors in research and extension (Kenya, Republic of, Ministry of Agriculture 1997:2).

In an effort to rectify this anomaly, the Kenya Government through the Ministry of Agriculture, commissioned a study to look into the deficits of the existing "information landscape" in the agricultural sector and suggest strategies for improving the situation (Kenya, Republic of, Ministry of Agriculture 1998:1). The Government voiced its concern by noting that although Kenya had accumulated a significant amount of agricultural data and information relative to other countries of sub-Saharan Africa, information on the agricultural sector was poorly coordinated and managed. This was partly because there were no systematic procedures for information collection, analysis, storage and dissemination, and partly because each development agency collects its own data with little or no co-ordination with the rest (Kenya, Republic of, Ministry of Agriculture 1998:2). A consortium of two Kenyan consulting firms (AITEC Consultancy Services and Wachira Irungu & Associates) was commissioned to undertake the study through the financial assistance of the Germany Development Co-operation (GTZ). The Commission assessed the information requirements needed for effective and efficient agricultural information system and suggested information management options to improve the situation. It recommended the establishment of an Information Management Division in the Ministry of Agriculture, which should be linked to the provincial and district agricultural offices. It also strongly recommended the adoption and use of ICTs in the acquisition, storage and dissemination of agricultural information (Kenya, Republic of, Ministry of Agriculture 1998:26). This was expected to improve communication of agricultural information and facilitate the transfer of new technologies to farmers. The ultimate goal is to improve agricultural productivity in the country.

Of particular significance to this study are the Kenya Agricultural Research Institute (KARI) and the Ministry of Agriculture and Rural Development (MoARD). KARI is the national agricultural research institute established in 1979 under the Science and

Technology Act. The mission of KARI is to develop and disseminate appropriate agricultural technologies to the farming community in collaboration with other stakeholders (KARI 2003:6). It further contributes to the sustainable improvement in the livelihoods of Kenyans by increasing agricultural productivity, post- harvest value of crop and livestock products, and conserving the environment (Kiome, 2001:2). To achieve its mission and objectives, KARI has established 15 national centres, 6 regional centres, and 12 sub centres strategically spread throughout the country to cater for different agro-ecological zones and socio-economic systems. The centres are assigned mandates and responsibilities according to research priorities and ecological diversity. The national research centres are the principal research organs for generating and testing improved components of technologies for improving national agricultural productivity. Each national centre has one or more multidisciplinary teams consisting of breeders, agronomists, pathologists, entomologists etc., related to the size and importance of the research problems to be addressed. Each centre has been given a clearly defined mandate and has a role in liaising with extra territorial and global research in mandate. Regional centres, on the other hand, focus on the identification and diagnosis of production problems in their agro-ecological zones, and adapting technologies for increasing production at the farm level. The research sub-centres are managed by the various regional and national research centres and assist in meeting the needs of research with mandate area (KARI 2003:7).

The Ministry of Agriculture and Rural Development (MoARD) is responsible for agriculture and livestock productivity in the country. The broad objective of the ministry is to contribute towards: 1) attainment and maintenance of domestic supply of food; 2) production of raw materials; 3) creation of gainful employment and increases in incomes of those involved in production; and 4) conservation of natural resources (KARI 2002:1). To achieve the objectives, the ministry has created eight divisions to coordinate various activities (Kenya. Republic of. Ministry of agriculture 1997:103). Among the divisions are the Planning and Information Services and the National Agricultural Extension Divisions. The establishment of the Planning and Information Services Division exemplifies the Government concern of the role information plays in agricultural production. The National Agricultural Extension Services (NAES) coordinates extension activities in the public agricultural sector in the country. KARI and NAES have developed a means of interfacing, so as to ensure that a two-way information flow between the farmers, extension workers and researchers actually occurs. This is yet to be realised and has been the focus of concern to the government and agricultural stakeholders (Kenya. Republic of. Ministry of Agriculture. National Agricultural Extension 2001: xi).

Given the declining agricultural production and rising levels of poverty and food insecurity, KARI as the main agricultural body in Kenya, has been under increasing pressure to demonstrate the relevance of its research products and their potential impact. KARI on its part identified the lack of relevant information in planning, managing and undertaking research as major contributor to low agricultural productivity (Kiome, 2001:2). It became clear that whereas KARI was generating useful information and technologies that were beneficial to diverse users within and outside the institute, there was no organised mechanism of packaging, storing and disseminating this information, particularly since the extension services within the Ministry of Agriculture was experiencing funding problems over the recent past (KARI 2002:46). KARI scientists were also not receiving adequate support in terms of accessing reference materials, including scientific journals and databases relevant to their programmes (KARI 2002:46). Consequently, an Information and Documentation Services Division (IDS) was, therefore, established by the end of 1990s. To effectively address the information issues that concerned the institute, IDS has three units, namely, Information Technology Unit (ITU); Library and Information Services Unit (LIS); and Publications Unit (PU).

With the hope of improving agricultural information flow and be in tune with current developments in the information age, KARI has taken the initiative of adopting ICTs in the management of agricultural information. The Information Technology Unit is responsible for ensuring effective electronic networking, as well as management of computer software and hardware throughout KARI. Computers with modems have been installed in all 21 KARI research centres to facilitate accessibility and communication of agricultural information among agricultural researchers, extension workers and other actors involved in research and extension (KARI 2002:46). Agricultural researchers also access electronic sources through the libraries in their respective centres. ICTs are expected to strengthen existing information systems and networks and enhance the linkages among agricultural researchers and extension workers in particular. They are also expected to provide an efficient and effective flow of agricultural information among and between KARI research centres.

1.3 The Statement of the Problem

Kenya's economic growth is directly related to the growth in the agricultural sector. It is, therefore, imperative to maintain a certain level of development in the agricultural sector to ensure not only food security but also people's livelihoods (Kiome, 2002:1). This development will very much depend on the quality of information disseminated from agricultural research through the extension system to the farming community. Unfortunately, information exchange and dissemination remain a serious constraint on the agricultural production potential in the country. Most of the dissemination approaches used in the past provided linear information flows and failed to provide feedback from the farmers. As a result they had minimal impact at the farm level. In addition, information generated from current research on improved production technologies, have remained 'locked up', for long periods, from farmers who might benefit from it (Owino, 1999:23). The research system has been blamed for just conducting research, producing useful scientific results and publishing but not going further to package these results into digestible products for the farmers. The extension system, on the other hand, is said to be ineffective in disseminating agricultural information to farmers. It is argued further that extension service must be reoriented to transform and modernize agricultural production from subsistence small holder farming to commercial, profit oriented undertakings (Kenya. Ministry of Agriculture, National Agricultural Extension Policy 2001: ix). Therefore research and extension are usually divorced from the farmer.

The rapid development and applications of the Internet and other forms of ICTs in the Kenyan agricultural sector have presented a whole new dimension in the transfer and access of agricultural information, which previously was difficult and expensive to obtain. It is expected that these technologies will improve communication and provision of agricultural information among agricultural researchers, extension workers and other actors involved in research and extension. The free flow of information is expected to facilitate the adoption of agricultural technologies ultimately improving agricultural productivity in the country. However, it should be noted that for ICTs to improve the provision of agricultural information other inputs and/or conditions are necessary such as skill development, policy and regulatory framework, and conducive infrastructure.

This study was conceived with the aim of mapping and auditing ICTs in the public agricultural sector in Kenya to establish the nature, types, and distribution of ICTs. It sought to find out the extent to which ICTs are used in communication of agricultural information among agricultural researchers and extension workers and whether ICTs had improved their linkage. It assessed the demand and use of ICTs by agricultural researchers and extension workers in their knowledge acquisition and dissemination process. It examined government and institutional ICT policies and their effect on diffusion of ICTs in the agricultural sector. The study investigated funding, maintenance and sustainability of ICTs in the agricultural sector. It established the knowledge gaps, constraints and challenges encountered in harnessing ICTs in the agricultural sector. Finally it suggests and recommends measures to be taken into account in improving diffusion of ICTs in the agricultural sector. The data obtained provided empirical evidence of the actual experience and effects of ICTs upon agricultural researchers and extension workers with particular reference to information sharing and exchange.

1.4 Motivation of the study

The researcher's interest in the subject of agricultural information management and ICTs came as a result of many years of involvement in the dissemination of agricultural information. The career of the researcher started in the Ministry of Agriculture in Kenya where he worked at the seed quality control services before moving to the library of the ministry. He later worked as a reference librarian in one of the agricultural universities in Kenya. Currently he is a lecturer in the faculty of information sciences at Moi University in Kenya, where he is coordinating and teaching a course on agricultural information resources, systems and services. The researcher has also attended several conferences, workshops, and seminars on ICTs and agricultural information. Participants in these conferences and workshops have often shared knowledge on the use of ICTs in the agricultural sector of many countries. During such forums the researcher has felt inadequate to comment about Kenya as there is no documented information indicating the application and use of ICTs in communication of agricultural information in the country. He has strongly felt the need to conduct a study to establish the nature, types and distribution of ICTs and how they have enhanced communication of agricultural information among agricultural researchers and extension workers in Kenya. The findings are expected to be beneficial to all stakeholders in the agricultural sector in the country.

The researcher has published in the subject area and is involved in projects in collaboration with IDRC, IICD and CTA on ICTs, agriculture and gender.

1.5 Aim of the study

The aim of the study was to establish the nature, types and distribution of ICTs in the agricultural sector in Kenya and assess the extent to which they were used in the communication of agricultural information among agricultural researchers and extension workers.

1.6 Objectives of the study

The broad aim of the study was addressed by the following specific objectives:

1. Mapping and auditing of ICTs in the agricultural sector in Kenya, to establish their nature, types and distribution and motivation behind the adoption.
2. Explore government and institutional ICT policies and their effect on adoption and diffusion of ICTs in the agricultural sector in Kenya.

3. Examine the information literacy programmes available in the institutions surveyed and how such programmes contribute towards use of ICTs among agricultural researchers and extension workers.
4. Investigate the extent to which information needs of agricultural researchers and extension workers are met through ICTs.
5. Assess the demand and use of ICTs by agricultural researchers and extension workers in their knowledge acquisition and knowledge dissemination process.
6. Investigate the impact of ICTs use on communication of agricultural information among agricultural researchers and extension workers in the agricultural sector.
7. Establish knowledge gaps, drawbacks, and limitations that hinder effective use of ICTs by agricultural researchers and extension workers.
8. Assess the funding, maintenance and sustainability of ICTs in the agricultural sector in Kenya.
9. Establish the constraints and challenges encountered in diffusion of ICTs in the agricultural sector in Kenya.
10. Suggest and recommend measures to be taken into account in improving diffusion and use of ICTs in the agricultural sector in Kenya.

1.7 Research questions

In order to realise the objectives of the study the following research questions were addressed:

1. What are the nature, types and distribution of ICTs in the agricultural sector in Kenya? What motivation is behind ICTs application and use in the agricultural sector?
2. Are there government and institutional ICT policies in Kenya? If so, what are there effects on adoption and diffusion of ICTs in the agricultural sector?
3. What information literacy programmes exist in the institutions surveyed and how do they contribute to use of ICTs among agricultural researchers and extension workers?
4. To what extent are the information needs of agricultural researchers and extension workers being met through ICTs?

5. To what extent are ICTs used by agricultural researchers and extension workers in their research and extension activities? How have ICTs affected the productivity and creativity of agricultural researchers and extension workers?
6. What is the impact of ICTs on communication of agricultural information among agricultural researchers and extension workers?
7. What knowledge gaps and drawbacks impede agricultural researchers and extension workers from effectively exploiting ICTs potential?
8. How is the funding, maintenance and sustainability of ICTs in the agricultural sector in Kenya?
9. What constraints and challenges are encountered in diffusion of ICTs in the agricultural sector in Kenya?
10. What measures should be taken into account to ensure that there is effective diffusion of ICTs in the agricultural sector in Kenya and that agricultural researchers and extension workers are served most effectively by these ICTs?

1.8 Assumptions of the study

Assumptions are guesses, expectations, or suppositions that the researcher makes as a prelude to the study (Mgenda and Mgenda 1999:28). They are facts that a researcher takes to be true without actually verifying them. They are values and beliefs held by the researcher about the findings from other studies (Ikoja-Odongo 2002: 18). They help in shaping the direction that the current research takes and are usually required for data analysis and conclusions. This study was based on the following assumptions:

1. The conventional agricultural information systems have been ineffective in communicating agricultural information among agricultural researchers and extension workers.
2. There is potential for significant use of ICTs by agricultural researchers and extension workers in their research and extension activities.
3. Constraints, including poor telecommunication infrastructure especially in the rural areas of Kenya have hindered diffusion of ICTs in the agricultural sector.

1.9 Significance of the study

Although the agricultural sector in Kenya is the mainstay of the national economy, it is undergoing changes that are posing challenges on its organization and role in future. First is the structural adjustment programme that has rapidly reduced the role of the government in regulation of domestic markets and provision of services. Secondly is the impact of the on-going globalisation of economies on the sector which is introducing new products into the markets. Consequently stimulating consumer demand and increasing opportunities for adding value to existing products. The impact of globalisation and liberalization on Kenya's agricultural sector will, therefore, depend heavily on the policy environment and the degree of technological preparedness of the sector as a whole to face the challenges. It will also depend very much on the availability and accessibility of market and technological information to all actors involved in research and extension. Thirdly, is the decline of agricultural production which has also affected the economic growth of the country. The major cause of the decline has been identified as inadequate information support to all actors involved in agricultural research and extension.

The Kenyan government is greatly concerned about the decline and the impending changes in the agricultural sector and consequently has instituted various measures to address the issues. It has implemented policies to address globalisation and liberalization and has also adopted the use of ICTs to facilitate free flow of information among agricultural researchers, extension workers, farmers and other actors in research and extension. However, it is observed that there is no documented information showing the nature, types and distribution of ICTs in the public agricultural sector and the extent to which they are used in the communication of agricultural information. The present study was, therefore, expected to establish the nature, types and distribution of ICTs and show the extent to which they are used in communication of agricultural information among agricultural researchers and extension workers. This information is useful for planning and managing the adoption and use of ICTs in the agricultural sector and would be beneficial to policy makers, planners, Director-Government Information Technology, donor community, stakeholders in the agricultural sector and actors involved in research and extension amongst others.

Secondly, it was expected that the existing knowledge gaps, constraints and challenges encountered in harnessing ICTs in the agricultural sector will be identified. It was further envisaged that critical factors necessary for successful diffusion of ICTs in the agricultural sector were to be established. Thirdly, the study was to suggest and recommend practical measures to address the shortcomings and subsequently improve the diffusion of ICTs in the agricultural sector. This information will be useful and can form the baseline or benchmark for any ICT initiative project in the country and will be useful for planning purposes. It will be beneficial to policy makers, planners, IT personnel, and all stakeholders in the agricultural sector in the country.

The study was to reveal new dimensions requiring further research on the topic. This information will provide ground for scholars and researchers to conduct further research in the area. Finally the completed study is expected to be a useful reference tool for scholars, researchers and other interested parties.

1.10 Scope and limitation of the study

1.10.1 Scope and coverage

Due to the diverse and enormous nature of the agricultural sector in Kenya, the study covered only the public agricultural sector. The private sector did not form part of the study as its contribution to research and extension in the country is minimal. Although the government is in the process of privatizing agricultural research and extension, these services are still largely the responsibility of the government through the Kenya Agricultural Research Institute and the Ministry of Agriculture and Rural Development.

The study, therefore, covered all the 21 main KARI research centres strategically spread throughout the country to cater for different agro-ecological zones and socio-economic systems. This ensured that the centres exhibited a broad ecological diversity and different levels of infrastructural development in the country. In addition, KARI headquarters was included for purposes of interviewing the top management staff and coordinators of research programmes. The study also covered the Ministry of Agriculture and Rural Development (MoARD). The MoARD have provincial and district agricultural offices distributed across the country. The study selected one province and clustered it into two regions, the high and medium agricultural potential areas and arid and semi-arid areas. One district was picked from each of the regions. The Uasin Gishu district represented high and medium agricultural potential areas, while Baringo district represented arid and semi-arid areas. The two districts also depicted different levels of communication infrastructure, and had densely as well as sparsely population. This disparity provided the basis for comparing diffusion of ICTs in the two districts. The MoARD headquarters and the Agricultural Information Centre (AIC) also formed part of the study.

1.10.2 Sample limitation

The respondents who included agricultural researchers, extension workers and key informants were drawn from the public agricultural sector in the aforementioned area of study. As already explained the public service is the single largest employer of agricultural researchers and extension workers. The private sector and international organizations deal with agricultural research but not extension. Most of them are also concentrated in the capital city Nairobi and are yet to have an impact in the rural areas. The constraints of time and money also limited investigating all agricultural researchers and extension workers in the institutions surveyed. A representative sample of 50% was, therefore, used. While agricultural researchers were drawn from the 21 main KARI research centres, extension workers were drawn from the Uasin Gishu and Baringo districts. The informants of the study were drawn from all the institutions surveyed. Conclusions and generalizations of this study will, therefore, only apply to population in the public agricultural sector.

1.11 Dissemination of Findings

According to Ocholla (1999:141) possession of information without dissemination is useless and that research is not complete until it is disseminated. The findings of this study will be disseminated to the Ministry of Agriculture and the Kenya Agricultural Research Institute at their annual conference scheduled for November 2004. Copies of the thesis will also be made available to the two institutions. The findings will also be disseminated through seminars, conferences and workshops such as those organised by the agricultural stakeholders and any other forum where the researcher will be invited. In order to reach a wider audience, the findings will hopefully be published in refereed journals.

1.12 Structure of the thesis

Preliminaries

Chapter one Introduction and background of the study

The chapter covers the introduction and background to the study. It gives the conceptual and contextual setting of the study, aims, objectives and research questions, scope and limitation of the study and its significance.

Chapter two: Agricultural knowledge and information systems in Kenya

This chapter discusses the state-of-the art of agricultural knowledge and information systems in Kenya which comprised research, extension , farming and libraries and information systems.

Chapter three: Theoretical Framework of the study

Chapter three discusses Rogers's diffusion of innovation theory and how it is applied in the study.

Chapter four: Literature Review

The chapter reviews literature related to the study drawn from both print and electronic sources. This is done in line with the objectives of the study.

Chapter five: Research methodology

The chapter covers the research methodology and design of the study. It discusses the survey research method, the qualitative and quantitative approaches used, the study population, the sampling methods used, and data collection instruments used. The data collection procedures and analysis are also discussed.

Chapter six: Presentation and analysis of findings

The chapter presents and analyses data obtained through questionnaires from agricultural researchers and extension workers. It also analyses data obtained through interviews with key informants of the study.

Chapter seven: Discussions of the findings

The chapter discusses the findings by collating and comparing results from chapter six which looked at responses from agricultural researchers and extension workers and also from the key informants. Information obtained from observation and document review is also included in the discussions.

Chapter eight: Summary, conclusions and recommendations

This last chapter provides the summary, conclusions recommendations based on the findings of the study. Suggestions for further research are also given.

References

Appendices

1.13 Summary

This chapter has covered the conceptual and contextual setting in which the background information on agriculture and ICTs have been discussed. The importance of the agricultural sector to the Kenyan economy has been discussed in detail indicating its contribution to GDP, employment and foreign exchange. It is noted that agricultural production in the country is declining due to a number of constraints which include inadequate information support to actors involved in research and extension. To improve the situation, there is need for an effective and efficient agricultural information system to enhance pluralistic information flows among and between the actors. It is noted that ICTs have been adopted to improve the information flow but empirical evidence is lacking on the nature, types and distribution of these ICTs and the extent to which they are used in communicating agricultural information. The chapter has also discussed the statement of the problem; motivation of the study; aim, objectives and research questions of the study; significance of the study; scope and limitations of the study. The dissemination of findings and the structure of the thesis are also provided.

The next chapter looks at the agricultural knowledge and information systems in Kenya.

CHAPTER TWO

AGRICULTURE KNOWLEDGE AND INFORMATION SYSTEMS IN KENYA

2.1 Introduction

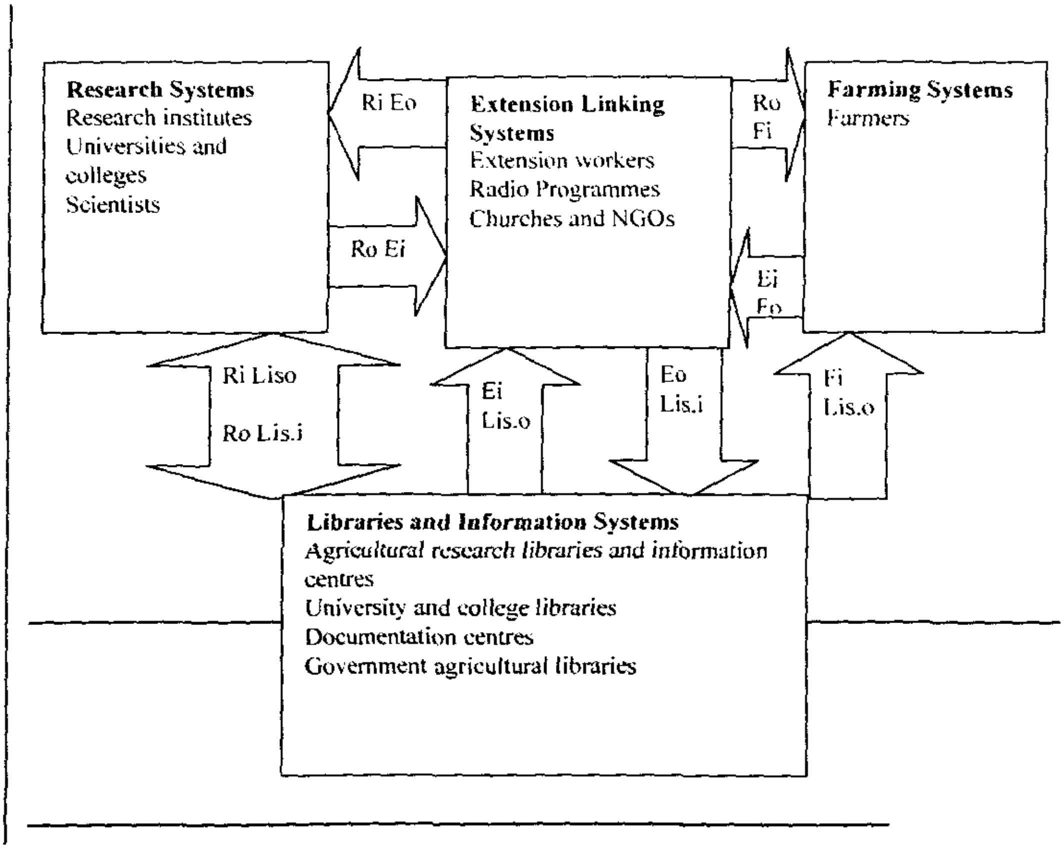
This chapter describes the Agricultural Knowledge and Information Systems (AKIS) in Kenya. The purpose is to provide background information and to show how these systems are linked up. The roles and functions of these systems are discussed in relation to dissemination of agricultural information. The chapter also highlights some of the ICTs adopted in the dissemination of agricultural information among agricultural researchers, extension workers and other actors involved in research and extension. Implications of these systems and services to access and use of information by agricultural researchers and extension workers is also discussed. A summary of the chapter has also been given.

In the Sessional Paper No. 2 of 1994 on National Food Policy, the Kenya Government states that there is need for the Ministry of Agriculture and Rural Development (MoARD) and the Kenya Agricultural Research Institute (KARI) to strengthen their collaboration at all levels. The government pointed out that such collaboration will facilitate the free flow of agricultural information among researchers, extension workers and farmers. In this way, relevant technological packages will ultimately reach the farmers. In the National Development Plan of 2002-2008 (p. 23), the Kenya Government further observed that agriculture's full potential had been hampered by lack of relevant information pertaining to use of appropriate technology, access to credit and market outlets for farm products. The government reiterated the need for stronger linkages among all the agricultural knowledge and information systems (AKIS). AKIS has been defined as a set of agricultural institutions/organizations, persons and linkages engaged in generation, transformation, storage, transmission, retrieval, regulation, and utilisation of agricultural knowledge and information (Kenya, Republic of, MoARD, National Agricultural Extension Policy 2001:2). The purpose is to work synergically to support opinion formation, decision making, problem solving and innovation in agricultural sector. Such a strong linkage will enhance development of sustainable technologies and dissemination of knowledge and information in a rapidly changing environment.

According to Ojiambo (1995:110), agricultural knowledge and information system in Kenya comprises four sub-systems namely: research, extension, information services and farming systems. He has categorised researchers as knowledge and information generators as well as consumers of information, while extension workers are described as both knowledge and information communicators as well as consumers of information. Library and information services constitute an information support system with the important role of acquiring, processing, repackaging and disseminating information to users. The weak linkages among the four subsystems impede the free flow of information within the systems. To achieve effective communication and free flow of agricultural information, the four subsystems must be integrated as illustrated in Fig 1.

Figure 1

Agricultural researchers, extension workers, Farmers and Library/Information Communication Systems



Source: Adapted and modified from Ojiambo (1995:111).

Ri = Research input (from extension workers, farmers and librarians)

Ro = Research output (research findings to extension workers farmers and libraries)

Eo = Extension output (feedback of farmers needs, problems and written reports)

Ei = Extension input (information and knowledge obtained from research scientists and library and information services)

Fi = Farmers input (adoption of innovations for improved farming)

Lis.o = library and information services output (dissemination of information to research scientists, extension workers and farmers)

Lis.i = Library and Information Services input (research findings from research scientists and reports from extension workers.

2.2 Agricultural Research System

The main purpose of agricultural research is to develop new or improved products and technologies, which add value to existing ones and are of significant benefit to the end user (KARI 2000:9). It is the source of knowledge and innovations that drive current and future agricultural development (KARI 2002:viii). Agricultural research is described as the interrelationship between plants (or animals) and soils and climates, chemistry and biochemistry, physics, geology and meteorology (Arnon 1989: 315). The mission is to apply a wide variety of scientific disciplines to the development of new approaches to agricultural production, and provide solution to the problems besetting the farmer (Ojiambo 1989:22). Its objective is to increase agricultural productivity in terms of yields, quality, profitability and sustainability of enterprises (KARI 2002:viii). Agricultural research can be seen to mobilise, assess, generate, transform, interpret, adapt and disseminate agricultural information which can help and contribute in realising agricultural development (Godake 2001:85). For agricultural researchers to be effective in their work, they need to possess the necessary qualifications and experience.

The agricultural research subsystem in Kenya comprises the public and private institutions. Public agricultural research is undertaken by the Kenya Agricultural Research Institute (KARI) which has 21 main research centres located in different agro-ecological zones of the country. Other major research institutions undertaking public agricultural research include the Kenya Plant Health Inspectorate Service (KEPHIS), the Kenya Forestry Research Institute (KEFRI), the Coffee Research Foundation, the Kenya Trypanosomiasis Research Institute (KETRI), the Tea Research Foundation, and the Pyrethrum Board of Kenya. Public agricultural research is also undertaken by public universities namely: the University of Nairobi at the College of Agriculture and Veterinary Sciences, Egerton University, Jomo Kenyatta University of Agriculture and Technology, and Moi University-Chepkoilel Campus. Colleges include Bukura Agricultural College, Kilifi Institute of Agriculture, Animal Health and Industry Training Institutes (AHITI) at Kabete, Ndomba and Nyahururu, Dairy Training School at Naivasha.

Private national and international research institutes/organizations also conduct research in specialised fields for their own purposes. Examples of private international agricultural research institutes in Kenya include among others:

- World Agroforestry Centre (ICRAF)
- International Livestock Research Institute (ILRI)
- Commonwealth Agricultural Bureaux International (CABI) (African Regional Office)
- International Centre for Insect Physiology and Ecology (ICIPE)
- International Plant Genetic Research Institute (IPGRI)

Public and private research organizations have their own libraries and documentation centres that support research activities by providing relevant information.

Despite the long history of research in Kenya, agricultural research continues to suffer from poor management; inadequate funding; manpower instability; limited research-extension-farmer linkages; weak monitoring and evaluation and lack of policy for biotechnology development and use (Kenya, Republic of, National Development Plan 2002-2008:38). However, the positive aspect in public agricultural research is that both KARI and Agricultural Extension Service Division are now under the ministry of agriculture unlike in the past when the two were in different ministries. With the privatization of agricultural research and extension service, and with pluralism in the service delivery, linkages of research and extension will be significantly affected (Kenya, Republic of, MoARD, National Agricultural Extension Policy 2001:12). For this reason, it is important that deliberate efforts be taken to strengthen these linkages. Moreover, the farmer must be part of the linkages so that it is actually 'Farmer-research-extension' linkages that are strengthened than the links between research and extension per se. For the linkages to be effective there must be free flow of information that addresses the needs of each of the actors within each of the subsystems. The actors include researchers, extension workers, farmers and other stakeholders.

Information needs of agricultural researchers are diverse as the nature of their work (Ojiambo 1995:119). These needs range from basic awareness about the existence of facts and analytical level of the subject. These may include situations where researchers have to make a choice among different types of soils suitable for particular crops; the analysis and prediction of yields and the forecasting of climatic and weather patterns (Kaniki 1995:25). Researchers may also require information to make decisions on an issue that they have little information about. Kaniki (1995:25) sums it up by pointing out that researchers need information about 'who', 'what', 'where', 'when' and 'how' of different aspects of their work. Effective agricultural information systems and services should, therefore, be put in place to provide timely, relevant and comprehensive information to agricultural researchers.

A number of studies conducted in Kenya show that research scientists rely heavily on scientific literature both print and electronic for their research work (Ayoo 2001, Ojiambo 1995). If they have to keep abreast of new developments in their fields, they need to have access to good libraries and documentation services. Such libraries and information centres must provide well-tailored services to their clients. This can only be achieved by employing competent and knowledgeable information professional staff. Studies such as this one and others (Ayoo 2001, Costa and Meadows 1999) indicate that researchers use mostly electronic resources and services provided via the Internet, CD-ROM databases and other communication systems. Costa and Meadows (1999:1) adds that significant impact of use of ICTs is the increase in democratisation of the international research community. Libraries and documentation centres should therefore adopt appropriate ICTs geared towards meeting the information needs of their clients.

In Kenya, the concern has been on research findings not reaching especially the majority of small holder farmer. In improving the situation KARI and other research institutions have adopted adaptive research and participatory approaches where farmers are involved and are made to feel that they own the research (KARI 2002:27). In June 2000 KARI initiated the Agricultural Technology and Information Response Initiative (ATIRI) in 9 research centres namely, Naivasha, Kitale, Lanet, Katumani, Njoro, Embu, Kakamega, Kisii and Mtwapa (KARI 2000:6). The ATIRI project aims at empowering farmers to demand agricultural technologies from service providers. The project's main goal is to work with partners to meet farmers' information and technology demands. The purpose of this initiative is to catalyse the dissemination process by instituting a paradigm shift from the 'supply model' to a 'demand model' (KARI 2001:5).

Research, as discussed earlier, generates agricultural knowledge (innovations) and extension transfers the knowledge generated by research in the most adaptable form for farmers' use.

2.3 Agricultural Extension System

Agricultural extension services were introduced in Kenya by the colonial farmers around 1910 (Ojiambo 1995:112). The public sector for many decades (1950s to 1980s) was the major player in the provision of extension services in the country (Kenya, Republic of, National Agricultural Extension Policy 2001:1). These services were very effective in assisting the majority of small-scale farmers improve their agricultural production. Over the last decade, extension services started experiencing some challenges due to socio-economic changes and agricultural sector reforms taking place in the country. The division was blamed for non-performance and lack of accessibility, and confidence in extension workers ((Kenya, Republic of, MoARD, National Agricultural Extension Policy (NAEP) 2001:ix). The budgetary allocation to the service was also declining. The traditional methods of service delivery were no longer sustainable and change was inevitable. There was a need to address these issues and the Kenya Government appointed a task force to look into the problems and recommend appropriate action (Kenya, Republic of, MoARD, NAEP 2001:ix). The task force recommended, among other items, *the enactment of a national agricultural extension policy*.

In December 2001, the government came up with the National Agricultural Extension Policy (NAEP). The policy was prepared to guide and harmonize management and delivery of extension service in the country and accommodate the impending changes. The policy supports the development of pluralistic and demand-driven agricultural extension services ((Kenya, Republic of, MoARD, NAEP, 2001:1). It will be used by ministry of agriculture staff, private sector extension providers, Non-Governmental Organizations (NGOs), Community Based Organizations (CBOs) and development partners supporting agricultural extension in the country.

In Kenya, the agricultural extension service is primarily concerned with effecting change through the adoption of innovations and changed practices and attitudes (Kenya, Republic of, MoARD, NAEP, 2001:9). Sometimes, however, extension simply facilitates farmers to learn when this may appear to be the most appropriate way to achieve the desired change. Kaniki (1995:26) observes that extension workers act as a link between researchers and farmers in providing advisory information, while at the same time feeding researchers with field problems which require further research. The National Agricultural Extension Policy (Kenya, Republic of, NAEP, 2001:9) outlines four conditions necessary if agricultural innovations are to be adopted by the farmer. Firstly, farmers must be aware of the existence of the innovation and its potential for practical relevance to them. Secondly, given the fact that farmers are generally risk-averse, the farmer needs to perceive that it is feasible to try out the innovation on a small-scale before large-scale adoption. Thirdly, the farmers should also perceive that the innovation is worth trying out. Fourthly, the farmers need to be convinced that the innovation if adopted would promote his economic and general welfare. The role of extension worker is, therefore, to provide relevant information necessary to the farmer's conditions.

In Kenya, the agricultural extension service is still largely the responsibility of the ministry of agriculture through the national agricultural extension division. The country consists of eight provinces, which are further divided into 52 districts. The District Agricultural and Livestock Extension Officers (DALEO) are responsible for agricultural development in each of their respective districts and they report directly to the Provincial Director of Agriculture, Livestock and Extension (PDALE). Each district is sub-divided into divisions and each division has divisional extension co-ordinators who are assisted by Technical Officers (TO's). The TO's are responsible for the supervision of extension activities of the frontline extension personnel. The frontline extension workers frequently get in contact with the farmers. They disseminate appropriate agricultural technologies while at the same time gathering information from the farmers and passing them over to the researchers

Extension services are also provided by the private sector. Accordingly, the current National Development Plan 2002-2008 (p. 38), outline the government position in encouraging greater community and private sector participation. Private agricultural extension services are provided by:

1. Religious organizations such as the Catholic Diocese and the World Vision.
2. NGO's, and private companies such as Kenya Breweries, British American Tobacco (BAT), Sugar Companies,
3. Parastatal Organizations, such as: Kenya Tea Development Authority (KTDA), Kerio-Valley Authority, Lake Basin Authority, Coffee Board of Kenya.

In order for extension workers to fulfil their role as links in agricultural production cycle, they require a constant supply of relevant and timely information on various issues relating to their work. Aina (1995) in Kaniki (1995:26) has identified information needs of extension workers to include among others:

- Identification and control of pests;
- Credit sources and co-operatives;
- Proper handling of insecticides and
- Marketing of agricultural products.

Kaniki (1995:26) further observes that extension workers require information on the best cropping methods, for specific soils and given crops and also on different types of livestock, planning demonstrations and field days, and advisory information on farming seasons. They must also keep themselves up-to-date on ICTs tools and services that can have a major impact on the economics of farming. A knowledgeable extension worker will find it easier to advise the farmer appropriately. The present study found out that some of the extension workers especially those in the frontline are physically isolated from modern communications and other infrastructural facilities. This is more prevalent in Arid and Semi-Arid Land (ASAL) as opposed to high and medium potential areas. There is need, therefore, for the government to improve basic infrastructure, rural access roads, electricity, water provision, telephone facilities and other services. This will pave the way for faster communication of agricultural information. These facilities will also enhance collection of specified data and information in areas in which extension workers provide service. Extension workers will also be in a position to exploit potential of ICTs in repackaging and disseminating new technologies to farmers. These will provide more avenues of dissemination, as no single extension approach can be considered appropriate to address the needs of all agro-ecological zones.

Various extension approaches have been used to address the needs of farmers in different agro-ecological zones (Kenya, Republic of, MoARD, NAEP 2001:11). Specific approaches to be used in a given area will depend on, among other factors, the following as outlined in the national agricultural extension policy document (Kenya, Republic of, MoARD, NAEP 2001:11): (a) agro-ecological zones; (b) farmer literacy level; (c) enterprise mix (d) land tenure system; (e) farmers' resources; (f) social-cultural factors; (g) farmers 'needs. Dibo (2003) cautions that approaches that emphasize the use of groups rather than individual farmers are recommended because of their relatively low cost, particularly in view of the current low staff/farmer ratio in public extension service.

The move now in Kenya is towards participatory approach with a strong element of demand driven extension service (Ndungu, Nkonge, Rees 2000:2). Variation in approaches depends on the extension system and cost effectiveness of the system. The extension methods currently in use by both the public and private extension providers as outlined in the National Agricultural Extension Policy document (2001:12) include provision of extension service to individual farmers, on-farm demonstration, agricultural shows, field days, film shows, mobile training units, adaptive on farm trials and mass media. Extension workers need to understand these methods and how to use them appropriately. They should be conversant with participatory methods and have good communication skills to enable them effectively participate in passing various technical messages to farmers.

Extension workers, therefore, occupy a strategic position in the agricultural production cycle. They are responsible for simplifying research information and delivering it to farmers in an effective and easy-to-understand manner and providing a feedback mechanism to researchers on problems faced by farmers (Kaniki 1995:26). They act as a bridge between researchers and farmers hence provides a two-way communication flow between researchers and farmers (Anholt & Zijp 2002:4). For extension workers to effectively fulfil their roles, they need a constant supply of relevant information which can only be provided by an effective and efficient agricultural information system.

2.4 Agricultural Libraries and Information Centres

According to Ojiambo (1995:115), agricultural information is provided through various formal and informal channels and sources which include mass media, electronic and printed media, interpersonal communication and libraries, and information centres. He argues that the choice of the channel or sources of acquiring agricultural information depends on factors such as proximity of the channel or source, perception of channel or source by user and availability of agricultural information sought by the user. Agricultural libraries and information centres play a vital role in acquiring, processing and disseminating agricultural information.

In Kenya, agricultural libraries. and information centres are characterised by the structure of their parent organizations. They can be classified into the following categories:

1. Research libraries and information centres:

These are libraries and information centres of national and international agricultural research institutes.

(a) Those of national agricultural research institutes include: the Kenya Agricultural Research Institute Information and Documentation Services, the Kenya Forestry Research Institute Library, the Coffee Research Foundation Library, the Kenya Tea Research Foundation Library among others.

(b) Those of international research institutes include among others: World Agro-forestry Centres' Library, Documentation and Information Services; International Livestock Research Institute Library; International Centre for Insect Physiology and Ecology Library and Information Centre; International Plant Genetic Research Library.

2. Educational agricultural libraries and information centres: these are agricultural libraries within the universities and colleges. They include Egerton University Library, Jomo Kenyatta University of Agriculture and Technology Library, Nairobi University College of Agriculture and Veterinary Sciences Library, Moi University, Chepkoilel campus. College libraries include Bukura College of Agriculture Library, Animal Health and Industry Training Institute Library, Embu Agricultural Staff College Library and Naivasha Dairy Training School Library.

3. Administrative agricultural libraries and information centres: these are libraries and information centres in the Ministry of Agriculture departments and parastatals dealing in agriculture and related areas. In this category we have the Agricultural Information Resource Centre (AIRC) commonly referred to as Agricultural Information Centre (AIC). This is a department within the ministry of agriculture and rural development responsible for repackaging agricultural information through the media for extension workers, farmers and other stakeholders. The other one is the Ministry of Agriculture and Rural Development Library and Information Services located at the ministry headquarters. Both are well developed in terms of facilities and human resources.

The following section discusses specific roles, functions and services of the major agricultural libraries and information centres in Kenya.

2.4.1 Agricultural Information Centre

Agricultural Information Centre (AIC) commonly known as Agricultural Information Resource Centre (AIRC) is a division within the Ministry of Agriculture and Rural Development (MoARD). It was established in 1966, as a small unit within the National Agricultural Research Laboratories (NARL) (Kenya. Republic of. MoARD 1997:8). Since then the unit has expanded into one of the most active divisions within the ministry. Currently, it is located on its own premises at Kabete on the outskirts of Nairobi. The primary role of AIC is to use the mass media to complement the extension services of the ministry (Kenya, Republic of, MoARD, AIRC 2001:1). The objective is to repackage agricultural information through the print and other media to suit the different needs of the farmers, extension workers and other interested parties (Kenya, Republic of, MoARD 1998:8). Other activities of AIC include the provision of training to extension workers to better their extension skills and the management of extension service. In 1993 AIRC commercialized its services and started offering them on a commercial rate or on cost recovery basis ((Kenya, Republic of, MoARD, AIC 2001:1). These services include mass media products, print materials for extension, and training services which are offered to government departments, international organizations, NGOs and commercial companies.

According to information obtained through a discussion with the director of the centre, (Yatich, 2003), the specific objectives of AIC are to:

- Enhance farmers' ability and increase the agricultural output through more effective information and training.
- Improve the skills of the extension workers both in public and private sector through training and provision of better extension materials.
- Improve the overall quality of agricultural information and training through close collaboration with other development agencies and
- Generates financial resources to support its operations and programmes and to become financially sustainable.

AIC is headed by a deputy director (information and extension), assisted by five assistant deputy directors in charge of the various units within the division. The deputy director and his five assistants have subject background in agriculture. They are holders of either a bachelors' degree or diploma in agriculture with specialized training in their specific areas of operations (e.g. radio production; library and information sciences, media studies). AIC staff are drawn from the ministry of agriculture and have wide experience in agriculture and extension work. AIC is governed by a board of management where the directors are drawn from both the public and private sectors.

For AIC to realise its objectives it has set up various units to provide for specific services. The units and their services are discussed below. The information was obtained mostly through discussions with the respective heads of units.

2.4.1.1 Radio Services Unit

According to information obtained through a discussion with the head of radio services unit, (Atsiaya 2003), and also through observation of the radio unit indicate that AIC has a modern radio studio equipped with professional sound recording equipment for both field and studio recording. The unit has four professionally trained radio producers' staff with background knowledge in agriculture. The work of the staff entails writing of scripts, designing the programmes, editing the material, translating it into Kiswahili and other vernacular languages, and recording, pre-testing and finally airing them on radio. Among the services offered by the radio unit include, audience research, program design and production, editing, dubbing and commercials. The radio production facilities are also available for hire. The unit collaborates with government and private radio and TV stations.

According to head of radio services the production cost of a 15 minutes programme in the national radio and TV station (KBC) is 15,000 Kenya shillings (about US$ 200). While the cost of airtime for 15 minutes Kiswahili programme is about 66,000 Kenya shillings ((US$ 800). Most programmes are in Kiswahili which is the national language in Kenya. It is usually expensive to air a Kiswahili programme through the national radio because of competitive demand for such programmes. AIC radio unit is now opting to use rural radio and TV stations to air agricultural programmes in vernacular languages as it is relatively cheaper (Atsiaya 1996:1).

According to Atsiaya (2003) the most popular Swahili and English radio programmes produced by the radio unit and aired through the national broadcasting radio station include amongst others:

- Sikio la Mkulima;
- Tembea na majira;
- Afya ya mifugo wetu;
- Wadudu wa nafaka;
- Mkulima na mazao;
- Bei ya mboga na matunda;
- Nipe habari and
- Farmers corner.

The above programmes have, therefore, proved very popular for farmers and extension workers. They have also been translated into vernacular languages and aired through the rural radio stations. Private companies that include Twiga Chemicals, Coffee Board of Kenya, Pyrethrum Board of Kenya among others do sponsor some of the programmes. The challenge faced by staff in the unit is in keeping pace with new technological equipment which requires additional funds and re-training of staff.

2.4.1.2 Video Services Unit

A discussion with the head of the Video Services Unit, Mrs Simbowo (2003), revealed that the video unit has five experienced video production crew consisting of three media production staff, one editor and one cameraman respectively. The unit has modern recording equipment and editing suites that produce high quality broadcast educational materials for farmers and extension workers. The video production facilities, equipment and personnel are also available for hire. According to Simbowo (2003) the unit produces three categories of videos namely:

- Documentaries;
- Training videos and
- Technical information videos.

According to Simbowo (2003), the video unit solicits work from clients who include agricultural departments, NGOs, private companies and parastatals. Since the centre has marketed its services well, most clients usually come directly to seek for services from the department. The work of staff of the unit include: writing of scripts, identification of location for shooting, making the film, editing and finally production of the finished product. The target groups for finished products are extension workers. farmers and researchers. The unit collaborates with KARI and Kenya Broadcasting Corporation (KBC) in producing a weekly TV programme titled "*Mkulima.*" It also collaborates with an NGO called Regional Reach in distributing and showing agricultural video programmes at the village market centres. Regional Reach has installed television sets and video machines at these market centres. The video unit has also installed television sets and video machines in 20 farmers training centres where farmers get access to view the programmes (Simbowo 2003). This has enhanced farmers' avenues and channels of agricultural information.

According to Simbowo (2003) the AIC programmes that have been screened on Kenyan and international TV stations include among others:

- Zero grazing;
- A school without walls;
- Runoff – a foe or a friend;
- A sun will still rise;
- Safari Njema;
- Mkulima;
- Maziwa safi and
- Ufugaji wa ndizi.

The last two are weekly TV programmes on the national Kenya Broadcasting Corporation (KBC) produced in collaboration with Kenya Agricultural Research Institute. The challenge facing the video unit is frequent breakdown of equipment which are donor funded and inadequate funds to sustain the activities of the unit.

2.4.1.3 Printing and Publications Services Unit

According to information obtained through a discussion with the head of printing and publications unit, Mrs Njogu (2003), and also through observation revealed that the printing and publication unit undertakes pre-press activities, printing and publication of agricultural technical handbooks, brochures, leaflets, newsletters, stationery, posters, annual reports and certificates. The unit has a desktop publishing facility (Apple Macintosh system) complete with computers, scanners and printers which ensure high quality camera'ready artwork and printing. The unit also has a printing facility equipped with Lithographer printing machines, high speed copy printer, binding equipment, perforator and cutting machine.

The staff of the unit consist of one editor, one graphic designer, one typesetter and two machine operators. According to Njogu (2003) the publication titles produced in the unit include among others:

- Field crops technical handbook;
- Local and export vegetable growing manual;
- Kilimo news quarterly magazines and
- Brochures such as water harvesting.

Currently the unit is understaffed and requires additional personnel. Funding is also not adequate to sustain equipment and activities of the unit. For example, Kilimo News which is a quarterly magazine and one of the oldest publications of the Ministry of Agriculture has stopped publications and requires funds to re-start.

2.4.1.4 Documentation Services Unit

A discussion with the head of the documentation services unit, Mrs Kungu (2003), indicated that the unit acquires and stores unpublished agricultural documents and publications. These include various reports, conference proceedings, theses and dissertations, journals and articles, statistical and development materials as well as other scientific and technical information on Kenyan agriculture.

Acquired documents are indexed and abstracted. Abstract and bibliographies featuring documents available in the documentation centre are produced regularly for reference and are used by policy makers and planners, extension workers, agricultural educators, researchers, farmers and other persons involved in agricultural matters. The documentation centre is partially automated using WINISIS text retrieval software. Internet and email services are also available within the library. The unit is an AGRIS inputting centre. International Information System for Agricultural Sciences and Technology (AGRIS) is a CD-ROM database produced by FAO on agricultural information literature worldwide.

The documentation centre has four staff. The documentalist in-charge of the centre has a masters' degree in information sciences and a bachelors degree in agriculture, while two of the staff have diplomas in agriculture with on job training in library work. The fourth staff member has a diploma in library and information studies. This blend of staff provides a strong working team for the documentation centre.

The challenge encountered by the department stems from the lack of adequate funds to buy necessary ICTs tools and equipment and also to improve the collection. Much of this is discussed in chapter 7.

The Agricultural Information Centre (AIC) also takes care of the main library located at the ministry of agriculture headquarters, Kilimo House. The librarian in charge of Kilimo library, therefore, reports directly to the director of AIC. The next section discusses the development, organization and services of the library.

2.4.2 Ministry of Agriculture and Rural Development Library and Information Services

The development of agricultural information systems and services in Kenya can be attributed to the British Colonial government which realised the potential of agriculture as a major economic resource in the country (Ojiambo 1995:113). In 1907, the ministry of agriculture library was established to provide agricultural information to the staff of the Department of Agriculture and the colonial settlers. The library was then known as the Department of Agriculture Library. In the 1960s the Rockefeller Foundation donated funds to the Department of Agriculture Library to enable it put up more libraries in the districts and in the farmers training institutes (Ojiambo 1995:113). Since then, the library has expanded both in terms of facilities and human resources. The library is now called "Agricultural Library and Information Services". It is also referred to as "Kilimo library" because it is housed in Kilimo House which is the ministry of agriculture headquarters. Kilimo library has branches at the livestock department (Hill Plaza), Farmers training centres, agricultural training institutes, at some of the provincial and district agricultural offices (Chebukaka 2003).

Discussions with the Librarian, Chebukaka (2003), indicate that the primary objective of the Kilimo Library is to collect, process, store, and disseminate relevant and timely agricultural information to the users who consist mainly of the technical staff in the ministry, department of livestock, veterinary services, fisheries and co-operatives. This category includes researchers, extension workers and policy makers. Members of academic staff and students from universities and colleges, consultants and other bona-fide researchers also make use of the library.

According to the librarian, the Kilimo library has a total of ten staff of which eight are professional staff with a minimum of bachelors' degree in library and information sciences. The other two staff are holders of diplomas in library and information studies. The library has a stock collection of 30,000 volumes of books, 12,000 volumes of periodicals, 10,000 documents of unpublished literature on Kenyan agriculture. The library is also a depository of FAO and Centres for Consultative Group on International Agriculture Research (CGIAR) documents. Currently the library has 120 titles of current periodicals mostly acquired through gifts, donations and exchange. The library also has 28 titles of agricultural databases on CD-ROM such as Crop Protection Compendium, CABI abstracts, Tropical and Rural Agriculture Abstracts (TROPAG) among others. It has acquired The Essential Electronic Agricultural Library (TEEAL) which has full-text articles drawn from 141 journals. The library also keeps official government documents, such as sessional papers, policy documents, and statistical abstracts. The library uses Universal Decimal Classification system (UDC) to organize the materials.

According to Chebukaka (2003), the automation process of Kilimo library started in 1997 when some computers were donated through the National Extension Project II (NEP II). In 2001 the Germany Technical Co-operation (GTZ) funded the automation project by availing the necessary funds and by donating two more computers. The computers were used to capture data of the library collection and also of documents kept in various offices within the building. The automation package used is WINISIS text retrieval software. So far 55,000 records of books and other documents have been entered into the library database. The GTZ project has ended and it is expected that the ministry will provide additional funds to complete the automation exercise.

The Library services include: lending, reference service, the current awareness service, inter-library loan service and reprographic services. The Internet and email services were yet to be installed in the library, but these services were available in five offices in the building where staff accessed the services. Networking of all the offices within the ministry building was also in progress. This is expected to be completed by the end of 2003 and the library will then be in a position to provide internet and email services.

According to the librarian, the challenges encountered by library are due to lack of adequate funds to acquire additional collection and complete the automation project. Although the ministry, through the Germany Technical Co-operation (GTZ) assessed the information needs and options for information management, the recommendations of this project are yet to be fully implemented (Kenya, Republic of, MoARD 1997). The library should continue developing a comprehensive agricultural database tailored towards meeting the information needs of the users.

The next section discusses Information and Documentation Services (IDS) at KARI.

2.4.3 Kenya Agricultural Research Institute (KARI), Information and Documentation Services

During the implementation of the different phases of the National Agricultural Research Project (NARP I & II), it became clear that whereas KARI was generating useful information and technologies that were beneficial in various degrees to diverse group of users within and outside the institute, there were no organized mechanisms of packaging, storing and disseminating this information (KARI 2002:46). The institute also found itself ill prepared to contribute to and benefit from cutting-edge information on technological innovations, and was, therefore, lagging behind. In particular, KARI scientists were not receiving adequate support in terms of reference materials, including scientific journals and database relevant to their programmes (KARI 2002:46). In 1990, KARI re-organized its library services and upgraded it into a division. Information and Documentation Division (IDS) was, therefore, established as one of the managerial divisions within KARI organization structure (Oguya 2003). Hence IDS was given the same status as the other divisions within KARI organizational structure. Subsequently, an assistant director (information) was appointed to head the division. Previously the assistant director was one of the researchers, but now an information specialist has been appointed to the post.

To effectively address the information issues that concerned the institute, IDS has three units, namely, the Information Technology unit (ITU), Library and Information Services Unit (LIS), and Publications Unit (PU) (KARI 2002:46). According to the head of the division, ITU is responsible for ensuring effective electronic networking, as well as management of computer software and hardware in all KARI centres, while LIS is responsible for library services, awareness creation, development and maintenance of databases. The PU prepares and packages technological content in various forms and at various levels of scientific depth and vigour, to suit the needs of different user echelons. A strong commonality of specialisation in training and services exists across the three units. IDS is therefore able to work favourably towards meeting objectives at both divisional and institutional level. Each of the three units is headed by a professionally trained staff in respective areas of their operations.

According to the head of the division, LIS unit co-ordinates libraries located at KARI research centres distributed in all agro-ecological zones in the country. The main library at KARI headquarters has three professionally trained staff with at least a bachelor's degree and above, 4 diploma holders and 2 certificate holders in library studies. The library subscribes to 50 current journals and has access to two database hosts through the courtesy of donors. The database hosts are Blackwell (Ideal) with over 600 electronic journal titles and EBSCO Host with over 500 electronic journal titles in agriculture and related areas. The library, through the support of World Bank and The Centre for Tropical Agriculture and Rural Co-operation (CTA) has acquired The Essential Electronic Agricultural Library (TEEAL) databases up to 2002 updates. TEAL provide over 141 journals with full text articles. The library has a stock of about 5,000 books. It subscribes to over 28 titles of CD-ROM databases such as AGRICOLA, AGRIS, CABI, TROPAG and RURAL.

According to the librarian, the library has 6 computers connected to the Internet. Through the support of donors, KARI researchers and other staff within the headquarters access Internet and e-mail free of charge. KARI has a local area network and researchers can access the Internet from their offices. The library through the support of CTA provides Question and Answer Services (QAS) to KARI researchers, policy makers and other interested parties such as, extension workers and farmers. QAS is an on-line service co-ordinated by Agricultural Information for the Development of Eastern Africa

(AGRIDEA) hosted in Uganda by the Agricultural Research Information Service (ARIS). Users are given the opportunity to request for any information which can be obtained electronically from any of the participating centres. It has proved very useful to KARI researchers and other stakeholders. KARI library is automated using WINISIS and its database has in excess of 50,000 records with citations and abstracts. These records reflect also what is available at KARI centre libraries distributed all over the country.

The creation of Information and Documentation Service division is, therefore, a clear testimony of the value attached to information by KARI policy makers. They have recognised the crucial role of information in agricultural research. IDS is providing an invaluable service to KARI researchers. In order to minimise the challenges facing the division, IDS has proposed to commercialise some of the information services for sustainability purposes.

The following section discusses libraries and information centres of international agricultural research institutes.

2.4.4 Libraries and information centres of International Agricultural Research Institutes

Libraries and information centres of international agricultural research institutes include: International Livestock Research Institute (ILRI) Library and Information services; World Agroforestry Centre (ICRAF) Library and Information Services and International Centre of Insect Physiology and Ecology Library and Information Services. The following section gives a brief discussion on these libraries and information centres.

ILRI conduct research primarily to develop technologies that enhance tropical livestock enterprises (ILRI 2003:1). There are two ILRI research centres, ILRI-Ethiopia and ILRI-Kenya. For purposes of this research only ILRI- Kenya library will be discussed. ILRI-Kenya library specialises in the biological sciences. It stock consists of 40,000 monographs and subscribes to 120 journal titles. The library circulates books and periodicals to ILRI staff and registered external staff (ILRI 2003:1). Users may also access the institute's in-house databases via ILRI local area network and via the Internet. Available external databases on CD-ROM include AGRIS, CABI abstracts, AGRICOLA, FAOSTAT, SESAME among others. Other services include Selective Dissemination of

Information (SDI), literature searches and document delivery. The library also distributes publications produced by ILRI. The library is staffed with experienced information specialists. In 1998, ILRI instituted a new information strategy. Its aim is to use new information and communication technologies to make available the wealth of information accumulated over the years by ILRI and create a hub of information exchange on livestock research and development in tropical developing countries. To meet this goal, the library has been equipped with the necessary ICTs tools and equipment and it is now possible to access in-house databases via the Internet.

The World Agroforestry Centre (ICRAF) conducts research on integration of trees, crops and animals and strives to diversify and sustain production for increased social, economic and environmental benefits for land users at all levels (ICRAF 2002:1). The centre's library assists ICRAF scientists and their partners to have access to relevant information needed for their work. The library has a specialized collection of books, journal literature with considerable back runs, reprints, videos and images on Agroforestry. These are all reflected in the catalogue of library holdings, the images databases, and publications databases. These databases are accessible online via local area network and the Internet. The products of ICRAF in terms of publications form the core of library collection. This is supplemented by shared resources held by partners such as Consultative Group of International Agricultural Research (CGIAR). The library has experienced agricultural information specialists.

The International Centre of Insect Physiology and Ecology (ICIPE) has the primary mandate of research, capacity and institution building in integrated arthropod management (ICIPE 2003:1). The ICIPE library is one of the four financially autonomous units that fall under the information services division created in 1997. The other units are the science editing, ICIPE science press and print shop and information technology unit. The library provides essential support services to ICIPE's research and training activities, and is used frequently by other scientists and students from the region. The library stock consists of 10,500 books and over 150 current journal titles. It also houses several databases and a sizeable collection of literature on insect science. The library has also developed a specialised database on pest management which is available on CD. The section of Library catalogue and pest management database can be accessed via the Internet. The library has one documentalist and a librarian.

2.4.5 Agricultural Libraries of Universities and Colleges

These are libraries that belong to academic institutions which include the University of Nairobi, Jomo Kenyatta University of Agriculture and Technology, Egerton University, Moi University, Chepkoilel Campus and agricultural libraries of training colleges. The following section gives a brief discussion on these libraries.

At the University of Nairobi, it is the college of Agriculture and Veterinary Sciences' library at Kabete campus, and College of Biological and Physical Sciences at Chiromo campus that provides agricultural and veterinary information services, mainly to the faculty, researchers and students. According to the librarian, the College of Agriculture and veterinary Sciences library has a total book stock and bound periodicals of about 60,000 and 500 journals titles mainly on agriculture and veterinary sciences. The library also has several agricultural databases on CD-ROM and provides Internet and email services. The library at the College of Biological and Physical Sciences has a book stock and bound periodicals of approximately 90,000 volumes and 600 journal titles mainly on medicine, veterinary medicine and biological sciences. The library also has CD-ROM databases, and provides Internet and email services to the users.

Egerton University is mainly an agricultural and veterinary sciences institution. Its library has a total book stock of about 150,000 volumes. In addition, the library has about 50 titles of CD-ROM databases, and up to date collection of TEAL databases that provide full text information from 130 agricultural journals. The library is partially automated. Jomo Kenyatta University of Agriculture and Technology library has a collection of about 80,000 volumes. The library is fully automated using T-Series library management software. Internet and email services are also provided. It subscribes to about 150 journal titles. Moi University, Chepkoilel campus has a library stock of about 30,000 books and subscribe to about 50 titles of periodicals. The library provides Internet and email services to the users. Other agricultural training colleges have their own libraries. Most of these libraries are poorly stocked and are managed by non-professional staff.

2.5. Implications of the systems and services to access and use of information by agricultural researchers and extension workers.

It is evident from the foregoing discussion that agricultural information is provided through various channels and sources. Agricultural libraries and information centres play a vital role in acquiring, processing, and disseminating agricultural information to agricultural researchers and extension workers. The majority of these libraries and information centres have adopted use of ICTs (such as the Internet, CD-ROM, electronic journals) in providing information. Mass media is also used to disseminate agricultural information to farmers and other stakeholders. The nature and types of ICTs in these libraries have also been discussed in chapter six.

An evaluation of the existing agricultural information landscape, including information flow indicates a significant improvement compared to what had been reported by a task force commissioned by the Government to assess the information needs and options for management in the agricultural sector (Kenya, Republic of, MoARD 1997, Kenya, Republic of, MoARD 1998). Efforts have been made to support agricultural knowledge and information systems by respective institutions in the public and also private sector. This is exemplified by KARI and the Ministry of Agriculture which have created divisions within their structures to coordinate information activities. At KARI Information and Documentation Services (IDS) is now well defined in the hierarchy of the Institution and granted status of a division. This has enabled the division to have a greater bargaining power for more resources to improve its services.

The Information Technology Unit was created within the IDS to coordinate and manage ICTs activities within the institution. The library has six computers connected to the Internet which can be accessed via local area network. This enables the researchers to access the Internet and email from their offices. Currently, the Internet and email services are accessed free of charge courtesy of KARI donor funded projects. Other library services include 5 in-house databases, several CD-ROM databases, and electronic journals. It suffices to say that agricultural researchers can now access enormous information needed in their day to day work. They can also access databases of international agricultural research centres within and outside the country. However, the researchers based in some of the research centres are disadvantaged in accessing and using ICTs. The majority of the centres lack well equipped Libraries with Internet and email facilities. While some of the centres rely on donor funded projects having Internet and email component, the problem is essentially that of sustaining these services once the projects end. .These centres also lack technical staff to maintain their ICTs facilities.

These shortcomings curtail the potential of researchers to conduct quality research due to lack of relevant information.

Agricultural Information Centre (AIC), on the other hand, has also been elevated to status of a division within the Ministry of agriculture with specific role of information acquisition, processing, packaging and distribution. The centre has been mandated to repackage agricultural information for extension workers and farmers. Extension materials are produced and distributed to extension workers across the country to assist them in disseminating agricultural information to farmers. This has proved very useful. Agricultural programmes are also aired through the national and private radio and TV stations. The farmers have diverse channels of accessing agricultural information. Other forms of ICTs such as the Internet and email are being adopted at district and provincial agricultural offices to improve communication of agricultural information. AIC oversee libraries and information centres within the ministry of agriculture. These libraries include the Ministry of agriculture library at Kilimo and a documentation centre located within AIC building. There is a need to improve libraries at provincial and district agricultural headquarters. During field visit it was established that that libraries do not exist at provincial and district agricultural offices. Most extension workers are cut off from libraries and the few college and university libraries available are usually restricted to students and faculty members. There is need to develop libraries at the provincial and district agricultural offices.

2.6 Summary

From the above discussion, it can be deduced that the Kenyan government has made significant efforts in strengthening agricultural information systems. The role of the library and information services is now well defined in the organization hierarchy of the Kenya Agricultural Research Institute. The Information and Documentation Services (IDS) as it is referred to, is now a fully fledged division accorded the same status as the other divisions within the KARI hierarchy. Similarly, at the Ministry of Agriculture, a whole division known as Agricultural Information Centre (AIC) has been created to provide agricultural information to extension workers and farmers. This is a clear indication that policy makers have now realised the importance of information in agricultural research and extension services.

From the discussion, it can be seen that libraries and information centres of the international research institutes have adopted advanced use of ICTs and their in-house databases are now available via the Internet. Although significant progress has been made in the expansion and modernization of agricultural libraries in the public sector, there is still room for improvement. This can be attributed to disparity in the distribution of communication facilities between rural and urban centres and lack of ICT policy in the country to address the imbalance.

There is need also to improve libraries at the provincial and district agricultural centres. Although there is networking of agricultural libraries and information services in the country, it is confined to those within the capital city, Nairobi. A policy should therefore be formulated to provide some guidelines on how agricultural libraries and information centres can network to make information resources available to the users.

Finally, the government recently removed the taxes on computers and their accessories. It is expected that agricultural libraries and information centres will take advantage of this and adopt appropriate ICTs in the provision of agricultural information.

The next chapter discusses the theoretical framework of the study.

CHAPTER THREE

THEORETICAL FRAMEWORK

3.1 Introduction

This chapter discusses the diffusion of innovation theory chosen as the theoretical framework of this study. The four key elements of the theory have been described. The applicability of the theory to the study has been discussed, indicating its strengths. The shortcomings of theory are also highlighted, showing how these did not affect the study.

A consideration of the objectives of the study suggests a theoretical framework that has components of technological innovation, adoption, diffusion and communication. The researcher carefully examined several theories in an attempt to find a theory that encompassed all the components. The theory that was found to be suitable as framework of the study is the diffusion of innovation theory commonly referred to as Rogers' theory. The theory has potential application to information technology, ideas, artefacts and techniques (Clarke 1999:1). It has been used as the theoretical basis for a number of information systems projects (Rogers and Scott 1999:8, Surry 1997:8, Larsen 1997, Larsen 1998). The theory has also been widely applied to investigate diffusion of agricultural innovations (Rogers and Scott 1999:4, Rogers 1995, Sunding & Zilberman 2000). Thus the theory's application to information technology and agriculture made it the most appropriate theoretical framework for this study. Studies in diffusion usually begin with a single innovation, with tracing of its diffusion through various channels. The strength of the theory is that adopters and non-adopters may be studied to identify the factors that influence their adoption behaviour (Lewis 1997:7, Ojiambo 1989:38). Some of these influences are the nature of the innovation, the communication channels, the characteristics of social group, institutions or organizations (Lewis 1997:7, Ojiambo 1989:38). These factors formed the focus of this study.

3.2 Diffusion of Innovations Theory

Rogers and Scott (1999:4) have defined diffusion as the process by which an innovation is communicated through certain channels over time among members of a social system. They observe that diffusion is a special type of communication concerned with the spread of messages that are perceived as new ideas. They underscored the importance of the theory in analysing and explaining the adaptation of new innovation in a social system. Its purpose is to provide individuals from any discipline interested in the diffusion of an innovation with a conceptual paradigm for understanding the process of diffusion and social change (Calvo and Rahrig 1999:2). Clarke (1999:1) further adds that the theory purports to describe the patterns of adoption, explain the mechanisms, and assist in predicting whether and how a new innovation will be successful. Larsen (1997:1) is of the view that the theory is regarded more robust in predicting adoption/diffusion as well as non-adoption/non-diffusion of an innovation than any other theory. Clarke (1999:1) sums it up by observing that the theory is concerned with the manner in which a new technological idea, artefact or technique, or a new use of an old one, migrates from creation to use.

Calvo and Rahrig (1999:1) traced the origin of diffusion theory to 1900's when Gabriel Tarde, a French lawyer observed certain generalizations about the diffusion of innovations that he called the laws of imitations. These laws have come to be referred to as adoption of an innovation. Calvo and Rahrig (1999) further observe that in the 1920's the British and German-Austrian diffusionist emerged and these were a group of anthropologists who undertook research in diffusionism. According to Rogers (1995:41) diffusionism was a point of view in anthropology that explained social change in a given society as a result of the introduction of innovations from another society.

Rogers and Scott (1999:4) opine that, the paradigm for diffusion research took a new dimension in the 1940s when rural sociology research tradition began. They observe that a study by Ryan and Gross in particular influenced the methodology, theoretical framework, and interpretations of later students in the rural sociology tradition, and in other diffusion research traditions. They report that Ryan and Gross in 1943 investigated the diffusion of hybrid corn among Iowa farmers. Hybrid seed was made available to Iowa farmers in 1928. The hybrid vigour of the new seed increased corn yields on Iowa farms, hybrid corn varieties withstood drought better than open-pollinated seed they replaced, and hybrid corn was better suited to harvesting by mechanical corn pickers. This innovation was adopted by almost 100 per cent of Iowa farmers by 1941. Ryan and Gross studied the rapid diffusion of hybrid corn in order to obtain lessons learned that might be applied to the diffusion of other farm innovations. However, the intellectual influence of the hybrid corn study reached far beyond the study of agricultural innovations, and outside of the rural sociology tradition of diffusion research.

Since 1960s, the diffusion theory has been applied in a wide variety of disciplines that include education, public health, communication, marketing, geography, and economics (Rogers and Scott (1999:4). They observe that the theory is being applied in studying diffusion of new communication technologies such as the Internet (p.12). This view is supported by Larsen (1997:1) who suggests that the theory can be used as the basis for understanding diffusion of information technology. Several studies have used the theory to investigate adoption and diffusion of software application packages in organizations (Bayer and Mellone 2002, Larsen 1997, Larsen 1993, Larsen 1998). The theory has also been used to establish the human, interpersonal and social factors that led to faster diffusion of QWERTY keyboard as opposed to the more superior Dvorak keyboard (Surry 1997:8). Cullen (2001:6) points out that some of the research into the digital divide, in particular barriers to the adoption of the Internet by groups, can be interpreted in light of this well tested and useful theory.

The researcher and writer who is credited for synthesising and explaining the most significant findings of the diffusion of innovation theory is Everett M. Rogers (Surry 1997:2). Through his book titled *Diffusion of Innovations* first published in 1962 and currently in its fourth edition discusses all the elements and dimensions of the theory than any other work. Calvo and Rahrig (1999:4) are of the view that many scholars consider this book to be the "bible" of the theory. Because of Roger's contributions the theory has come to be referred to as "Roger's diffusion of innovations theory" (Lewis 1997:8).

3.3 Key elements of diffusion theory

Rogers and Scott (1999:4) define diffusion as the process by which an innovation is communicated over time among members of a social system. The four main elements in the diffusion theory have been identified as the innovation, communication channels, time, and the social system (Clarke 1999:1, Rogers and Scott 1999:4, Rogers 1995:5). These elements are discussed below.

3.3.1 Innovation

Rogers (1995:5) defines an innovation as an idea, practice, or object that is perceived as new by an individual or other unit of adoption. Rogers and Scott (1999:5) observe that characteristics of an innovation, as perceived by the members of a social system, determine its rate of adoption. This is because certain innovations may spread more quickly than others. Rogers (1995) collected and reviewed scores of studies and identified the following attributes or characteristics determining an innovation's rate of adoption:

- Relative advantage;
- Compatibility;
- Complexity;
- Trial-ability, and
- Observability.

Glanz, Lewis and Rimer (1997:273) have added other attributes that also determine the speed of adopting an innovation. These include:

- Impact of social change;
- Communicability;
- Reversibility;
- Time required;.

- Risk and uncertainty;
- Commitment required and
- Modifiability.

These characteristics and attributes are presented in following chart.

Characteristics/attributes of the speed and permeability of the Diffusion Process

Relative advantage	Is the innovation perceived to be better than what it will replace?
Compatibility	Is the innovation consistent with values and needs of potential adopters?
Complexity	Is the innovation easy to use?
Trialability	Can the innovation be adopted on trial?
Observability	Are the results of the innovation observable and measurable?
Impact on social relations	Does the innovation have a disruptive effect on the social environment?
Communicability	Can the innovation be understood clearly and easily?
Reversibility	Can the innovation be reversed or discontinued easily?
Time required	Can the innovation be adopted with minimal investment in time?
Risk & uncertainty	Can the innovation be adopted with minimal risks?
Commitment required	Can the innovation be used effectively with only modest commitment?
Modifiability	Can the innovation be updated, modified, or reinvented over time?

Source: Glanz, K, Lewis, FM, & Rimer. BK (1997). Health behaviour and Health Communication: Theory, Research and Practice. San Francisco: Jossey-Bass Publishers. Page 273. (Modified).

3.3.1.1 Relative advantage

Rogers and Scott (1999:5) explain that relative advantage is the degree to which an innovation is perceived as better than the idea it supersedes. They observe that although the degree of relative advantage may be measured in economics terms, social prestige, convenience and satisfaction are also important factors to consider.

3.3.1.2 Compatibility

Rogers (1995:224) defines compatibility as the degree to which an innovation is perceived as being consistent with the existing values, past experiences, and needs of potential adopters. He cautions that an idea that is incompatible with the values and norms of a social system will not be adopted as rapidly as an innovation that is compatible. According to him needs compatibility involves matching up of the innovation with the perceived needs of potential adopters so as to have a faster rate of adoption. Accordingly, he argues that change agents should have a high degree of empathy and rapport with their clients until they understand the potential and consequences of the innovation.

Citing Arensburg and Niehoff (1964), Rogers observed:

> A negative experience with one innovation can damn the adoption of future innovations....When one innovation fails, potential adopters are conditioned to view all future innovations with apprehension....For this reason, change agents should begin their efforts with a particular audience with an innovation that has a high degree of relative advantage, so that they can build successively on this initial success (Rogers, 1995:228)

3.3.1.3 Complexity

Rogers and Scott (1999:6) explain that complexity is the degree to which an innovation is perceived as difficult to understand and use. They are of the view that some innovations are readily understood by most members of a social system while others may be more complicated and will be adopted more slowly. Accordingly, they observe that new ideas that are simpler to understand are adopted more rapidly than innovations that require the adopter to develop new skills and understanding.

3.3.1.4 Trialability

According to Rogers (1995:243), trialability is the degree to which an innovation may be experimented with on limited basis. Rogers and Scott (1999:6) are of the view that new ideas that can be tried on an instalment plan will generally be adopted more quickly than innovations that are not divisible. In other words by introducing the new technology gradually, give amble time to the adopters to get acquainted with it and gain confidence in using it.

3.3.1.5 Observability

Rogers and Scott (1999:6) have defined observability as the degree to which the results of an innovation are visible to others. They reason that the easier it is for individuals to see the results of an innovation, the more likely they are to adopt it. Such visibility *stimulates peer discussion of a new idea. Rogers (1995:244) asserts that by observing* others using the innovation not only increases its probability of being adopted, but also strengthens the perceived ability to judge whether an innovation has relative advantage over another. He opines that observation may indicate whether the innovation is compatible and sufficiently simple to understand and implement.

3.3.1.6 Impact on social relations and communicability

These attributes are discussed under the elements of social system and communication channels respectively.

3.3.1.7 Reversibility and Risk/uncertainty

Glanz, Lewis, and Rimer (1997:273) assert that reversibility is being in a position to easily reverse or discontinue an innovation. They observe further that adopters of an innovation should consider the possibility of adopting an innovation with minimal risks and uncertainty.

3.3.1.8 Commitment required and modifiability

Glanz, Lewis, and Rimer (1997:273) are of the view that an innovation can be considered in relation to the commitment required. They observe that some innovations may require total commitment while others require only modest commitment. The two authors assert that the attribute of modifiability is important in establishing whether an innovation can be updated, modified or re-invented over time.

It can be summarised that innovations that are perceived by individuals as having greater relative advantage, compatibility, trialability, observability, and less complexity will be adopted more rapidly than other innovations (Rogers and Scott 1999:6). In addition, the adopters should also assess the innovation in terms of the attributes as outlined by Glanz, Lewis, and Rimer (1997:273).

3.3.2 Communication channels

Rogers and Scott (1999:6) have identified the second element in the diffusion of innovation theory as the communication channels. They define communication as the process by which participants create and share information with one another in order to reach a mutual understanding. Rogers (1995:18) explains that communication channels are the means through which knowledge about innovations is conveyed from one individual to another. He opines that the channels may influence the rate of adoption. Accordingly, Rogers asserts that mass media tends to be more effective at knowledge stage diffusion, while opinion leaders via interpersonal contact are more effective in persuading people to adopt an innovation. Rogers and Scott (1999:6) are of the view that most individuals evaluate an innovation, not on the basis of scientific research by experts, but through the subjective evaluation of near-peers who have adopted the innovation. Glanz, Lewis and Rimer (1997:273) cautions that channels used must also ensure that characteristics of an innovation are matched with those of the target population. Accordingly, they assert, this will enable the target population to understand the potential of the innovation.

3.3.3 Time

Rogers and Scott (1999:6) have identified time as the third key element in the diffusion of innovations theory. Lewis (1997:10) opines that time refers to the rate or speed of adoption by potential users. Glanz, Lewis and Rimer (1997:273) explain the attribute of time as the duration that takes an innovation to be adopted. They are of the view that some innovations require longer time while others may take shorter time. According to Rogers and Scott (1999:6) the time dimension is involved in diffusion in three ways. The first one, they say, is where time is involved in the innovation-decision process. Accordingly, Rogers and Scott observe that innovation-decision process is the mental process through which an individual (or other decision making unit) passes from first knowledge of an innovation to forming an attitude towards the innovation. They observe that the process continues to the point where a decision is made either to adopt or reject an innovation, up to the implementation stage. The two authors argues that an individual seeks information at various stages in the innovation-decision process in order to decrease uncertainty about an innovation's expected consequences.

According to Rogers and Scott (1999:6) the second way in which time is involved in diffusion is in the innovativeness of an individual or other unit of adoption. They contend that innovativeness is the degree to which an individual or other unit of adoption is relatively earlier in adopting new ideas than other members of a social system. They identify five adopter categories, or classifications of the members of a social system on the basis of their innovativeness. They include innovators, early adopters, early majority, late majority, and laggards.

Rogers and Scott (1999:6) observe that innovators are usually the first 2.5 per cent of the individuals in a system to adopt an innovation. Accordingly, they argue that interest in new ideas leads innovators out of a local circle of peer networks and into more cosmopolite social relationships. They are of the view that communication patterns and friendships among a clique of innovators are common, even though the geographical distance between innovators may be considerable. The two authors identified characteristics of early innovators to include stable financial base, ability to understand and apply complex technical knowledge and high degree of coping with uncertainty about an innovation.

The early adopters have been identified by Rogers and Scott (1999:6) as the next 13.5 percent of the individuals in a system to adopt an innovation. They observe that in most systems this adopter category has the greatest degree of opinion leadership. The two authors are of the view that potential adopters look to early adopters for advice and information about the innovation.

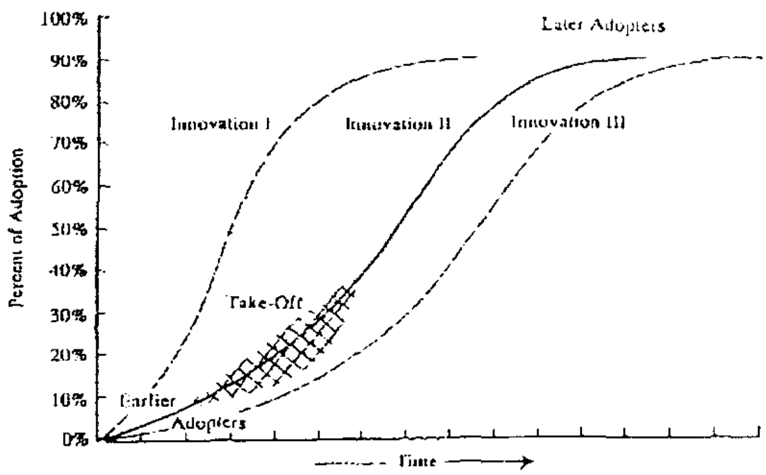
Rogers and Scott (1999:7) identify the next group of adopters as early majority who consist of 34 percent of the individuals in a system to adopt an innovation. They opine that early majority interact frequently with peers, but seldom hold positions of opinion leadership in a system. Early majority's unique position between the very early and relatively late to adopt makes them an important link in the diffusion process. In other words, they provide interconnectedness in the system's interpersonal networks.

The late majority are the next 34 percent of the individuals in a system to adopt an innovation (Rogers and Scott (1999:7). Adoption by this group maybe the result of increasing pressures from peers. Rogers and Scott (1999:7) argue that innovations are approached with sceptical and cautious air, and the late majority do not adopt until most others in their system have done so.

According to Rogers and Scott (1999:7) the last 16 percent of the individuals in a system to adopt an innovation are the laggards. They view laggards as individuals who possess almost no opinion leadership and are near isolates in the social networks of their system. The two authors observe that laggards make their decisions based on the past and often are suspicious of new innovations.

Rogers and Scott (1999:7) identify the third way in which time is involved in diffusion as the rate of adoption. They define the rate of adoption as relative speed with which members of a social system adopt an innovation. They are of the view that, the rate of adoption is measured according to the number of members of the system that adopt the innovation in a given time period. Rogers in Lewis (1997:10) asserts that most diffusion studies have established that the diffusion of an innovation followed the s-shaped or sigmoidal distribution curve over time. This is indicated in the following figure:

Figure 2 Rate of Adoption



Source: Rogers, E.M. and Scott, K.L. The Diffusion of Innovations Model and outreach from the National Network of Libraries of medicine to Native American Communities P.5

The figure depicts an S –shaped or sigmoidal distribution curve. At first only a few individuals adopt a new idea (innovation), then the rate of adoption spurts as a large number of individuals accept the innovation, and finally the adoption rate slackens.

3.3.4 The social system

According to Rogers and Scott (1999:7) the fourth element in the diffusion of innovations theory is the social system. Rogers (1995:23) has defined a social system as a set of interrelated units that are engaged in joint problem solving to accomplish a common goal. He observes that members or units of a social system may be individuals, informal groups, organizations and subsystems. Although each unit of a social system can be distinguished from other units, all members co-operate to the extent of seeking to solve a common problem in order to reach a mutual goal.

Rogers and Scott (1999:7) assert that diffusion of innovation depends very much on the social structure of the organization and norms of its members. Accordingly, they defined norms as the established behaviour patterns for the members of a social system. Glanz, Lewis, and Rimer (1997:273) observe that some innovation may impact negatively on the social relationships of people in an organization if their characteristics and behaviour pattern is not considered. Rogers (1995:37) adds that the social or communication structure of a system can facilitate or impede the diffusion of innovations in the system. It is noted that change agents play a vital role in influencing clients' innovation decisions in a direction that is deemed desirable (Rogers and Scott 1999:8).

3.4 Application of diffusion theory to the study

This section examines the various elements of diffusion theory in context of this study.

3.4.1 Agenda Setting

There are always reasons for introducing an innovation in an organization. As rightly pointed out by Rogers (1995) the innovation process begins with agenda setting where one or more individuals in an organization identify an important problem and then seek an innovation as a means of coping with the problem. The author further observes that the problem usually emanates from a performance gap which is the discrepancy between how the organization is performing in comparison to its potential. He is of the view that the discrepancy is identified by members of the organization and is a strong impetus that compels them to search for an innovation to solve the identified problem.

The agenda setting in the Ministry of Agriculture and Rural Development (MoARD) was prompted by the problem of low agricultural production in Kenya. The main factor that contributed to low production was identified as lack of adequate information support to all stakeholders in agricultural research and extension. In mid July 1996 the MoARD commissioned a study to critically evaluate the existing information landscape, including information flow among actors involved in research and extension (Kenya, Republic of, MoARD, 1997:1). The study revealed information deficits due to ineffective agricultural information system. It recommended the establishment of the Agricultural Sector Information Network (ASIN) to acquire, process and disseminate information to the staff of the ministry and other stakeholders (Kenya, Republic of, MoARD 1997:26). The system was to be established at the ministry headquarters and networked directly via communication links to the branches at the provincial and district agricultural offices. It was further recommended that ICTs should be adopted to facilitate communication of agricultural information among all actors involved in research and extension. Similarly, the Kenya Agricultural Research Institute (KARI) found itself ill prepared to contribute to and benefit from cutting-edge information on technological innovations, and was therefore lagging behind (KARI 2002:46). In particular, KARI scientists were not receiving adequate support in terms of accessing reference materials, including scientific journals and databases relevant to their programmes. An Information and Technology Unit was, therefore, established to coordinate adoption and use of ICTs in the institution (KARI 2002:46). The policy makers at MoARD and KARI therefore identified ICTs (innovation) as a solution for improving communication of agricultural information. The innovation in this study is, therefore, ICTs.

The study looks at diffusion as a process by which ICTs (innovation) are communicated through certain channels (e.g. information literacy programmes) over time among agricultural researchers and extension workers (members) at KARI and MoARD (social systems).

3.4.2 ICTs as innovation

Agricultural researchers and extension workers previously used conventional communication channels to disseminate agricultural information to farmers and other stakeholders. Although the channels have been used widely they have been monologue and have not allowed much interaction. New ways of communication are being adopted via ICTs such as the Internet, email mobile phones, electronic sources among others. ICTs are, therefore, innovations that are perceived as new by both the agricultural researchers and extension workers and have been adopted to facilitate communication of agricultural information

Roger's theory of diffusion of innovations defines five attributes of an innovation which have been shown to affect the rate of its adoption in a society (Cullen 2001:6). The five attributes also known as characteristics are: relative advantage, compatibility, complexity, trialability, and observability. Perceptions of these attributes have been found to play a significant role in several information technology related studies (Larsen 1997:4). For example Surry (1993) studied the perceptions of weather forecasters in regard to innovative computer-based training and found relative advantage, complexity and compatibility as important adoption considerations. The five attributes are discussed below in the context of the present study.

3.4.2.1 Relative Advantage

The study investigated whether the respondents perceived the use of ICTs in communication of agricultural information as better than the previous mode of communication. It sought to establish the convenience and satisfaction of using ICTs by the respondents as opposed to conventional methods. The rate of adoption of innovations also depends on social prestige. It is assumed that ICTs such as the Internet, email and mobile phone were adopted faster by the respondents due to social status and environment that compels one to keep pace with the technological changes. The change agents, in this case, librarians and IT personnel must also demonstrate to the respondents the relative advantage of new ICTs tools and services over previous means of obtaining and communicating agricultural information. Rogers and Scott (1999:8) observe that the greater the perceived relative advantage of an innovation among individuals, the more rapid its rate of adoption will be.

3.4.2.2 Compatibility

The study sought to establish whether the adopted ICTs in the agricultural sector were consistent with the values, experiences and needs of agricultural researchers and extension workers. In this case the institutions had the obligation to manage changes that were brought about by the new technology. This could be achieved through continuous provision of information literacy programmes. It was also assumed that use of ICTs had been affected by behavioural attitudes and social and economic factors. The study sought to find out if the respondents' information needs were met via ICTs. Rogers and Scott (1999:6) caution that adoption of an incompatible innovation often requires the prior adoption of a new value system, which is relatively slow process. The adoption rate of ICTs diffusion would, therefore, depend on good skills, value attached to these technologies and responsive content.

3.4.2.3 Complexity

The study sought to establish whether agricultural researchers and extension workers perceived ICTs as complex tools requiring new skills and knowledge. In a study conducted by Ayoo (2000:123) it was established that the Internet use among industrial researchers in Kenya was yet to realise its full potential because of lack of computer and Internet literacy skills. Rogers and Scott (1999:6) note that new ideas that are simpler to understand are adopted more rapidly than innovations that require the adopter to develop new skills and understanding. It is assumed, therefore, that ICTs such as the mobile phone could be adopted faster than the Internet since it does not require much skill to use.

3.4.2.4 Trialability

Information and Communication Technologies (ICTs) such as the Internet, email, electronic sources require gradual introduction to users to allow acquisition of necessary skills and knowledge at point of need. Information literacy programmes should, therefore, be offered in instalments to allow agricultural researchers and extension workers to gradually acquire the necessary skills and knowledge. The study believes that such a process would prepare the respondents with adequate skills and knowledge to cope with the new changes. An innovation that is trialable represents less uncertainty to the individual who is considering it for adoption, who can learn by doing (Rogers 1995:243).

3.4.2.5 Observability

Observability is an attribute which can be "seen" in the process of being used or tried by others and indicates whether an innovation has relative advantage and is compatible (Lewis 1997:13). It is assumed that observation and peer discussions facilitated the adoption and use of ICTs by agricultural researchers and extension workers. The more the respondents used the Internet and email, for example, the more its rate of adoption.

3.4.2.6 Reversibility

Innovations such as ICTs require good amount of initial capital investment for hardware and software and in developing human resource capacity to manage and maintain the technology effectively (O'Farrell and Norrish 1999:2). Accordingly, discontinuing ICTs diffusion in an organization may lead to a great financial and capital loss. The policy makers at KARI and MoARD should, therefore, plan carefully before adopting a particular type of ICTs. The planning should involve financial and human capital to sustain ICTs in the long run. Many donor funded projects have often stalled because of lack of planning, and monitoring and evaluation mechanisms.

3.4.2.7 Risk and uncertainty

Adoption of ICTs requires heavy investment, which may interpret to mean taking high risks. The situation is more volatile in most African countries where the infrastructure may require a face-lift and the need to develop human resource capacity to manage and sustain the technology. The study was interested in establishing the risks and uncertainties involved in the adoption of ICTs at KARI and MoARD.

3.4.2.8 Commitment Required

The success of any ICTs project depends on the adopters' commitment. This study sought to establish the degree of commitment of KARI and MoARD towards the management and coordination of ICTs diffusion. The commitment required is in the provision of adequate funds, development of human capacity to manage and use ICTs, and formulation of ICT policy to guide the diffusion process.

3.4.2.9 Modifiability

Accenture, Markle and UNDP (2001:1) report on 'lessons learned from specific interventions' underscores the importance of designing and shaping ICTs to be demand-driven and meet the needs of the target population. There is need, therefore, to evaluate and identify appropriate ICTs that can meet the demands and needs of agricultural researchers and extension workers. Modification may involve developing interfaces to make the systems to be more user friendly and also developing content that is relevant to agricultural researchers and extension workers.

3.4.3 Communication Channels

Rogers (1995:18) asserts that different communication channels play different roles at various stages in the innovation-decision-process. This investigation sought to establish the communication channels used in the process of ICTs diffusion among agricultural researchers and extension workers. It examined the information literacy programmes in place and how they are being conducted. The change agents who in this case are the librarians and IT personnel play an important role in training the respondents to be competent in using the adopted ICTs. The training sessions could be on-one-to-one basis or in groups. Innovations such as ICTs and in particular the Internet requires highly developed skills to access and interpret information (Cullen 2001:2). It is, therefore, important to impart the requisite skills to the respondents so that they can be able to effectively utilize the technology.

This study assessed the communication structures/or networks within KARI and MoARD and how they were being used in channelling ICTs diffusion. Such structures include local and wide area networks and other communication links in place.

3.4.4 Time

The policy makers at KARI and MoARD realised that lack of inadequate information support was due to ineffective agricultural information system. Consequently, they instituted measures to improve the situation by adopting use of ICTs in communication of agricultural information. This process took time to conceptualize, plan and implement. Similarly, acquisition of the requisite ICT skills among agricultural researchers and extension workers is a process of gradual growth and so is the ICT use. The rapid growth will only occur when more respondents are ICT literate. This growth is expected to stabilize when the majority of the respondents are able to use ICTs and in particular the Internet, email and electronic sources. The rate of adoption of ICTs among agricultural researchers and extension workers can therefore be graphically represented by Roger's S-shaped or sigmoidal curve.

This study is of the view that the innovation-decision-process is essentially an information seeking and information processing activity in which the individual is motivated to reduce uncertainty about advantages and disadvantages of ICTs (innovation). In other words the policy makers, agricultural researchers and extension workers sought information to reduce uncertainty on ICTs potential and use during the innovation-decision- process.

Rogers and Scott (1999:6) define innovativeness as the degree to which an individual or other unit of adoption is relatively earlier in adopting new ideas than other members of a social system. They categorised the adopters into five groups namely: innovators, early adopters, early majority, late majority and laggards. Innovators are the risk takers and pioneers who adopt an innovation very early in the diffusion process (Surry 1997:3). In this study innovators played an important role in the diffusion process by launching the use of ICTs at KARI and MoARD. Such individuals may include IT personnel, librarians, agricultural researchers, extension workers, and policy makers who also played the role of gate keeping and channelling of information about ICTs into their institutions. According to Rogers and Scott (1999:7) they are usually the first 2.5 per cent of individuals in organizations to adopt the innovation.

The early adopters were the next to adopt ICTs at KARI and MoARD. They are individuals who maintain a central position in communication networks and would always make judicious innovation decisions. Such individuals are often outgoing and ahead of others. They are usually respected by their peers, and are the embodiment of successful, discrete use of new ideas. At KARI and MoARD such individuals may be heading research centres or agricultural offices and because of their proactiveness, they are likely to have initiated the adoption of ICTs earlier than others. They could also be heads of departments or even individual agricultural researchers and extension workers. Early adopters play an important role in influencing others by conveying subjective evaluation of ICTs (innovation) to near-peers through interpersonal networks. They may have consisted of 13.5 per cent of the population at KARI and MoARD.

The early majority are categorised as those respondents who may deliberate for sometime before completely adopting ICTs such as the Internet, email and electronic sources.

Rogers and Scott (1999:7) are of the view that early majority may be willing to adopt an innovation, but opt for others to lead the way. Accordingly, they say, the early majority consist of 34 per cent of the individuals in an organization.

The late majority in this study represent those respondents who are sceptical and cautious to adopt and use ICTs until the majority have done so. They will only adopt and use after increasing pressures from colleagues. Often other factors such as behavioural attitude, social and economic status and lack of skills slow or impede their adoption and use of ICTs. According to Rogers (1995) the late majority consist of 34 per cent of individuals in an organization.

The laggards are agricultural researchers and extension workers who are resistant to ICTs adoption and use in the agricultural sector. They may resist due to limited resources or because of their past experience. This group are usually suspicious of change agents who may include IT personnel, librarians and probably policy makers. Because of uncertainties of the new changes some may opt for a 'wait and see' attitude.

3.4.5 The social system

The Kenya Agricultural Research Institute (KARI) and the Ministry of Agriculture and Rural Development (MoARD) are regarded as the social systems in this study. These institutions have a set of interrelated units consisting of agricultural offices, research centres, divisions and departments. The staff members in these units work according to the established mission of their respective institutions and, therefore, share the common objective that binds them together. KARI and MoARD are working together towards solving the problem of low agricultural productivity in the country. Lack of adequate information support to actors involved in research and extension has been identified as a major cause of low agricultural production. Consequently ICTs were adopted to improve information flows and communication of agricultural information between and among all actors. Rogers (1995:37) notes that the social or communication structure of a system could facilitate or impede the diffusion of innovation in a system. KARI and MoARD have established information divisions within their structures to coordinate information activities within the respective institutions. In chapter two, agricultural knowledge and information systems in the two institutions have been discussed showing their implications in the provision of agricultural information to agricultural researchers and extension workers.

Calvo and Rahrig (1999:2) caution that person(s) introducing an innovation in a social system should take into consideration the characteristics of the target population and the innovation itself. Accordingly, they assert that knowing these characteristics provides for proper planning to avoid disruptive effect on the social environment. These views are shared by this study which established the characteristics of agricultural researchers and extension workers and showed their relationships in the application and use of ICTs. Those introducing ICTs to KARI and MoARD are expected to have considered the demands and needs of the respondents in order to match them with appropriate ICTs. The study also investigated how the staff were trained on use of ICTs. Rogers and Scott (1999:7) explains that a change agent is an individual who attempts to influence clients' innovation-decisions in a direction that is deemed desirable by a change agency. In this study, policy makers, IT personnel, librarians are considered as important change agents with the responsibility of facilitating the adoption and use of ICTs.

Redefining or restructuring is the stage at which the innovation is modified and re-invented to fit the situation of the particular organization and its perceived problem (Rogers 1995). This concurs with the views of Larsen (1997:1) who observes that adopters of ICTs usually mould the innovation in accordance with their own perceptions and needs. The study sought to establish how KARI and MoARD are moulding or redesigning ICTs to suit the needs and demands of agricultural researchers and extension workers. These may include development of interfaces, in-house databases and also networking of offices to facilitate information flows among the staff. This is what Rogers (1995) refers to as altering organizational structures to accommodate the innovation. The study assumes that the ultimate goal of KARI and MoARD is to put ICTs into full and regular use to the point where they become part and parcel of institution ongoing activities.

3.5 Shortcomings of Diffusion of Innovations Theory

Rogers (1995) argues that although diffusion research has made numerous important contributions in understanding human behaviour change, its potential would have been even greater had it not been characterized by shortcomings and biases. The author identify pro-innovation bias as the most serious shortcoming of the theory. He pointed out that this was the implication in most diffusion research that an innovation should be diffused and adopted by all members of a social system. He further observes that most researches held the view that innovation should be diffused more rapidly, and that it should neither be re-invented nor rejected.

Furthermore, Rogers (1995) contends that pro-innovation bias is caused by change agencies that fund much of diffusion research with the aim of promoting an innovation. The author identified the second cause as being where most diffusion researchers investigate successful diffusions, leaving those, which are not successful. He attributes this to the fact that successful innovations usually leave a rate of adoption that can be retrospectively investigated by diffusion researchers, while unsuccessful diffusion does not leave visible traces that can be easily studied.

Rogers (1995) suggests that the problem of pro-innovation bias can be overcome by investigating an innovation while the diffusion process is still underway. He observes that such an in-process diffusion research design allows a scholar to investigate less successful as well as more successful cases of innovation diffusion. These views are shared by the present study which investigated diffusion process of ICTs in the agricultural sector in Kenya. In particular, it focused on KARI and MoARD, where ICTs diffusion is still in progress. Besides, ICT diffusion is an on-going activity that needs to be evaluated from time to time and improved according to the changing needs of the users. The study investigated both successful and unsuccessful ICTs adoption in the agricultural sector. It established whether the adopted ICTs were meeting the needs of agricultural researchers and extension workers. It investigated cases where particular type of ICTs had been modified or re-invented to suit the demands and needs of agricultural researchers and extension workers. The shortcomings of diffusion of innovation theory, therefore, did not affect this study.

3.6 Summary

The chapter has discussed the diffusion of innovation theory chosen as the theoretical framework of the study. The four key elements of the theory have been described in detail. The applicability of the theory to the study has been discussed showing how each of the key elements fitted into the study. These elements include innovation, communication channels, time and social system. ICTs represent innovation in this study. The attributes determining innovation's rate of adoption have been discussed in context of the study. These include relative advantage, compatibility, complexity, trialability, observability, reversibility, risk and uncertainty, commitment required and modifiability.

The strengths and shortcomings of the theory have been highlighted. The theory was found to be suitable as a framework of the study as it has potential application to information technology. It has been used as the theoretical framework for a number of information systems projects that include diffusion of hardware and software packages. It has also been widely applied to investigate diffusion of agricultural innovations. Thus the theory's application to information technology and agriculture made it the most appropriate theoretical framework of the study. The shortcomings of the theory have been examined indicating how these did not affect the study.

The next chapter reviews literature related to the study.

CHAPTER FOUR

LITERATURE REVIEW

4.1 Introduction

This chapter reviews the literature related to the study. According to Mgenda and Mgenda (1999:29) the review of literature involves the systematic identification, location and analysis of documents containing information related to the research problem being investigated. In this connection the chapter reviews literature in the following areas: potential of ICTs with specific emphasis on communication of agricultural information; ICTs and socio-economic development; ICTs and linkages between agricultural researchers, extension workers and farmers; information needs, access and utilization of ICTs; adoption and diffusion of ICTs; mapping and auditing of ICTs; ICT policies; sustainability of ICTs and digital divide.

The use of Information and Communication Technologies (ICTs) has great potential to improve and enhance the process of agricultural technology transfer and for improving productivity in agriculture (Ajit 2003:1). A similar sentiment is shared by Vernon (2001) who observes that the use of ICTs will improve the efficiency of the agricultural process thereby benefiting the farmer. This view is consistent with Munyua's (2000:2) observation that ICTs have the potential of getting vast amounts of information to rural population in a more timely, comprehensive and cost effective manner. She argues that although the Internet is not a panacea for food security and rural development problems, it can open new communication channels that bring new knowledge and information resources to rural communities. A CTA (1998:13) seminar on "the role of information for rural development in ACP countries" concluded that "these modern technologies offer new and multiple perspectives, such as faster and better focused access to information."

Ajit (2003:1) asserts that in developed countries, ICTs have enabled automation and decision making in many agricultural operations. He observes that this has resulted in optimal utilization of resources such as water, soil nutrients, energy and labour. He is of the view that ICTs have transformed agriculture by providing greater control over production and market supply chains bringing in many instances just-in-time approaches to cultivation, harvesting, processing, transport, marketing, and consumption. In contrast, Richardson (2003:1) argues that in developing countries, despite a high demand for ICT services and a growing telecommunication market, access to basic services such as voice telephony remains a major concern. He remarks that while the rest of the world is moving quickly into an Internet dominated world of ICTs, most rural Africa was yet to enjoy these facilities. Munyua (2000:2) underscores the importance of connecting rural communities, research and extension networks to provide access to the much needed knowledge, technology and services.

World Bank in Richardson (2003:8) evaluated extension approaches used in developing countries including the dominate training and visit system (T&V) and found that the approaches were not meeting farmers demands. As a result there has been a shift to demand-driven extension. Lightfoot (2003:2) advances the view that demand-driven extension service involves the partnership between government and the private sector. Richardson (2003:8) adds that it is a shift from public sector extension delivery to a negotiated system through which farmers and rural community members determine their needs and have some control over the financing of extension services delivered by public, private, and NGOs. He is of the view that demand-driven extension opens the door for examination of how ICTs can be cost-effective and practical tools for facilitating and channelling farmers' demands. This perspective is in line with CTA (2003:2) view that extension agents (whether public servants, private input providers or NGO staff) as intermediaries between farmers and other actors in the agricultural knowledge and information system, are especially well-placed to make use of ICTs to access expert or other types of information.

The use of ICTs in agricultural research and extension for rural development has immense potential to benefit National Agricultural Research System (NARS) shakeholders (Balit 1998:29). This view is shared by Ajit (2003:1) who remarks that the forces of globalisation of trade in agricultural commodities and consequent changes in national agricultural policies are affecting national agriculture and, in turn, are making the NARS renew their mandates. The author argues that with the renewed mandates, NARS have new stakeholders that enlarge and increases the complexity of the information required. He suggests that NARS need to use ICTs to integrate its information sources and services. NARS, extension services and other stakeholders should therefore embrace ICTs to provide the link and enable better access and sharing of agricultural information.

Aina (1995) in Nkhata (2000:202) has defined agricultural information as all published and unpublished knowledge on all aspects of agriculture. He observes that agricultural information is inter-disciplinary in nature as agriculture itself. He categorised agricultural information to include the following:

- Technical/scientific information that emanates from research and development work carried out in various agricultural research institutions and universities.

- Commercial information that covers credits and co-operatives, national and international market prices.

- Social/cultural information that encompasses traditional information on agricultural practices, local cultures, background information on farming communities, labour availability and related information.

- Legal information that includes all legislation affecting agriculture such as land tenure, the production, distribution and sales of agricultural produce.

CTA (2003:3) is of the view that different actors in research and extension have different kinds of information needs and communication problems, and different access to ICTs. The author argues that ICT potential for improving information flows among the actors will vary greatly between different countries and regions.

4.2 ICT Potential

Adeya (2001:3) has identified the main characteristics defining the period of rapid technological developments and information revolution as the twin concepts of globalization and information economy. Pigato (2001:1) adds that, the current wave of globalization and the trend towards worldwide integration of markets is spurred by the development of ICTs including the Internet, mobile phones, and satellite networks. Adeya (2001:3) asserts that ICTs transformation embodied social, economic political, technical and cultural processes, and affects all sectors of the economies. Mugabe (2001:3) is of the view that ICTs are creating faster ways of acquiring, storing and disseminating information. He argues that ICTs are breaking barriers to knowledge and integration into global economy. The author is of the view that the rapid technological developments are creating public expectations, anxiety and uncertainty. Similar sentiments are shared by Pigato (2001:3) who contends that ICTs have the potential to process and disseminate vast amounts of information and therefore can have greater impact on the lives of people. In contrast, Caspary (2002:4) cautions that there is little empirical evidence of the supposed enormous developmental impacts of ICTs. Adeya (2001:3) emphasizes that ICTs only provide new mechanisms for handling an already existing information resource. Pigato (2001:3) cautions that ICTs is not a goal but a means of achieving the goal.

The African Development Forum (Post ADF Summit) underscores the need to accelerate African development through the increased use of ICTs (Economic Commission for Africa 2001). Participants of the summit identified the major concern often voiced by national policy makers when considering allocating resources to the use of ICTs. This was the question of "why use scarce funds on new and unfamiliar technologies when needs for basic services such as fresh water and classrooms are not yet met?" The participants addressed this question by giving it a threefold answer (ECA 2001:2):

- ICTs are an enabling tool with a multiplier effect which can cut the costs, improve the quality and speed the, delivery of basic infrastructure and services;

- ICTs offer many opportunities for rapid economic growth which will ultimately provide more finance for the many demands on the government coffers;

- ICTs have the potential to fundamentally transform the way governance operates, improving the ability of marginalised groups to participate across the spectrum - from the local grassroots level, to national governments and the regional and global forums which have insufficient representation from the south (ECA 2001:2)

The threefold answer stresses the ICT potential and capabilities of ICTs. The summit concluded by reemphasising the need for policy makers in Africa to create an enabling policy and regulatory environment to ensure that ICT infrastructure was put in place for the benefit of all sectors of society and economy (ECA 2001:4).

The sentiments of Economic Commission for Africa (ECA) are shared by Accenture, Markle and UNDP (2001, section 2.1.1: 1) who identified the unique characteristics of ICTs as follows:

- ICTs are pervasive and crosscutting. Thus, ICTs can be applied to the full range of human activity from personal use to business and government.

- ICTs foster the dissemination of information and knowledge by separating content from physical location. This flow of information is largely impervious to geographic boundaries allowing remote communities to become integrated into global networks.

- ICTs power to store, retrieve, sort, filter, distribute and share information seamlessly can lead to substantial efficiency gains in production, distribution and markets.

- The increase in efficiency and subsequent reduction of costs brought about by ICTs is leading to the creation of new products, services and distribution channels within traditional industries.

- ICTs facilitate disintermediation, as it makes it possible for users to acquire products and services directly from the original provider, reducing the need for intermediaries.

- ICTs are global. Through the creation and expansion of networks, ICTs can transcend cultural and linguistic barriers by providing individuals and groups the ability to live and work anywhere.

According to Accenture, markle and UNDP (2001) the above characteristics makes ICTs to be powerful enablers of development.

Accenture, Markle and UNDP (2001, section 2.1.1:1) argue that ICTs have capabilities for improving communication and exchange of information and ultimately strengthening and creating new economic and social works. Ajit (2003:4) adds that ICTs such as computers, cellular telephony and the Internet, enable the use of multiple and mixed media enabling broader and richer communications. He observes that cellular telephony, in addition to audio messaging, enables text based short messaging services and transmission of video images. The Internet, he says, enables the use of multiple media that include text, graphics, audio, video and tactile. These sentiments are shared by Atibila and Odame (2003:3) who are of the view that radio and televisions stations linked through telephony and the Internet enable mixed media use in messaging offering listeners and viewers to use email, telephone to connect to the broadcasting station. Accenture, Markle and UNDP (2001 section 2.1.1:1) observe that ICTs have potential of facilitating global connectivity, resulting in new ways of creating and delivering products and services on a global scale. They argue that the potential of ICTs provide developing countries with access to new markets and new sources of competitive advantage from which to drive income growth. They caution that ICTs can only be conceived as a means and not an end in itself.

In case studies carried out by Accenture, Markle, and UNDP (2001, section 2.2.6, p: 1) to assess the impact of ICTs on development found that it was important for national strategies on ICTs to have explicit development focus. Consequently, it observed that there should be strong linkages between ICTs interventions and national level programs. In order to achieve this, the study underscores the need for a framework for deploying ICTs for development and to prioritise ICTs interventions, identify synergy's, maximise development impact and co-ordinate the actions of stakeholders. Such a framework can assist developing countries such as Kenya to embark upon bold strategies to harness the power of ICTs for the benefit of all the citizens.

4.3 ICTs and socio-economic development

According to Pigato (2001:3) global knowledge is becoming increasingly important in promoting economic growth through higher competitiveness, and enhancing human development and reducing poverty. The view is supported by the findings of a research conducted within the Asia-Pacific region (Kraemer & Dedrick (1998), which indicates that countries with higher levels of annual growth in ICT consumption such as Thailand, South Korea, India and Taiwan exhibited the highest levels of growth in productivity and Gross Domestic Product (GDP). The authors observe that research in India between 1984 and 1990 shows a strong correlation between growth of ICT consumption, productivity and GPD. They contend that within this period India achieved an average growth rate of 22.21% per annum in IT-related investment. In a similar study in the United States titled "US, Digital economy 2000" it concluded that the production and use of information technology had contributed half or more of the acceleration in U.S. productivity growth in the second half of the 1990s.

Ajayi (2002:2) is of the view that ICTs are now regarded as utility such as water and electricity and hence have become major factor in socio-economic development of every nation. Zongo (2001:6) observes that the advancement of ICTs in Africa is both an opportunity to overcome inherent and historical disabilities in the economies of the region, and a challenge to ensure that these countries do not get left even further behind the developed world. This view concurs with Adeya (2001:7) who observes that the economic gap between Africa and the rest of the world will continue to widen unless African countries grasp the opportunities and potential of ICTs to accelerate socio-economic developments. Oguya (2001:1) cautions that the exclusion of developing countries from global information society would have severe implications for their societies and economies. She argues that for sub-Saharan African countries to leapfrog many stages of development and close the digital divide they need to adapt and exploit the opportunities offered by ICTs in acquisition, storage and dissemination of information. Zongo (2001:6) contends that ICTs present an opportunity to those who can respond to the new paradigm and a threat to those who cannot. He argues that although the immediate returns of investment in ICTs may not be readily apparent, the long term positive impacts on social and economic development cannot be ignored. These views concurs with those of Pigato (2001:4) who analysed several studies on ICTs and investment and came up with three important observations concerning the impact of ICT diffusion. He outlines them as follows:

- First, there is a significant time lag necessary for benefits to accrue -possibly spanning many years or decades. Diffusion of ICTs must achieve a 'critical mass' in terms of coverage, organizational adaptation and learning by doing before widespread productivity gains become observable.

- Second, organizational and management changes, including redesigning and development of new business or organizational cultures, are important factors in diffusion of ICTs. Productivity gains do not arise directly from the technology, but from associated improvements in worker productivity that come from changes in systems, procedures, skills and attitudes.

- Third, a large proportion of the benefits of ICTs are not directly measurable - including product and service improvement factors relating to quality and choice (Pigato 2001:5).

Pigato (2001:5) is of the view that the above non-economic variables of ICT diffusion are likely to be of greater importance for countries in a nascent stage of technological development where practitioners are at early stage of learning by doing.

4.4 ICTs and communication of agricultural information

Adeya (2001:7) asserts that ICTs will lead to decreased costs of access and dissemination, and therefore aid rural development by increasing agricultural development. This sentiment is supported by Accenture, Markle and UNDP (2001, section 2.2.3) study that investigated the role of ICTs in rural development in developing countries such as Tanzania, Gambia India, Chile, Brazil, Malaysia and Costa Rica among others. The authors are of the view that ICTs could enhance rural productivity by enabling local communities to access practical information on small business, weather trends and farming best practices. They established that timely access to market information via communication networks helped farmers make astute decisions about what crops to plant and where to sell their produce and buy inputs. They cited the example of Chile where Internet networks among farmer organizations has dramatically increased farmers incomes by providing information about crop status, weather, global, market prices and training.

The above findings are shared by Esaku (2002) who reports of a project by World Space Corporation of USA, which, in 1998 installed a satellite, Afrisat station in Gabon. He observes that World Space in collaboration with NGOs which include the World Vision are able to provide weather information using a satellite antenna, and a digital radio receiver that picks signals from satellite Afrisat, stationed over Gabon in West Africa. The author reports that through the project farmers in the remotest part of sub-Saharan Africa could now access agro-meteorological information. He observes that apart from the climate and weather information the farmers were also provided with information on agriculture, food processing, animal husbandry, water sanitation, environment and health. Some beneficiary farmers in Uganda, had this to say "the quarterly weather forecast helps us know what crops to plant and when", while another observed "I learned many things, such as making compost manure and how to rear rabbits" (Esaku 2002:1). The author observes that agricultural information was also passed on to extension workers, local chiefs and radio stations such as Rock FM in Tororo for wider dissemination. However, there is need for more empirical data on the extent of use of these ICT facilities by extension workers and farmers.

Quek and Eyzaquire (2001) report on the innovative uses of ICTs at the International Plant Genetic Resources Institute (IPGRI) based in Italy with regional offices in many countries. They observe that ICTs were used to collect and propagate local biodiversity content. They advance the view that innovative uses of ICTs enabled IPGRI and its partners to help farmers promote the documentation and sharing of Indigenous Knowledge (IK) within and across local communities. As part of these efforts an IK journal was introduced to enable farmers to compile papers in collaboration with visiting scientists. Quek and Eyzaquire (2001) point out that the IK journal provides a means to recognize the contributions of farmers through citation of their knowledge by scientists. The ICTs used in the project include simple battery operated tape recorders; video cameras to record traditional technologies; radio to disseminate knowledge within and outside the communities; computers to store and provide access to the local information; and the Internet to market their indigenous products and share their knowledge. The reports by Esaku (2002), Quek and Eyzaquire (2001) indicate that a combination or cluster of ICTs can be applied successfully in the acquisition, processing, storing, and disseminating information to rural communities including farmers. These findings are shared by Chowdhury (2000:7) who observes that a cluster of ICTs innovations experience stellar diffusion, especially in developed countries, with the larger among developing countries now catching up.

4.4.1 Use of ICTs to improve linkages between agricultural researchers, extension workers and farmers

According to Munyua (2000:4) weak linkages between researchers, extension workers and farmers have been a major constraint that has resulted in research findings not being applied by rural farmers. This view is consistent with the argument advanced by Kassam and Odame (2002:2) that the full potential of agricultural research is not being realised because communication between scientists, extension workers and farmers throughout the developing countries is weak. Similar sentiments are shared by FAO (2002:1) who observes that weak linkages between extension and research often result in systematic knowledge and "information bottlenecks" and limit the effectiveness of research to contribute to agricultural development. FAO (1996:2) suggests improved linkages and integration between all the stakeholders in agricultural production. The author observes that such a linkage would provide for an effective and efficient transfer of technology to the farmers. Munyua (2000:4) asserts that ICTs can improve and strengthen these linkages and ensure knowledge and information, which are essential for improving food security are communicated to all stakeholders.

Several ICT models have been developed to improve the linkage between researchers, extension workers, farmers and other actors involved in research and extension. The next section reviews some of the models. FAO (2002:1) is of the view that the new Internet-based ICTs provide a potentially powerful tool for improving communication between research, extension and farmers. In this connection FAO through its Research, Extension and Training Division and the World Agricultural Information Centre (WAICENT) have developed a prototype network - the Virtual Extension, Research Communication Network (VERCON), which is an Internet based tool. The concept of VERCON is aimed at strengthening linkages among and between human and institutional elements of agricultural research and extension systems (FAO 2002:1). The Internet tool allows networked members to capture and develop local content, share, store, retrieve and disseminate information and connect geographically dispersed people from research and extension institutions, faculties of agricultural education, NGO workers and agricultural producers (FAO 2002:2). VERCON uses Internet standards and is accessed through the

Internet, or using a combination of CD-ROM and Internet, depending on the specific situations. The author observes that the tool can facilitate communication, sharing information and supporting improved agricultural production and can further broaden and strengthen collaboration through facilitating co-ordination of rural, local, national and regional development programmes. VERCON has been applied in Egypt to improve the linkage between and among researchers, extension workers, farmers and other actors (O'Farrell 2003:15). According to O'Farrell the system has improved the linkages and provided two-way horizontal and vertical communications among actors involved in agricultural research and extension.

Van Crowder and Fortier (2000) report of the Farmer Information Networks (FARMNets) which is an ICT- based project initiated by FAO in Latin America. The project involved agricultural producers and farmer associations, extension services and NGOs in Chile and Mexico. The authors point out that the essential information on inputs, prices, markets, weather and credit are exchanged through the electronic network (via the Internet) to farmer organizations, co-operatives and local government. An evaluation of the project by Balit (1998) indicates that the Internet was found appropriate for transmitting information across the network. Farmers and their associations were able to sell their produce at much higher prices than they could fetch in the local market and strategize on what quantities and when to produce. It was established that users of the centres found the Internet to be a cheaper, timely and appropriate option. The author argues that knowing the future prices of cereals and oilseeds enabled the association to better plan the quantities to plant. In addition vegetable producers reported that the information on weather conditions informed them of climatic conditions faced by competitors in other states and countries. This information enabled farmers to plan for markets for their products. It was also established that the Chilean network had developed and published local content on its' web site with most of the information in Spanish. This made it more accessible to the entire Lusophone community.

Bernard (2003) reports of the Rural Universe Network (RUN) system developed by the German Centre for Documentation and information in agriculture. According to Bernard (2003) RUN promotes the use of Internet technology in rural areas and develops tools that facilitate communication and information management. It is a web publishing system that allows the creation of e-journals in agriculture. The major objective of the RUN is the improvement of the availability of local knowledge and information as well as the communication system. This system is currently being tried by the Caribbean Agricultural Research and Development Institute (CARDI) (Caribbean Agricultural Information Services, 2002:1). There is need to evaluate the system and asses its impact in bridging information gap among actors in research and extension.

Manhertz (2003) reports on the Jamaica Agricultural Marketing Exchange (JAMEX) system that was developed in respond to the major marketing challenges confronting domestic agriculture. According to the author, the system provides practicable and implementable solutions, drawing on the knowledge and background of the main functionaries and beneficiaries comprising the market value-chain. JAMEX is a web-based Internet tool integrated into two platforms, the Jamaica trade website and the Agricultural Business Information System (ABIS). The author is of the view that the two complementary Internet facilities make it possible for JAMEX to allow for the secure communication of real time market intelligence as well as actual product information to various stakeholders in the value market chain. However, no empirical evidence is provided on the extent of use of the system. It is assumed that JAMEX is still on trial basis and its impact is yet to be assessed.

Annerose (2003) reports of MANOBI system in Senegal that uses mobile phone and Internet platform to provide multi-channel services to farmers, extension workers, exporters, suppliers, fishermen, middlemen and women. According to the author, the system has been designed to provide low-cost innovation multi-channel services within any mobile and fixed telecom network and Internet infrastructures. The system provides market information, access to credit, bidding, negotiations and transactions. It also provides communication services such as email, news, message board, and alerts. According to the author, the system has improved relationships between farmers and actors involved in research and extension. It has strengthened the farmers' role in negotiations and transactions and has also provided better market opportunities. The author is of the view that the system has created a common interest in the market value chain. MANOBI was recently voted as the best e-content and creativity from around the world in the e-inclusion category in the World Summit on Information Society held in Geneva in December 2003. This exemplifies the potential of the system in improving the linkage and communication among the farmers, extension workers, financial and credit organizations, stockists and traders in agricultural products, exporters, and researchers.

4.4.2 Electronic agricultural information sources

Nkhata (2000:203) posits that institutions, organizations and government throughout the world recognize the importance of information in the improvement of agricultural production. The view held in this discussion is that this can be seen in the numerous activities aimed at improving provision of agricultural information in various parts of the world. These sentiments are shared by Munyua (2002:5) who observes that the rapid development of ICTs is generating agricultural information in various electronic formats. She noted that various local, national, regional and international organizations have developed useful information resources (statistical, bibliographical and full-text) which are of relevance to researchers, extension workers, farmers and other actors in research and extension. Kebede (2000:94) asserts that development of electronic information resources have changed the way library and information systems store, access, process and disseminate information. McMurdo in Kebede (2000:94) identifies a number of changes in library and information systems resulting from developments in electronic information resources, including instantaneous delivery of information, provision of multiple copies, multiple access to a single copy, and new less non-linear readership. Provision of electronic information resources is also affecting the way users seek information. According Kebede (2000:94) unique requirements, from user's point of view comprise of availability and access to these resources. Chowdhury (2000:3) adds that the users should posses the requisite ICT skills in order to effectively use the technologies.

Electronic information is packaged in a cluster of technologies that include print, audiotapes, microfiche, radio and television programmes, videos, CD-ROMs and on the World Wide Web (Nkhata 2000, Munyua 2000:5, Chowdhury 2000:11). Riggs (2001:159) observes that FAO through its World Agricultural Information Centre (WAICENT) web site makes available many FAO's published sources, including FAOs Global Information and Early Warning System (GIEWS), the AGRIS and CARIS databases, and FAO Statistical database. Munyua (2000:5) identifies other electronic database producers to include Commonwealth Agricultural Bureaux International (CABI), Royal Tropical Institute (KIT), The US National Agricultural Library (NAL), The Centre de Co-operation Internationale en Recherche Agronomique pour le Development (CIRAD) and the American Institute for Cooperation on Agriculture (IICA) among others. Oguya (2003:5) reports that CABI has developed multimedia encyclopaedic database which contains information on 1560 pests and natural enemies. She is of the view that the compendium contains economic and statistical databases, quarantine aids, a glossary and soft linking system allowing logical connection to be made from any piece of text.

Munyua (2000:5) points out that the Consultative Group for International Agricultural Research (CGIAR) has produced several multimedia products and institutional databases which could be very useful to extension workers and literate farmers in the rural areas. She single out the Agricultural Internet Users Association (AIUA http://www.aiua.org) as the most important web resource designed to help the exchange of information among Internet agricultural community. Examples of these research institutions include the World Agroforestry Centre (ICRAF) that has produced forestry compendium called Agroforestree database, and Botanical Nomenclature database, Prunus Net and Marula Net (www.worldagroforestrycentre.org). The International Livestock Research Institute (ILRI) has produced ILRI publications database containing information on animal health, diseases and management (www.cgiar.org/ilri/info/databases.cfm).

Oguya (2003:4) asserts that a project that has taken advantage of the strengths and capabilities of CD-ROM's in the storage and dissemination of data is the TEEAL (The Essential Agricultural Library) database initiative. The TEEAL database is an agricultural library on CD-ROM that is a complete stand alone system. It is a project initiated by the Albert Mann Library of Cornell University in association with the Rockefeller Foundation and co-operating publishers (Oguya 2003:4, Nkhata 2000:205). The database contains over 750,000 full text articles from 141 journals in agriculture and related field. It is available to only developing countries at a subsidised cost of $10,000 as opposed to the real cost of acquiring the hard copies which would cost $375,000. Oguya (2003:5) observes that researchers and other users have found the database to be very useful. She argues that a researcher can find information on the topic of research, the complete article of the citation and can keep up to date by browsing through the journals. More empirical evidence is needed on the uses of these databases and the present study attempts to fill this gap.

FAO is playing a major role in helping developing countries to manage local scientific and technical agricultural information. Munyua (2000:7) suggests that FAO could work with relevant producers and disseminators of agricultural knowledge and information to develop standards for managing information and knowledge targeted for various categories of users. She is of the view that FAOs' multilingual thesaurus (AGROVOC), classification scheme and guidelines for bibliographic analysis has been adopted and adapted widely in developing countries for managing agricultural information. The author suggests that AGROVOC could be harmonised with other existing standards (such as CABI's and UNEP's), in processing and indexing agricultural information at national level and on the World Wide Web. It is envisaged that standardisation would facilitate the pooling of relevant resources from different communities on the Internet. She observes that intermediaries could then tap these resources and repackage the information in different media to suit the needs of the users.

4.4.3 Information needs, access and utilization of ICTs

4.4.3.1 ICT skills and knowledge

Adeya (2001:18) argues that many studies and literature written on the impact of ICTs in Africa tend to over-emphasise the number of ICTs tools and products being made available without giving an indication as to who was using these tools and products. She argues that such an indication would help in measuring productivity and the impact of ICTs on development. These views are shared by Pigato (2001) who investigated patterns of utilization, ownership and affordability of ICTs in sub-Saharan Africa and South Asia. The findings revealed that long term strategies for ICTs diffusion among a wider population must be centred on revised education policies such as integrating ICTs skills into programs of vocationally based training which emphasize wider information handling skills, business and management skills and entrepreneurship training. Zongo (2001:28) believes that reaping the full benefits of information technology requires full understanding of IT applications, their potential and readiness to change. These views are shared by Ajit (2003:7) who argues that physical connectivity to ICTs requires users to be ICT literate and have technical skills to access.

Munyua (2001:6) cautions that in order to ensure more meaningful participation in rural development, and pave way for the creation of a critical mass of people to harness ICTs in developing countries, training and capacity building must be an integral part of all ICTs projects. She argues that this would ensure that they have skills and knowledge of ICTs, which they can then impart to the users. Adeya (2001:19) asserts that continuing ICTs education for working professionals are critical for capacity building. She is of the view that the long term deployment and exploitation of the Internet by the developing countries would depend less on technology and costs and more on their capacities to educate their young populations. Adam and Wood (1999) establish among other things under utilisation of ICTs in sub-Saharan Africa and observe that this was due to lack of awareness and requisite skills among other constraints.

4.4.3.2 Information needs and access to ICT

Wilson (2002:4) asserts that systems designers are not so much concerned with how information is processed but with how computers are used. Their interests, he observes, appear to be almost entirely in the area of how computer interfaces (screen, mouse, and keyboard) can be designed to provide the user with more effective means of navigating the system. It is important, therefore, to understand the information needs of users so as to provide relevant information via appropriate ICTs.

4.4.3.2.1 Use of Telecentres

Caspary (2002:4) is of the view that a model of ICTs provision in the rural areas of developing countries and in particular sub-Saharan Africa and one which attempts to combine phone access to other ICTs are the telecentres. Benjamin in Adeya (2002:5) notes that there has been great interest in using telecentres to provide access to ICTs, in projects initiated by governments, the private sector, the international donors, and community organizations.

Adupa and Asaba (2003) report of a project funded by IDRC on "Electronic delivery of agricultural information to rural communities in Uganda (EDAI)" under the Acacia Programme. They observe that the aim was to develop agricultural information resources at Nabweru, Buwama and Nakeseke telecentres in order to empower the farming communities and to facilitate the work of agricultural extension agents and other stakeholders. The project succeeded in developing relevant and appropriate local agricultural content through the acquisitions, adaptations and repackaging that was disseminated to meet the stated needs. The overall objective of the project is to improve access to agricultural information by rural communities through the use of ICTs to increase agricultural production.

The authors report that after the implementation of the project a study was then carried out to provide baseline information on "agricultural information and communication needs in Luwero and Mpigi Districts. The baseline study objectives were, (i) identification of agricultural information needs, sources and priorities of communities around the Nabweru, Buwama and Nakaseke telecentres (ii) assessment of ICT needs and preferences of various channels (iii) identification of training needs of MCT staff, extension agents, NGOs/CBOs in use of ICTs, for delivery of agricultural information and (iv) identification of existing groups and institutions working in agriculture. Both quantitative and qualitative methodologies were in the study.

The findings show that at the end of the project, a relatively large number of farmers were able to access agricultural information relevant to their needs as identified during the needs assessment at the beginning of the project. The authors observe that most of this information was delivered through the radio, interpersonal, question and answer services and outreach programmes. However, the authors point out that some of the critical information needs of the farmers were not met. These included information on: marketing/prices, inputs, early warning/weather/climate and credit. It was noted that underutilization of telecentres was constrained by distance, information costs, and lack of time, information retrieval technicalities such as lack of skills, technophobia, and generally telecentres with modern ICTs being a new concept. The research shows the adoption of new technologies and practices and awareness of the role of ICTs in contributing to answers of production problems. It noted that under explored opportunities for applying ICTs in rural areas lie in marketing farmer's produce. It suggested a need for improvement in achieving stronger links between the telecentres and farmers. It recommended mechanisms for self-sustenance and demand driven information provision which should be build by all parties involved in the delivery. The findings of this study indicate the potential of telecentres in the provision of agricultural information to farmers and extension workers. This can only be achieved if agricultural information is repackaged in formats that are familiar to the users. It also indicates that sustainability of telecentres does not only involve the aspects of financial and skill development but also the provision of information to meet the needs of users.

Prakash (2000:1) asserts that the content and programming for telecentres should be tailored towards meeting primarily the needs and aspirations of target users. This view is shared by Munyua (2000:7) who observes that the information systems established within the telecentres should be multi-sectoral (agricultural research, extension, training and education, and health). She is of the view that the telecentres should provide a stage for rural communities to address their training and development needs and vision. Prakash (2000:2) observes that that the telecentres in the Pacific countries have improved Research-Extension-Farmer linkages by supporting agricultural extension workers in providing information and guidance to the farming community. Kiplangat (2001:85) contends that telecentres directly link research work and farmers' units, thereby enhancing the flow of agricultural information. Oguya (2001:78) reports that the Kenya Agricultural Research Institute (KARI) through Agricultural Technology and Information Response Initiative (ATIRI) has set up telecentres in the rural areas. She observes that the telecentres are expected to improve communication of agricultural information.

Kiplangat (2001:85) identified the challenges for development and expansion of telecentres in sub-Saharan to include the following:

- Low telecommunication penetration;
- Lack of supportive government policies and legislation on applications;
- Lack of adequate skilled manpower;
- Inadequate resources to acquire and maintain ICTs needed for telecentres, especially once the donor leave and
- Language barriers to understanding content of messages.

He asserts that multipurpose community centres with appropriate ICTs and content would enable rural communities to solve their development problems in ways that build upon local goals, cultures, strengths and processes to promote equitable and sustainable development. This view is shared by Munyua (2000:7) who observes that multipurpose community telecentres could play a key role in the "information renaissance" in developing countries and ensure universal access. She observes that the location for telecentres must be carefully selected, and that it should take into consideration the level of potential of demand for communication and information services from a large number and wide range of users. She asserts that the location of telecentres should take into consideration the proximity to other organisations and institutions, infrastructural and socio-cultural issues.

4.4.3.2.2 Other studies on information needs

Balit (1998) evaluated the demand and use of FAO Internet based project in Latin America aimed at imparting skills and knowledge to intermediaries and extension workers. The ultimate purpose of the project was to enable extension workers and other intermediaries to impart the acquired skills and knowledge to subsistence farmers. The study assessed the use and demand of the Internet by the farmers and investigated appropriateness and cost effectiveness of the adopted ICTs. It established that a critical mass of national staff were trained in the production and use of various communication channels preferred by peasant farmers and semi-literate rural populations. Accordingly, the project proved very successful and soon spread throughout the region and beyond to china, Mali, Indonesia and the republic of Korea.

An evaluation of the FAO Internet project indicated that the methodologies and ICTs used were appropriate and cost effective. It established that intermediaries and extension workers had acquired more knowledge, skills, and experience to train farmers and provide them with technical information. The study found out that all the stakeholders had access to better communication tools that facilitate transfer of knowledge and skills to the wider community. It further observed that the stakeholders could access market information and that they had achieved an integrated approach to economic and social development. It was established that many countries in Latin America including Argentina, Costa Rica, Honduras and Mexico had replicated the project.

Two surveys were undertaken in year 2000 to investigate information needs and access to ICTs by poor urban and rural households in Nepal and India (Pigato 2001:20). Interviews were conducted with 250 and 400 households in Nepal and India respectively. Villages chosen had high poverty rates and low basic services. Households were asked about sources of information, the type of information received and whether this information was useful. Results indicate that the poor rely mostly on informal networks for their information needs. Family, friends, and village and local leaders are the most trusted sources of information. By contrast, formal sources such as NGOs, newspapers or schoolteachers, are rated low and in both countries politicians are the least trusted. The poor have no access to digital information and the new forms of ICTs (Internet, fax and computers) are accessible to some degree by only 2% of low-income households, mainly in the urban areas in both countries. By contrast, the poor have access to the radio, and increasingly, to television in urban areas. The findings indicated that keeping abreast with current events and entertainment is an important priority for radio and TV listeners/viewers. But the interviews revealed an unmet demand for additional information regarding employment opportunities and training (in urban areas) and agricultural practices, market and prices (in rural areas). Overall, the poor are optimistic about the potential of ICTs for improving their socio-economic condition.

Evidence is presented on the findings from two studies, the first conducted by Duncombe and Heeks (1999) in Botswana and the second by Mungunasi (2000) in Tanzania. The studies aimed at investigating information needs and ICTs impact on small and medium enterprises (SMEs). About 100 SMEs were interviewed in each country on information needs and access to ICTs using the same methodology and questionnaires. Findings are remarkably similar, the main difference being that ICT use is more widespread in Botswana than in Tanzania. In both countries computer-based information systems (including e-mail and Internet access) are utilized mainly by enterprises in the tourism and services sectors and in foreign-owned enterprises. Firms catering for the domestic market tend to utilize more basic ICTs.

The findings indicate that in order to satisfy their information needs all SMEs rely greatly on informal networks of family and friends, the local business community and own knowledge and experience. The surveys reveal that SMEs believe that there is substantial information gap between desired and actual information. The question is, would the availability of more ICTs help SMEs meet their information needs and improve productivity? The findings of these surveys would suggest that more technology is not what firms need. What is most needed in both countries is raising the skills and overall capacity of SMEs to access and use new technologies, as well as to upgrade their managerial capabilities and skills, marketing, financial services and credit arrangements. Many entrepreneurs simply do not know how to make proper use of computers. In turn, this may be the result of a gap that exists between the design conceptions of much business software and the organizational realities of many small enterprises (Heeks and Bhatnagar, 1999). This design-reality gap is the key priority that needs to be addressed, together with issues of related software skills within a country. The findings of the two studies indicate further that much of the content was not relevant to the needs of SMEs. It was suggested that information centres and intermediaries should fill the content gap and provide training with respect to computer usage and information access. The lessons learned from these studies are similar to the findings of the present study reported in chapter 7.

A study conducted by Mchombu (2000) to investigate the impact of information on rural development in Malawi and Tanzania established that a large number of rural people access agricultural information from community centres. The majority (in-groups comprising farmers and extension workers) found the information to be beneficial in increasing agricultural productivity. The study established that there was a demand for use of community centres and there was a likelihood of these centres increasing grassroots participation in rural development. The findings indicate the need to establish community centres in the rural areas that correspond to the information needs of the community. These centres will help to eliminate information poverty in the rural areas and provide relevant information to researchers, extension workers, farmers and other stakeholders.

4.4.4 Impact of ICTs use on productivity and creativity

Studies carried out recently have found positive association between the use of the Internet by scholars and their productivity (Cohen 1996, Kaminer &Braustein 1998). Productivity increase maybe related in part to the increasing co-authorship of papers and co-ordination of research via the web (Costa and Meadows 1999:4, Lubanski and Mathew 1998). An earlier study conducted by Norton and Price (1989) found out that social scientists involved in quantitative work were more likely than other respondents to credit computers with improving their research creativity. If this is the case, it is assumed that Internet and other types of networks will increase creativity and productivity of scientists.

Costa and Meadows (1999) investigated the impact of computer usage on scholarly communication among social scientists in Brazil and the United Kingdom (UK). The social scientists were drawn from two disciplines, economics and sociology and were restricted to academic staff in universities. Both interviews and questionnaires were used in the survey. The results indicate that major changes in communication habits were occurring. Differences were found between economists and sociologists, with the former more active in their use of electronic facilities. Computer usage in scholarly communication was influenced, in part, by pressures from the research community and from the institutional environment. One conclusion of the study was that social scientists perceived computerisation as improving communication and research productivity. Thus, there is a positive association between the use of the Internet by respondents and their productivity and creativity. One significant impact of information technology seems to be an increasing democratisation of the international research community. The present study sought to establish whether the use of ICTs by agricultural researchers and extension workers had also increased their productivity and creativity.

4.5 Adoption and Diffusion of ICTs

Adeya (2001:21) underscores the importance of assessing the adoption and diffusion of ICTs in key sectors of the economies of African countries. She cautions that diffusion may be difficult to measure without proper awareness of the current realities on the ground. This view is shared by Accenture, Markle and UNDP study (2001: Section 3.1.1) which analysed communication infrastructure in some developing countries including Tanzania, South Africa, Malaysia, Brazil, Costa Rica and Estonia. The case study method was applied in the study. The findings indicate that adoption and diffusion of ICTs depend on well-developed infrastructure. This means that deploying ICTs as enabler of development requires a country to develop strategically focused network infrastructure capacity to allow all key sectors of economy to take advantage of new technologies (Accenture, Markle, UNDP 2001 section 3.1.1). The focused capacity should include reasonable level of global connectivity, community networks and public access points. Jensen (2002:1) adds that very limited diffusion of telecommunication networks exist in rural areas of Africa due to non-existent of electricity supplies. He observes that although there has been notable efforts in some countries to reduce duties on computers, communications equipment and peripherals are often charged at higher rates. This observation concurs with that of Pigato (2001:1) who cautions that effectiveness of ICTs must be assessed alongside existing information systems, and in context of interaction within pre-existing organic information environments. The author is of the view that ICTs must focus on strategic benefits in areas where complementary investments have already been built. These views are shared by Ondari-Okemwa (2002:329) who underscored the need for more studies to investigate the work practices, organizational structure and concurrent attitudes in the African environments where ICT and virtual learning were being introduced.

Adeya (2001:19) argues that any effort to build the information super highway in Africa must focus on telecommunications on which other information services are constructed. This perspective is in line with Cullen (2001) who investigated the digital divide in New Zealand and established the need to improve telecommunications infrastructure especially in the rural areas to facilitate broadband access to the Internet. Her study recommends deregulation of telecommunication industry but cautions that competition alone was not going to bring higher bandwidth to the remote areas of New Zealand. She is of the view that legislation and partnership was possibly the way forward in solving the problem of inadequate bandwidth. Accenture, Markle and UNDP (2001, section 2.2.6) asserts that involvement of the private sector had hastened the adoption of ICTs in developing countries, particularly in case of wireless and mobile. This assertion is shared by Pigato (2001:18) who observes that the highest growth rates of telephones were in countries, which had adopted policies of liberalization and privatization of their networks. She posits that wireless networks were expanding rapidly in sub-Saharan African countries due to privatization programmes.

Pigato (2001:45) reports of considerable benefits of liberalization in Ghana and observes that before liberalization, Ghana Telecom had installed 77,000 lines over a 22-year period. The author argues that after liberalization, 70,000 new lines were installed within a period of 2 years following private sector involvement. Other developments include a rapid increase in the provision of payphones, competition in the provision of analogue and digital cellular (mobile) phone networks, the introduction of VSAT-based networks, and new Internet access services offered by competing private sector ISPs, each with their own direct international backbone connections. The findings are consistent with Richardson's (2003:3) argument that private sector participation in developing telecommunication infrastructure is the key to universal access. This view is shared by Jensen (2002:10) who observes that liberalization of the telecommunication sector and the introduction of competition are seen as a key to driving down prices and increasing the quality of service.

Pigato (2001:24) observes that there is great potential of ICTs if the private sector is in partnership with the public sector. She cites successful initiatives in India where application of ICTs was used to manage milk collection of the co-operative societies. A system of testing and weighing milk was created and tested in a national, public laboratory and was subsequently marketed by two private firms. Pigato (2001) asserts that the automation of collection and payment procedures to farmers had improved the efficiency of the process and introduced transparency. She further observes that producers trust the objectivity of the weighing and quality determination procedures, and feel they are getting a fair price for their milk, and have an incentive to produce more. The study illustrates the success of partnership between public and the private sector in delivering ICT services to rural communities.

The Post ADF Summit (Economic Commission for Africa 2001:22) observes that ICTs policy should be inclusive for it to be adaptable and facilitate diffusion and use of ICTs in all the sectors of economy. The summit argues for policies that support liberalization and creation of competitive environment in ISP markets, as they resulted in rapid diffusion of

ICTs. These views are shared Richardson (2003:20) who analysed studies of universal access and concluded that private sector participation and competition significantly increases the number of telecommunication access lines and ICT services, and that competition lower prices. The author gives the example of Indonesia where telecommunication and liberalization backed by an enlightened and transparent government regulatory structure provided fertile ground for a rich harvest of consumer choices and low costs. Pigato (2001:22) adds that sub-Saharan African countries that had adopted deregulation and privatization policies have experienced rapid growth in the expansion of communication networks. The author is of the view that in a sufficiently competitive liberalized market (i.e. with a transparent legal framework) the private sector is effective in providing commercially viable communication services (pg ii). The author concludes by advocating the need of an integrated framework to develop appropriates policies of access and diffusion of ICTs within developing countries.

Duncombe (2000) analysed the role of private sector in extending ICTs in the rural areas of sub-Saharan African countries. The findings show the effectiveness of the private sector in extending telecommunication services to rural populations and to the poor. The author found that the pro-private sector policy environments, recently adopted by many countries, have introduced liberalization and competition and have removed the barriers to market participation. He says, within this environment, many countries have introduced specific interventions to attain universal access through the private sector. This includes service requirements ensuring a minimum level of access throughout payphones, phone shops and, more recently, telecentres. Pigato (2001:22) singles out the Grameen phone project as the most successful experience of the private sector in reaching the poor through telecom services.

4.5.1 Analysis of ICTs interventions

The Accenture, Markle and UNDP (2001, section 2.2.6) study analysed ICTs initiatives targeting key development sectors in developing countries and reported lessons learned from specific interventions. The findings indicate that some ICTs initiatives exhibited a substantial impact while others experienced barriers to scalability and sustainability. The lessons learned from these initiatives include:

- ICTs initiatives should be explicit about their development goals and how they will directly impact the target population.

- ICTs initiatives should be driven by user demands identified and realised through direct participation and ownership. The lesson indicates that technology imposed on the community of users who have not independently identified the need for it is unlikely to flourish.

- ICTs solution should be "built to last." It was established that ICTs initiatives that were planned and managed using a business model and had a cost recovery system were likely to be more sustainable and may have a substantial impact.
- ICTs initiatives should be sensitive to local conditions and limitations. In other words technology employed should be affordable, physically accessible, easy to use and maintain, and flexible enough to accommodate user demands and services.

- The interests of key stakeholders must be broadly aligned with each other and with the goals of the intervention. To achieve this goal there is need for a clear vision and direction, defined roles and responsibilities, adequate funding, sufficient technical and administrative means, and integration with existing local institutions.

- Initiatives with most impact have approached development problems in a holistic and co-ordinated way, not only through the provision of ICTs.

ICTs interventions must therefore take into consideration the above interrelated issues for them to have an impact. Okpaku (2002:4) reports of a study commissioned by the African Regional network and the Economic Commission for Africa to collect evidence on success story of ICTs interventions in Egypt, Uganda and Kenya. The author identified that for ICT interventions to be successful they must be demand-driven, the target group must feel that they own the project, and they must learn by doing. He established that ICT initiatives that were limited in scope and scale did not achieve much impact. He argues that as stand-alone initiatives, it was difficult for them to address the policy and infrastructure issues necessary in ensuring their success. ICTs initiatives should, therefore, be conceived as part of a comprehensive national ICTs strategy.

The two studies were broad and were not able to provide evidence on the impact of ICTs on specific sectors of economies such as agriculture. The present study sought to fill this gap by investigating diffusion of ICTs in communication of agricultural information among agricultural researchers and extension workers.

4.6 Mapping and auditing of ICTs

Adeya (2001:17) is of the view that many studies conducted in Africa lack substantive analytical work and accurate statistics on the nature, types and distribution of ICTs. She argues that the paucity of accurate statistics on status of ICTs in African region hampers any meaningful empirical analysis. She cautions that with the rate at which ICTs applications continue to grow any attempt to collate empirical evidence have been inevitably out of step with realities on the ground. The author noted that useful indicators for many of the least developed countries in Africa such Somalia were virtually non-existent. She observes that empirical vacuum has sometimes been filled by unsubstantiated claims as to the opportunities and threats posed by the information society, obfuscating in-depth analysis and realities. The author, however, noted that UNECA through the National Information Communication Infrastructure (NICI) was attempting to address the problem. It is with this reason in mind that the present study was carried out to establish the nature, types and distribution of ICTs in the agricultural sector in Kenya. The study aimed at coming up with empirical evidence on the realities of ICTs at the Kenya Agricultural Research Institute (KARI) and the Ministry of Agricultural and Rural Development (MoARD).

Jensen (2002) conducted a study to analyse the status of ICTs in Africa in the last five years. He noted that the use of ICTs had grown rapidly in most urban areas and that every capital city had Internet access. The author further observed that in the same period more mobile phones were deployed on the continent more than the number of fixed lines laid in the last century. He furthermore noted that hundreds of new local and community radio stations had been licensed, and satellite TV was now widely available. The author, however, cautions that digital divide is still at its most extreme in Africa, where the use of ICTs is still at very early stage of development compared to other regions of the world. Jensen (2002) observed that of the approximately 816 million people in Africa in 2001, it is estimated that only:

1 in 4 have a radio (205m)
1 in 13 have a TV (62m)
1 in 35 have a mobile phone (24m)
1 in 40 have a fixed line (20m)
1 in 130 have a PC (5.9m)
1 in 160 use the Internet (5m)
1 in 400 have pay-TV (2m)

These statistics shows that although ICT diffusion in most African countries is moving fast, there is still more to be done to improve the situation. The status is more general and does not provide evidence of ICT diffusion in various sectors of economies such as agriculture and the present study attempts to fill this gap.

To better understand the digital divide in Africa, and help prioritise development assistance IDRC commissioned a survey of international Internet gateways in Africa, to determine the size of the infrastructure and to map this against current populations. Jensen (2002) conducted the study. ISPs and telecommunication operators were contacted during March 2002 in almost every African country, as well as many international providers in Europe and North America. The International Telecommunication Union (ITU) and Telegeography also provided information to help cross-check the statistics. Corporate and private networks such as those operated by the bank and many multinationals and diplomatic organizations were not included in the survey. The findings of the survey indicate that there is almost no intra-African Internet

Connectivity and the majority of international bandwidth lands in the G8 countries, principally North America and Europe. It was established that high intra-regional telecom prices have limited the establishment of links between neighbouring countries. The only links that existed were those of Gambia-Senegal, and South Africa's links to Namibia, Lesotho, Swaziland, Zimbabwe and Botswana. The study concluded by observing that increasing amounts of intra-African traffic must be transited through high cross-continental links.

Soltane (2002:14) reports of initiatives to map ICTs in Africa which include "Out of Africa" which is commissioned by IDRC to measure the digital divide in Africa. It defines Bits per Capital indicator to evaluate the communication capacity and readiness of African countries. It argues that International Internet bandwidth provides a better measure of Internet activity. This information can be obtained from: URL: http://www.idrc.ca/acacia/divide/

Soltane (2002:14) also reports on the National Information and Communication Infrastructure (NICI) that attempts to map the status of the NICI strategies, Africa's Internet situation and tele-density, the number of ISPs (and ownership), mobile density, and broadcasting. The site can be found at: http://www.uneca.org/disd/ict/.

4.7 Government and institutional policies and their impact on diffusion of ICTs

The emergence of the global network economy in the 1990s, fuelled by the digitalization and telecommunications and later by the rapid expansion of the Internet, created an impetus for a wider variety and number of developing countries to adopt national ICT policy frameworks (Accenture, Markle and UNDP 2001, section 2.3: 1). Adeya (2001:17) reviewed studies conducted on ICTs in Africa and noted the amorphous nature of the terms used by various authors in referring to ICTs policies. She outlined the terms used to include: Networking Policy, an ICT policy, an IT policy, an Information Policy, a Computer Networking Policy, a National Policy for Telecommunications and Information Technology, a National Information Technology Policy, a National Communication Policy, a National Informatics Policy and a National Information Policy.

She suggests a standard definition to be adopted by all African countries but cautions that such a definition should not be 'Africanized' or 'regionalized' but should be applicable to the rest of the world. These sentiments concur with Accenture, Markle and UNDP (2001, section 2.3:1) who observes that in some countries, the ICT policies and strategies were not clearly differentiated from ICT sector and telecommunications policies and, in most cases, had no explicit connection with national development. It established that ICT policies in developing countries vary substantially in terms of their objectives, design and approach to implementation.

Soltane (2002:7) asserts that the creation of an enabling policy and regulatory environment is essential to ensure that actions initiated in the ICT infrastructural development and sectoral applications are encouraged. Richardson (2003:7) advance the view that ICT and telecommunication policies facilitate the process of achieving universal access. He defines universal access as the policy of providing telephone in every home. The author cautions that the concept of universal access, its content and the implementation of the policy may vary depending on a country's specific needs. He asserts that the objectives of universal access policies and programs should focus on social and economic development of rural and remote areas. Ajit (2003:15) adds that the effective use of ICT for agricultural and rural development is influenced by a set of international and national policies. He identified the policies to include (1) international agreements related to telecommunications and information exchange and (2) national policies and strategies on telecommunication and ICT, rural development, intellectual property rights, information management, agricultural and agribusiness development. Richardson (2003:14) argues that for universal access policies to work effectively, the beneficiaries must be enabled to participate in making decisions about how and where telecommunication technologies will be put.

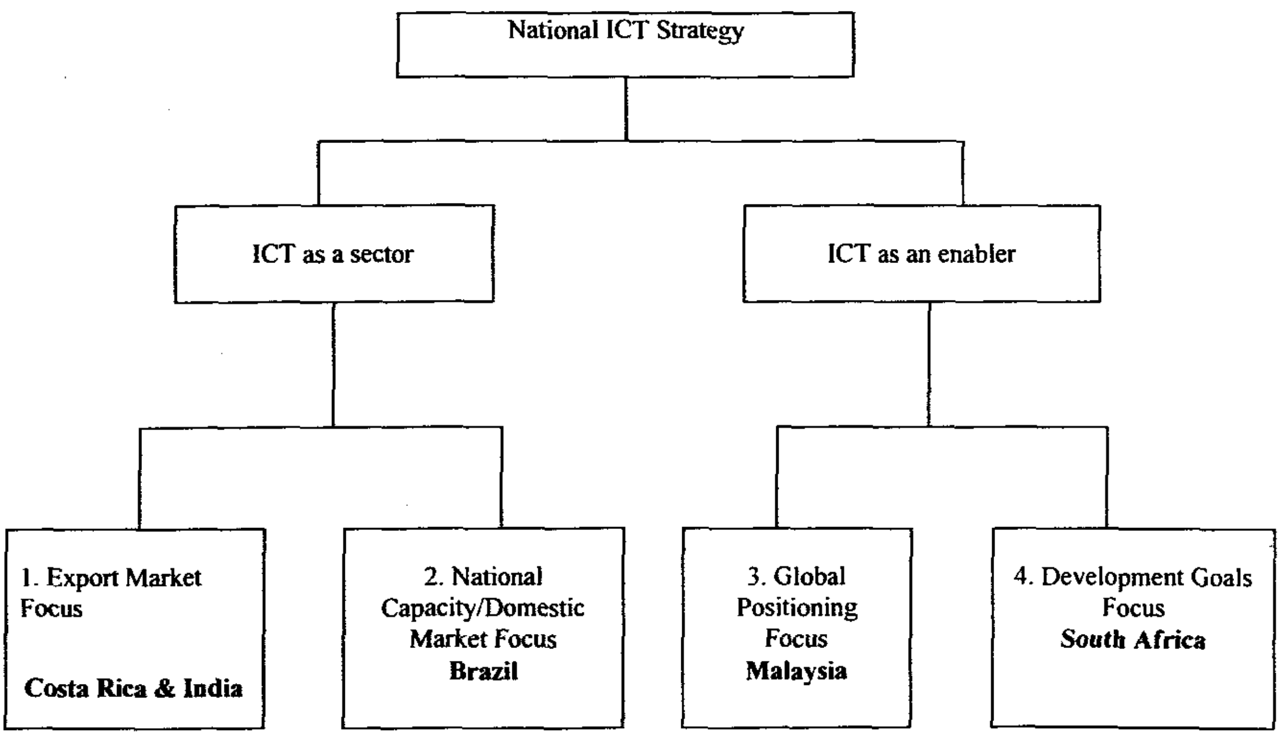
The Accenture, Markle and UNDP (2001, section 2.3:2) analysed national ICTs frameworks in a number of countries and established that while strategies pursued by each country had unique features, the role assigned to ICT could be broadly characterized in one of the following two ways:

- ICT as a Production sector. This involves policies, which focus on the development and/or strengthening of ICT-related industries such as computer hardware, software, telecommunications equipment and ICT-enabled services.
- ICT as an enabler of socio-economic Development. This involves the adoption of holistic, cross-sector strategies which aim to harness the uniqueness of ICT to accelerate a wider development process.

The Accenture, Markle and UNDP (2001, section 2.3:2) cited typology of ICT policies in various countries and highlighted the main focus of their approach. The following figure depicts these policies.

Fig. 3

A Typology of National ICT Strategy



Source: Accenture, Markle and UNDP (2001, section 2.3, p: 2). National approaches to ICT. [Online], available: http://www.markle.org/news/pages/2.3.html.

The above figure depicts the two approaches, ICT as a sector within the economy of a country (Costa Rica, India, Brazil) and ICT as an enabler (Malaysia, South Africa). The approach of ICT as a sector can focus on either domestic or export market. While the approach of ICT as enabler focuses on ICTs deployed to improve positioning in the global economy and using ICTs to directly target the full range of development objectives (Accenture, Markle and UNDP 2001, section 2.3:2, p: 1). The authors further observed that policy formulation was the responsibility of national governments and that other stakeholders were only brought on board to enable sharing of good practices and expertise. These views are shared by Munyua (2000:7) who observes that the governments of respective countries were better placed in formulating overall objectives and priorities, and in articulating coherent strategy at the national level.

The African Development Forum on Post ADF Summit underscored the need for African countries to be committed to policy and regulatory change in order to develop an enabling ICT environment (ECA 2001:11). Soltane (2002:2) observes that the African Information Society Initiative (AISI) was launched in 1996 with the aim of harnessing information and knowledge for Africa's development. The authors are of the view that since its inception, AISI has been the backbone of major ICT development of the continent. They observe that each country was to formulate their National Information and Communication Infrastructure (NICI) plan. The Economic Commission for Africa (ECA 2001:11) outlines the policies and strategies of AISI programme aimed at addressing key issues to include:

- the deployment and use of ICTs within the economy and society;
- the development of a local ICT industry to facilitate the production, manufacturing, development, delivery, and distribution of ICT products and services;
- the development of the human resource capacity to meet changing demands of the economy;
- the development of the national information and communication infrastructure;
- the development of the legal, institutional and regulatory framework and structures; and

- The development of standards practices and guidelines to support the deployment and exploitation of ICTs .

Soltane (2002:2) asserts that the AISI initiative has successfully created a framework within which national stakeholders, as active and central players, set their own course of actions and implement projects based on their priorities and development goals. This view is in line with Pigato's (2001:8) who says policies of access and diffusion of ICT in context of poverty alleviation strategies should be conceived within the specific environment of institutions and political, economic, socio-cultural factors of each country. In addressing the issue of universal access to ICTs the post ADF summit proposed a National Rural Access Task Forces on ICT Innovation to extend access, especially in rural areas of Africa (ECA 2001:12). The areas to be addressed by the Task Force include:

- In *Financing Mechanisms*, by providing micro-finance for community-based ICT micro-enterprises, providing local call tariffs for dialup Internet access from anywhere in the country, subsidised broadband connectivity costs for education and health institutions, and providing tax-breaks for companies making computer donations to public institutions.

- in *Technology Solutions*, by building existing technology such as local radio stations linked to the Internet, deploying low-cost ICT solutions to provide access among rural populations, supporting the spread of top quality low cost open-source software such as Linux, and using transport and electricity networks for connectivity;

- in *Institutional Innovation*, by supporting local community built and owned networks;

- in *Regulatory Innovation*, through relaxing existing regulation and piloting new mechanisms, in particular by reducing the high license fees for ISPs and telecom operators, and by allowing ISPs to put up their own wireless data links as long as they do not carry voice traffic, as has been done in Mozambique, Ghana and Uganda. (ECA 2001:12).

If the above issues are addressed in each of the African countries, there is a likelihood of achieving universal access and bridge the digital-divide.

4.8 Externally funded ICT-initiatives

In recent years many non-commercial community-based initiatives supported through external funding (i.e. NGOs, international development centres or bilateral donors) have flourished throughout Africa with the purpose of extending ICTs access to rural communities (Pigato 2001:24). This view is consistent with Soltane (2002:2) who observes that various bilateral and multilateral partners were supporting ICT initiatives in many African countries. Pigato (201:24 adds that in many instances external funds have supported government, non-government and private organizations such as educational establishments, research organizations and agricultural extension services. The author cites the example of the USAID that provides funds through the Africa Link Programme to promote increased ICTs networking in agricultural extension and research organizations. Similar sentiments are shared by Lugovane, Kimwaki, Onyancha, K'aluoch (1995:1) who report that ICT initiative in the agricultural sector in Kenya and specifically at KARI was financed by donor communities which, include Department For International Development (DFID) and the Netherlands Government.

Evaluation reports of donor funded initiatives made in Uganda, Zambia, Tanzania and Ethiopia echo many concerns. Thus, Pigato (2001:25) observes that externally funded initiatives present several limitations that include:

- *Cost effectiveness*. Most projects for extending connectivity have to overcome considerable technical obstacles, utilizing for example satellite technology to establish effective communication links. These tend to be relatively expensive technological solutions for providing relatively limited access facilities.

- *Sustainability*. Donor-funded programs have tended to provide initial investment capital rather than maintenance and running costs. For local organizations with limited finances, the follow-on investment costs for updating and expanding the technology, and the recurrent costs for associated with maintenance have remained largely unaffordable.

- *Technical support.* Many locations outside capital cities lack any technical support that can often result in a significant amount of downtime when technical problems arise.

- *Financial opportunity costs.* Which arose as a consequence of overpriced equipment, higher financing costs, institutional efficiencies and the extra infrastructure costs associated with extending access to rural and remote areas.

Pigato (2001:26) asserts that technology is not a goal in itself, but a means of achieving development goals. Thus, the modernization of information systems, and the introduction of ICTs, should be fully integrated into the process of organizational and social change, driven not by technology itself, but by real needs for economic, and social and institutional development. Donor funded ICT projects should be introduced when real needs of the target groups have been established.

4.9 Cost, sustainability and maintenance of ICTs

Adeya (2001:20) observes that ICTs investment could be categorised into physical and human capital. She is of the view that physical capital includes computers, computer networks and other equipments while human capital includes skills needed to run ICTs systems. Duncombe and Heeks (2002:8) assert that investments for internet access are significant in terms of initial capital outlay, running costs, and time and skills. They observe that such investments need to be accompanied by significant benefits in terms of frequency of use and the quality of the information. In other words there should be an analysis of the cost in relation to benefits accruing from the use of ICTs.

Pigato (2001: iii) however, warns that even when ICTs initiatives are successful and have brought measurable benefits, there remain issues of financial sustainability and how to ascertain what value "users" attach to services provided. She reiterates that in recent years, externally donor-funded initiatives have mushroomed throughout sub-Saharan Africa aimed at extending ICTs access especially to the marginalised communities. She cautions that although these initiatives had potential benefits to the communities, they faced problems of financial sustainability and lack of local demand for ICT-based information. These views are shared by Munyua (2000:7) who observes that most projects established with external funding face major challenges after the project period has ended. She is of the view that sustainability of these projects should be considered from the outset and, where possible should have government, private sector and community support. She suggests that users should also pay for services but cautions that the cost will depend on how much they can afford. This sentiment is shared by the Accenture, Markle and UNDP study (2001, section 3.1.2, p: 1) which singled out unaffordable access as the main reason for low use of ICTs in developing countries. The authors suggest the use of national ICTs strategies to facilitate mechanisms for subsidised use of these technologies and support reform measures that would lead to the reduction of costs and access charges. They further contend that countries should focus on educating and retaining a core of professionals with the technical capabilities to provide and maintain ICT infrastructure and related services, and to adapt new technologies for local requirements. Their study proposes the development of incentives to reduce "brain drain". Munyua (2000) concludes by observing that there are yet few examples of success in attaining ICTs sustainability in Africa, and there is an urgent need for viable models to be developed and tested. The present study sought to establish the costs, sustainability and maintenance of ICTs in the agricultural sector in Kenya

4.10 Concept of Digital divide

Richardson (2003:3) observes that ICT access is unevenly distributed often favouring the urban and wealthy residents as opposed to the rural population. A similar view is shared by Jensen (2002:1) who observes that in Africa the divide between urban and rural areas is even greater as the majority of the population lives in the rural areas. The author observes that there is very limited diffusion of the telecommunication network in the rural areas and irregular or non existed electricity supplies are a common feature and a major barrier to use of ICTs. Cullen (2001:1) cautions that in the global digital age, those who are unable to access the Internet and the World Wide Web through the application of ICTs, are increasingly disadvantaged in their access to information. She observes that the 'digital divide' has become a convenient metaphor to describe the perceived disadvantage of those who either are unable or do not choose to make use of these technologies in their daily life. The author is of the view that the phrase 'digital divide' has been applied to the gap that exist in most countries between those with ready access to the tools of information and communication technologies, and the knowledge that they provide access to, and those without such access or skills. Adeya (2001:) advances the view that appropriate use and application of ICTs could address development problems and make a qualitative impact in slowing this marginalization process. Caspary (2002:4) adds that this would ensure the proper allocation and use of the limited resources to suit particular needs of marginalised communities and hopefully close digital divide. Many studies attribute the problem of digital divide to socio-economic factors, geographical factors, educational, attitudinal and generational factors, as well as physical disabilities (Jensen 2002, Cullen 2001, Pigato 2001, Munyua 2000, Alemna 1999, Moyo 1996, Opoku-Mensah 1998, Sheba 1998).

According to Pigato (2001:i) the digital divide has emerged both within countries and between developed and developing countries. This view is consistent with Cullen (2001:5) who observes that a further gap between developed and underdeveloped world in the uptake of technology is evident within the global community, and may be of even greater significance. Pigato (2001:I) opines that the rapid growth of ICT usage in high-income countries was raising concern about a digital divide emerging between rich and poor nations. The author cautions that lack of access to ICTs in developing countries has not traditionally been viewed as a deprivation in the way that the lack of food, basic health care have been. The author believes that there is increasing evidence that access to ICTs could have direct impact on raising living standards and quality of life of rural communities.

Cullen (2001) assessed the gap in the state of ICTs, and the levels of access and utilisation of the Internet in developed nations and the situation in less developed countries. She noted the dramatic differences in access to the Internet, as usage in the developed countries reaches 25% of the population and exceeds 50% in the most advanced Internet nations-the United States and Scandinavia. The author observes that the situation of Internet use in Africa is pathetic with South Africa having the highest population of Internet users representing only 4% of the total population. Her views are shared by Pigato (2001:i) who cautions that although the Internet had began to be utilised in both the urban and rural areas of sub-Saharan African countries, constraints to expansion were considerable. The author cites the constraints to include lack of basic connectivity to telephone networks, high connection charges, and low computer skills. Cullen (2001:10) concludes by suggesting that to reduce digital divide countries should focus primarily on physical access and ICTs skills training. She noted that once the ICT infrastructure and the skills to access the technologies were in place it would be easier to change attitudes and encourage the development of relevant content. This perspective is supported by Richardson (2003:12) who argues that telecommunication networks are critical in the rural areas as they support other applications such as the Internet.

In a world communication report by UNESCO (1998) on 'the media and challenges of new technologies' observes that bringing the Internet to an African village by the means suggested by some enthusiasts, using battery operated computers, satellite access focuses on the wrong end of the technology spectrum. The report is of the view that this may not be of most benefit to the world's poorest communities. In support of these views Cullen (2001:2) observes that the Internet is not in itself an education, it does not teach literacy, and requires highly developed skills to access and interpret information found. The UNESCO (1998) report is of the view that a better solution for most of the rural communities in Africa is in the use of very basic technologies to promote traditional forms of education, enhance delivery of information, to improve animal husbandry and crop management. These views concur with those of Mugabe (2001:3) who cautions that while the industrialised world households expectations revolve around new and higher quality gadgets, in Africa expectations focus on having 'appropriate technologies' to respond to immediate and urgent basic needs.

4.10.1 Who are disadvantaged in the digital age?

A number of studies and policy papers addressing the issue of digital divide identify specific groups of people as being especially disadvantaged in their uptake of ICTs (Ngenge 2002, Hafkin and Odame 2002, Cullen 2001, Gartner 2001, Pigato 2001, Alemna 1999). These include people with low incomes, low literacy levels and few educational qualifications, the unemployed, elderly people, women and girls. Ngenge (2002:8) is of the view that these people are often disadvantaged in terms of education, social and health status, income and health status. Cullen (2001:2) adds that because of their attitudinal and cultural factors many are identified as having a very low uptake of ICTs. Her study on 'addressing digital divide in New Zealand' established that the indigenous Maori people had specific cultural and educational needs that were the focus of government programmes aimed at closing digital divide. Pigato (2001:i) is of the view that the majority of those who are disadvantaged are concentrated in the rural areas.

4.10.2 Digital divide and socio-economic status

Studies carried out to examine patterns of utilisation, ownership and affordability of ICTs have identified socio-economic status as the major factor contributing towards digital divide among the rural communities in developing countries (Pigato 2001, Gartner Group 2001, Cullen 2001 Munyua 2001). Cullen (2001) reports of a Gartner study that investigated the socio-economic status of households in relation to the use of the Internet. The study was conducted in the United States in February 2000 and the methodology used was a survey where data was gathered from clustered households in terms of socio-economic status. The study established that there is a very strong correlation between socio-economic status and participation in the digital economy that suggests cause and effect. The findings of the study indicate that only 35% of households in lower socio-economic groups had access to the Internet, while 59% of those in lower middle income groups, 73% of those in upper middle income groups, and 83% of those in the top income groups had access to the Internet. These disparities are exacerbated by an even distribution of population in the various income groups.

The Gartner report argues that while it is absolutely true that minority groups are at a distinct disadvantage when it comes to having the Internet access, the reason for this is not that they are minorities but that they are at socio-economic disadvantage due to lower education levels and poorer incomes. The report observes that being in the wrong side of digital divide is only a symptom of being poor. It established that the lower socio-economic groups also have far lower household incomes, less access to educational opportunities. It suggested that this group should be granted equal access to educational and economic opportunities, which the Internet can provide.

Despite these disparities in access the Gartner study found little difference in attitude towards the importance of computing skills in using the Internet. Cullen (2001:3) argues that the study possibly erroneously assumes that it was only the lack of resources that prevents people from using the Internet. But this assertion is untested. Further research in a wider variety of groups is necessary to establish other barriers preventing people from using the Internet and other forms of ICTs. Among the objectives of the present study was to investigate factors that impede agricultural researchers and extension workers from effectively utilising ICTs.

4.10.3 Barriers to use of ICTs

Constraints to ICTs development in Africa and other developing countries have been well documented by researchers (Jensen 2002, Opoku-Mensah 2002, Pigato 2001, Munyua 2000, Alemna 1999, Moyo 1996, Opoku Mensah 1998, Sheba 1998, Adam and Wood, Cullen 2001). These studies have interchangeably used the terms 'constraints' and 'barriers' and this apply also to the present study. The constraints identified include the lack of infrastructure, absence of ICTs policy, lack of local content, few trained or skilled personnel, poor knowledge of ICTs at all levels from suppliers to users, high rate of illiteracy, financial constraints, sustainability of ICT projects. The studies indicate that the constraints had exacerbated digital divide. Adeya (2001:7) cautions that ICTs and development in Africa have been perceived erroneously as if the continent was homogenous yet each of the African countries have unique problems. She observes that the level of the constraints/barriers differs from country to country. The following section discusses these barriers under the following headings:

- Physical access to ICTs;
- ICTs skills and support;
- Attitudes and
- Content.

Cullen (2001:3) asserts that any attempt to address the digital divide must take these potential barriers into account if it is to succeed. A recent UK government report (2001) on 'national information policy' identifies the barriers more succinctly as the three C's: connectivity, content, and competencies. The report attributes attitudinal barriers to lack of relevant content and lack of ICT skills. Cullen (2001:4) in her study observes that the New Zealand government had identified the three C's as the guiding principles of ICTs initiatives in the country.

4.10.3.1 Physical access

Richardson (2003:15) asserts that universal access to ICTs is determined by telecommunication infrastructure. He identifies tele-density as a standard indicator used by the International telecommunication Union (ITU) to measure the number of telephone lines per 100 people. The issue is revisited by Cullen (2001:4) who also identified the main barriers under physical access as lack of a robust telecommunications infrastructure with sufficient reliable bandwidth for Internet connections. She is of the view that cost is a barrier that limits user's ability to purchase, rent or travel to utilise without hardship, the necessary equipment. Pigato (2001:8) advances this view by observing that financial resources needed to harness ICTs include those necessary for supply of a technical infrastructure and those necessary to create demand for user technologies, information and communication services. Munyua (2000:5) observes that telecommunication and electricity infrastructure, in developing countries especially Africa is lacking or inadequate. She attributes this to uneven distribution in the development of the infrastructure between urban and rural areas. Caspary (2002:4) in support of these views observed that the private sector was not keen to invest in ICTs in the rural areas of developing countries because of low purchasing power of the local people. Munyua (2001:5) points out that in the urban centres of most African countries the infrastructure was inadequate and users of Internet experienced problems due to low bandwidth. She suggests the need to strengthen the Internet backbone. These views are shared by the present study which investigated the barriers that hinder agricultural researchers and extension workers from effectively using ICTs.

4.10.3.2 Telecommunication infrastructure, access and low bandwidth

Many studies and policy papers have pointed out that Africa's telecommunications infrastructure is the least developed (Mugabe 2001:1, Richardson 2003:3, Jensen 2002:5). Jensen (2002:1) observes that 75 percent of most of the African countries telephone lines are concentrated in the capital or big towns. Similar views are shared by Richardson (2003:3) who noted that the sub-regions of the African continent, Central Africa, East Africa and West Africa have the lowest teledensity in the world. For example, Jensen (2002:5) reports that by 2001 Africa had about 21 million fixed telephone lines. These views are shared by Pigato (2001:9) who observes that only a few of the sub-Saharan African countries have achieved tele-density levels greater than the average for low middle income countries, the most significant being South Africa with 11.46 Direct Exchange Lines (DELs) per 100 inhabitants. Jensen (2002:4) adds that the overall fixed teledensity as of 2001 was one per 130 inhabitants in sub-Saharan Africa (excluding South Africa).

A study conducted by Anderson (1999) titled 'Native Americans and digital divide' focused on the American Indian and Alaskan Native population.' The study examined the state of telecommunications in the Indian country, explored challenges facing the communities and discussed efforts of bringing information services to the communities. The findings indicate that telecommunications in the Indian country was impacted by a myriad of issues and that no one solution could close the gap. Anderson (1999) study recommends that a set of geographic, economic and social factors should be considered when examining the state of technologies in the Indian country. It underscores the need for communities to focus on developing telecommunications services and control terms under which they were being introduced. Only then can they ensure that these technologies are deployed in a manner that best meets the needs of individual communities. The author cautions that telecommunications infrastructure and services do not exist in a vacuum. He argues that they are tools that help shape, and are shaped by the individuals and communities that use them.

In her study to investigate the digital divide in New Zealand, Cullen (2001) found out that telephone access in New Zealand was by no means universal and hence not uniform across all ethnic and income groups. She found out that up to 75% of Maori in households with income of less than $15,000 in some depressed rural areas had no access to a land-line phone at home, although some had access to a mobile telephone. The findings indicate that even the affluent rural communities suffered from geographic isolation, low bandwidth, unreliable connections, and interference from electric fences. The author observed that the rapidly developing mobile telephone technology was likely to improve the Internet access to some rural communities. The findings indicate that technical problems and costs will continue inhibiting telephone and Internet access to rural communities. However, the study does not provide any empirical evidence on how mobile telephone technology was being applied in accessing the Internet.

4.10.3.3 Lack of skills and support

Lack of literacy and technical skills and support has been identified as a significant factor that prevents certain groups of users from using the Internet and other forms of ICTs (Ajit 2003, Munyua 2000:5, Pigato 2001:6, and Cullen 2001:5). This is attributed to low levels of computing technology and literacy skills. Mansell (1998:35) observes that illiteracy was a fundamental barrier to participation in 'knowledge societies'. These views are shared by Pigato (2001:7) who observes that lack of skills and human resources may be the greatest barrier for diffusion of ICTs especially among the rural community. Munyua (2001:5) concurs with these views by observing that illiteracy makes individuals to be disadvantaged because they lack the basic skills required to harness the benefits of ICTs.

Cullen (2001:5) opines that the rapid spread of skills among communities depends very much on the value they attach to them. She is of the view that computer skills may not be highly valued by rural communities who may prefer other skills such as handicraft. The author is of the view that factors such as: cost, restricting access to equipment; low educational achievement; and cultural, age, or gender counteracts against dissemination of computer and technological skills to disadvantaged communities. She suggests that educational programmes intended to bring these skills to such groups must overcome a range of such barriers.

4.10.3.4 Attitudinal barriers

Ajit (2003:7) observes that access to ICTs is limited to social and cultural barriers among individuals and communities. Cullen (2001:5) adds that cultural and behavioural attitudes towards ICTs impede many communities from using ICTs. She observes that communities usually view computers as for 'brainy' people, for males, for the young, difficult to use and computers generally belong to a middle class 'white culture'. The author further observe that some people are concerned over the lack of security of personal information, while others perceive computers as being 'unsafe' because of the amount of unsuitable material on the Internet. Studies conducted on gender disparities and use of the Internet indicate that women were marginalised more than men in the uptake of ICTs (Hafkin and Odame 2002, Cullen 2001, Ngenge 2002). Cullen (2001:5) cite the example of Nielson study on gender disparities and the use of the Internet in Australia, New Zealand, USA, Singapore and United Kingdom established that in the developed countries disparities of Internet use by gender were not large. The findings of the study indicated that use of the Internet by gender were as follows: USA 50% male and female respectively, UK 61% male and 39% female, Australia 55% male and 45% female, New Zealand 53% male and 43% female and Singapore 60% male and 40% female. In a paper presented by Secretary General of the United Nations (ECOSOC 2000) observed that gender disparities on use of the Internet and other forms of ICTs were much greater in developing countries. The paper reported the involvement of women to be as low as 5% in some areas in some African countries. This has serious implications for women's participation in a growing global economy, and also involves a significant wastage of talent which such countries can ill afford. The study further observed that the majority of women who were marginalised live in the rural areas.

4.10.3.5 African informal communication networks

Pigato (2001:6) observes that surveys of urban and rural households in Africa suggest that the majority of people in the rural areas favour informal networks of trusted family, friends and local leaders over formal sources of information. This view is shared by Cullen (2001:5) who is of the view that in many cultures which, place high value on oral culture, personal communication and strong family and kinship networks, will not place high priority on the use of computers. These sentiments are shared by Obijifor (1999:161) who contends that Africans are strongly networked culturally and prefers oral communication that provides immediate feedback. He cautions that any modern communication channel should take this into considerations. Obijifor (1999:161) suggests that the telephone could be the technology of choice for the future as it embraces the African mode of communication. This could also be the reason for rapid spread of mobile phones among the rural communities. This maybe attributed to compatibility and relative advantage over other modes of communication as indicated by Rogers Diffusion of Innovation Theory.

4.10.3.6 Content

Batchelor (2002:6) observes that there seems to be an assumption that the supply of information created by global network of ICTs will be sufficient to enhance livelihoods of the rural communities, as long as they have access. He cautions that there is need for content that is grounded in the reality of the local context. This view concurs with that of Ballantyne (2002:3) who underscored the importance of content in the digital divide equation. This is further supported by a study by Anderson (1999) who investigated the digital divide among the Native Americans and found that content was among the key issues raised by the communities as being essential in development of the web as a resource for economic development. Ballantyne (2002:3) defines local content as the expression of the locally owned and adapted knowledge of a community, where the community is defined by its location, culture, language, or area of interest. He opines that content should be viewed as emanating from the local communities and not for local communities. Ballantyne (2002:3) observes that the content includes global content that has been transformed, adapted and assimilated into community's knowledge base and local content emanating from the communities themselves. He is of the view that when this content is disseminated using digital means, it can be termed e-content.

Ajit (2003:7) is of the view that relevant and useful content for use by agricultural communities through ICTs was scarce in developing countries. Ballantyne (2002:3) cautions that just because little e-content from developing countries is found on the Internet does not mean that there is a local content problem but the problem is getting means of accessing local content. The author observes that most content initiatives using ICTs tend to push external content towards local people. He suggests that people in Africa should stimulate e-content creation and communication for local and global use. These views are shared by a study conducted by Accenture, Markle and UNDP (2002:1) to investigate 'content and applications' in developing countries that include Brazil, Tanzania, South Africa, Estonia and Malaysia. The study observed that ICTs capabilities could not be leveraged without content that was responsive to user needs and local conditions. It suggested that content should be in a language that is commonly understood, and with technical specifications that are sensitive to the actual use and working environment of users.

Caspary (2002:4) cites the case of 'infoshops' in Pondicherry, India, as a good example of the creation of relevant local content. He observes that after information requirements had been identified during a trial period, volunteers from the village created a local database comprising government programs for low-income rural families. The database contained information on cost and availability of farming inputs such as seeds and fertilisers, grain prices in different local markets; a directory of insurance plans for crops and families; pest management; information on rice and sugarcane; a directory of local hospitals, medical practitioners and their specialities; a directory of local veterinarians, cattle and animal husbandry programs. Caspary asserts that this is a typical example of a successful ICTs access project.

4.10.3.6.1 Content and local languages

Rajasekaran, Martin and Warren (1993:1) underscore the need to identify, document, and incorporate indigenous knowledge systems into agricultural extension organizations in order to achieve sustainable development. FAO (1998:3) advocates special emphasis to be placed on developing and disseminating local content, as well as capturing and auditing all relevant local resources using ICTs. The author emphasizes the need to involve local communities in the production and packaging of resources into local languages, to make services offered more valuable and accessible. This contention is shared by Cullen (2001:9) who observes that inappropriate or inaccessible content continues to be a major deterrent in the uptake of ICTs especially the Internet. She cautions that the use of English as the lingua franca of the Internet inhibits the use of the Internet, as cultures using other languages grow more rapidly. The author suggests the development of local content and more widespread use of automatic translation systems to address the issue of content. She cites the example of China where the Internet was developed in Chinese characters and 95% of the population who do not read English showed interest in connecting to the Internet. She observes that usage also increased by 10-fold. Martindale (2002:7) reports on the efforts being made in South Africa to translate computer programmes into official languages such as Xhosa, Zulu, and Venda. The author observes that by using a language they understand to access and utilise computer facilities, the local communities are given a chance to be more creative and self-confident and this will reduce the digital divide. In the same perspective, Oguya (2001:79) reports on the use of vernacular languages to transmit agricultural programmes through radio in Kenya. She observes that these programmes have proved very effective especially for farmers listening groups which is one of the extension approaches used in Kenya.

Most studies addressing the issue of content are biased towards the rural communities. To address this gap the present study aimed at establishing whether the Internet and other forms of ICTs provide content that is responsive to the information needs of agricultural researchers and extension workers in Kenya. The study subscribes to the assumption that the adoption of ICTs as a new technology innovation requires relevant content in the language that is understood by the users/community. This is a key issue in persuading the users of the relative advantage of the technology, and reducing the complexity involved in its use as indicated in Rogers Diffusion of Innovation Theory (Rogers 1995).

4.10.4 ICT models and bridging of digital divide

Anderson (1999:5) contends that the large initial costs that accompany the deployment of ICTs make it difficult for the communities to obtain and access them. This view is supported by Cullen (2001:8) who cautions that there are no quick or easy solutions to the problem of digital divide, either within nations or between nations. She asserts that the low economic status of those who are marginalised makes it difficult to have adequate capital to invest on ICTs. Cullen (2001:2) argues that technology does not in itself solve social and economic discrepancies within societies, and can often exacerbate them. She cites the example of India where massive growth in the use of ICTs has had no impact at all on what has been described as 'the highest concentration of poverty in the world.' The next section reviews some of the ICT-initiatives/models and projects that have been developed in an attempt to close the digital divide in both the developed and developing countries. Some of the successful models in other countries can be replicated in the sub-Saharan African countries such as Kenya.

4.10.4.1 Use of the wireless technology to bridge digital divide

4.10.4.1.1 Mobile Technology

Many initiatives to rural communities in Africa are contemplating the possibility of leap-frogging many stages of development by deploying more advanced wireless or satellite technologies. However, Anderson (1999:5) cautions that the large initial costs that accompany the deployment of any telecommunication technology can make a wireless network seem just as unobtainable as wire line for many rural communities. Pigato (2001:11) points out that despite a five times greater cost in monthly subscription rates between mobile and fixed line connection, the mobile phone has continued to grow even faster. The author observes that mobile subscribers represent over 20% of total telephone subscribers across African continent. This view is shared by Jensen (2002:1) who points out that within the period 1995-2001 mobile cell phones were deployed in the continent than the number of fixed lines laid in the last century. He argues that due to the low cost and long range of the cellular base stations, many rural areas have been covered (p. 4). This view concurs with Pigato's (2001:12) who observes that the growth of mobile cellular phones has been most rapid in countries with low population and/or poor existing infrastructure and difficult geographical conditions, despite tariffs being considerably higher than those of fixed line connections.

The International Telecommunication Union (ITU) in Pigato (2001:12) advanced the view that the mobile phone offers many advantages. They can be installed rapidly allowing customers to bypass lengthy waiting lists for fixed line connections. The author argues that pre-paid mobile services offer more flexible payment systems that are suitable for low-income users who may not afford regular monthly charges for fixed line services. Pigato (2001) carried out a study to analyse the level of access and affordability of mobile phones in sub-Saharan Africa and South East Asia. The findings suggest little relationships between the level of mobile penetration and per capita income, unlike the strong relationship exhibited for fixed line network services.

4.10.4.1.2 Grameen Phone Project

In a study conducted by Accenture, Markle and UNDP (2001, 2.2.3) to analyse ICTs for economic opportunity in developing countries noted that ICTs initiatives that clearly identify development goals within the needs and context of the target population were more likely to develop effective operating models and deliver tangible results. The study cited the Grameen phone project as a success story. The Grameen Phone is a commercial operation which started in 1996, with the purpose of providing cellular services in both urban and rural areas of Bangladesh. This project is unique due to the successful marrying of communal telecommunications facilities (using cellular wireless technology) and a financing scheme through the Grameen Bank (Pigato 2001:53, Richardson 2003:24). The Accenture, Markle and UNDP study observe that Grameen phones' explicit goal was to have a significant impact on poverty through the economic empowerment of women in rural Bangladesh. The partners in the project are Grameen

Bank, Telenor Invest AS of Norway, Marubeni Corporation of Japan, and Gonofone Development Corporation of USA. The authors observe that the project was an initiative of the Grameen Bank (GB), which manages the entire phone system. The Bank operates the GSM network and loan money to its members (mostly women) to purchase GSM cellular phones. Phone owners rent the phones out to village farmers and other community members for a fee and also provide messaging and incoming. The village pay phone operators were chosen because of their excellent repayment record for GB loans. They were to have some degree of literacy and their residences had to be located near the centre of their village (Pigato 2001:53). The Accenture, Markle and UNDP (2001, 2.2.3:2) study reported the illustrative impact of the project and outlined them as follows among others:

- Phones have been placed in 1,100 villages to serve about 65,000 people;
- Village phones have increased incomes (by 24%-40%) and savings accumulation among phone owners, mostly women (i.e. reduced transport cost to capital city Dhaka);
- Phone users, mainly local farmers, have increased their productivity through access to market information, weather reports and pest and disaster alerts;
- Farmers in phone villages receive up to 10 per cent higher prices for farm products and improved security of supply inputs;
- Significant portions of phone owners' profits have been spent on paying for improved education and health services for their families and
- The phone service has also contributed to improvements in disaster response, crime rates and livestock mortality through better access to public services.

Munyua (2002:4) reports on the success of the project in providing jobs to poor rural entrepreneurs and connecting the community to the world. Caspary (2002:4) adds that the project is widening its scope and aims at spreading phone access to over 100 million inhabitants of Bangladesh who are so far unwired.

Pigato (2001:53) outlines the factors facilitating the success of the Grameen phone. First, are the current regulatory and commercial circumstances that prevent existing telecom operators from meeting the demand for telephone services. Within this context, GSM cellular phones appear to be the best available technical solution for rural universal access, although they are a high cost solution. A second factor is the link to a micro-credit organization. Loans to creditworthy customers enabled them to start profitable businesses providing much needed telecommunication services to villagers. The final success factor is accurate planning, detailed guidelines for implementation, and close supervision.

The Accenture, Markle and UNDP (2001:2) study observed that although the Grameen project was a success story it was not without challenges. The findings indicate a major challenge of the project as that of the Grameen network, which is not integrated with the national fixed line network due to telecommunication regulation in the country. The authors further warn that the technology chosen by Grameen was based on well-known international standards and was expensive and not optimal for rural areas. In spite of the challenges, the Grameen project is a success story, which can be replicated, in sub-Saharan Africa countries such as Kenya.

4.10.4.2 Linkages between agricultural research and rural radio

Odame and Kassam (2002:1) report that in October 2000, the International Service for National Research (ISNAR), along with four global partners, embarked on a project study titled "training needs and organisational constraints assessment." The project focused on Sub-Saharan Africa. It was conceived with the aim of strengthening and developing the working relationship between researchers and broadcasters to ensure a two-way exchange of knowledge with farmers. Partners in the project held a series of workshops to identify the training needs and organisational constraints among the participants. The project partners included the university of Guelph, Canada; the Developing Countries Farm Radio Network, Canada; the Food and Agricultural Organisations of the United Nation and the Canadian International Development Agency. The project partners in Africa came from Cameroon, Ghana, Mali, and Uganda. They comprised two main groups of institutions: national agricultural research centres and rural radio stations.

Odame and Kassam (2002:1) technically defined rural radio in terms of its relatively local range (25-50 km radius) or functioning at frequencies of less than 1000 MHz. They contend that the terminology of rural radio is more often used to refer to the multiple technologies behind rural broadcasting, which may include satellite communications and the Internet. The outcome of the project indicated several benefits of linking agricultural research with rural radio. Firstly, is the fact that research findings can be shared across long distances in languages and terminologies familiar to audiences through radio. Secondly, live discussions can be held with farmers to obtain their feedback on various technologies and this could be broadcast to a wider audience. Thirdly, the radio can relay disaster preparedness, weather and market information. The authors are of the view that this could be achieved either through live discussions in the field or in consultations via letter, telephone, or, possibly, Internet as facilitated by the radio broadcaster.

The authors identified the constraints that hindered effective linkage between agricultural research and rural radio to include the following:

- Lack of necessary policy procedures to support the linkage;
- Lack of public relations and communication policies within the existing agricultural research systems. This affected dissemination of agricultural research findings;
- Radio producers often encounter 'closed gates' of research facilities whenever they want to gather data for agricultural programs and
- Inadequate human resource development in the context of severe budgetary shortfalls in agricultural research and rural radio organisations was found to be a major constraint.

The study concluded that a critical gap does exist between agricultural researchers and rural radio broadcasters when it comes to the exchange of information and communication with rural communities. This gap was best revealed by the project participants' observations that the two 'facilities' of research and radio rarely met. Both partners underscored the importance of understanding farmer's needs and having frequent interaction with certain rural groups such as women. They agreed that the policy issue should be addressed urgently to support agricultural research and rural radio.

4.10.4.3 Community radio and Internet access

Caspary (2002:4) cites Kothmale Community Radio in Sri Lanka as an example of exceptional ICTs access project since it has combined community radio and Internet access. The project has a leased line connection to the Internet. Caspary observes that, during 'radio browsing programme' presenters browse the Web in the studio on behalf of the listeners who provide requests/input through phone or post. Relevant experts from the community who include lawyers and doctors interpret the information for listeners. However, Caspary is unable to provide any empirical analysis of the success or failures of Kothmale Community Radio. There is a need to carry out further research on the linkage between radio and the Internet. The radio is still best placed in providing information especially to rural communities in sub-Saharan Africa. This assertion is supported by Pigato (2001:16) who observes that radio ownership shows the highest overall level ownership, reaching about 85% among the wealthiest, and falling to below 10% for the poorest in Sub-Saharan African countries. In contrast, he asserts that advanced ICTs such as the Internet are used by only 2% of low-income households in these countries. This is clear evidence of the potential role of radio in disseminating agricultural information to the rural communities.

4.10.4.4 Use of Cable TV to access the Internet

James (2001:385) carried out a study to examine the various ways in which low-cost computers and other related devices could help bridge the digital divide. He examined how cable TV can be used to access the Internet with low costs. The study cites Worldgate Communications Inc. which offers Internet access via cable set top box using a common household television and a special keyboard. He observes that Worldgate combines the cable infrastructure with the television platform so that subscribers are able to reach the Internet without a personal computer or any additional phone lines. He further observes,

> Worldgate does not require an in-home computer, phone lines, costly set-top appliances, special training or high monthly service charge. All that television viewers need

> to receive the Internet is a set-top box and a remote control or a wireless keyboard all of which are supplied by cable operator (James 2001:390).

James (2001) contends that the model of cable TV was quite affordable to most people in developing countries. He cites the example of India where the cost of cable connection is between US$ 1.50 and 4 per month, and is thought to be affordable to almost 60% of all Indian households. It concludes by observing that cable television access to the Internet will drive up the figure of people connected to the Internet in developing countries. However, the study was unable to provide empirical evidence on this assertion. For example, according to the National Association of Software and Service Companies (NASSCOM) of India, approximately 75 million people in India have television sets compared to 4.3 million with personal computers and 26 million with telephones. NASSCOM gives the figure of Internet connections in India to be about 1 million. This represents a huge potential for non-PC based Internet access. A study is, therefore, needed to investigate whether cable TV have increased Internet connection in India. The cable television model can be replicated in Africa but it all depends on its success in India and other countries where it is being tried.

4.10.4.5 Use of low cost computers and related devices to bridge the digital divide

4.10.4.5.1 Proprietary vis-à-vis open source software

James (2001:385) carried out a study to investigate ways in which low-cost computers and related devices could help bridge the digital divide and enable developing countries to gain greater access to the Internet and World Wide Web. The methodology used for the study was documentary review in which different sources of low-cost computing technology were examined. He cautions that a complete measure of the digital divide between rich and poor countries require data in all aspects of the divide, such as mobile phones, fax machines, e-mail and Internet access, and telecommunication.

The study examined the use of proprietary software vis-à-vis open source software. It identifies proprietary software as that which is sold in a form that customers can use, but not change. It observes that the price charged for the software is usually prohibitively high by the standards of most developing countries. It suggests the use of open source software such as 'Linux' by developing countries. The author is of the view that open source software was more appropriate because it could be tailored to the users needs. James (2001:385) cites the example of "Silicon Bazaar" in Kenya which has tailored 'Linux' for use by small and medium sized firms at the prize of just US$ 6.50. He compares this to Windows Operating System that cost US$100 and the Windows Office Suite Applications that may cost US$ 800 in Kenya. He furthermore observes that in a continent where the average annual per capita income is less that US$ 250, proprietary software, with its accompanying licensing difficulties is a major drawback for would-be windows users. It is further pointed out that major forms of proprietary software contribute to premature obsolescence of computer hardware. He cited the case of the United States of America where 62 million computers were rendered obsolete in terms of ability to run software between 1999 and the year 2001. The author observed that the machines had been built with an average functional lifespan of at least eleven years, but with the software industry, newer faster software continuously demands newer faster computers.

The study observed that in countries such as Mauritius and Senegal the government had facilitated the adoption and use of 'Linux'. It observed further that Chinese government had come up with a policy requiring all government ministries to adopt the use of Linux operating software. The study concludes by suggesting that the widespread use of 'Linux' in Africa can be achieved if the governments of each country could facilitate their adoption and use. Since the methodology of the study was a documentary review it was unable to provide empirical analysis on the use of Linux in the countries covered. The present study sought to establish the proprietary and open-source software used in the agricultural sector in Kenya.

4.10.5.2 Refurbished computers

James (2001:386) in his study also examined the use of low-cost computers commonly referred to as 'refurbished computers.' The study observed that the transfer of used computers from the developed to developing countries required the computers to be recycled for re-use. It gave examples of Non- Governmental Organisations (NGOs) that undertake this kind of activity. These include Computer Aid International in the UK which in the year 2000 and 2001 managed to send 6,000 fully refurbished computers to needy organisations in developing countries such as schools and community organisations. The other NGO mentioned in the study is World Computer Exchange in the United States of America (USA) with the goal of soliciting used computers from companies and various institutions in the USA, recycling them for re-use and transporting them to developing countries. The study observes that the World Computer Exchange is currently working with 42 partners, and 80 potential partners in 42 countries. The digital partner's goal was to enable exploitation of affordable refurbished computers to be shared widely among the recipient countries, the majority being in Africa. Digital partners also provided skills and other resources required for effective use of computers donated. However, the study was unable to provide any empirical evidence on the appropriateness and use of refurbished computers among the beneficiary users.

James (2001) furthermore examined efforts being made in redesigning computer hardware to lower cost of Internet access. He observed that in order to bring about drastic reduction costs, the designers of the innovations had employed a variety of ways. He cited the case of India where cheap computer hardware called 'simputer' was designed in the year 2001. He additionally noted that in order to reduce the costs, the designers bought electronic components of the computer in volume 'off the shelf.' The computer uses open source software. He also gave the example of Brazil where low cost computer 'Volkscomputer' was developed and commissioned by the government to be sold to low income earners in instalment of US$ 15 per month. Other targeted beneficiaries included public schools, with the objective of bringing Internet access to some 7 million children. The author observes that the indigenously designed computer was able to achieve costs reduction because it contained neither a hard drive nor the ability to use floppy disks. The computer only had in-built modem, a colour monitor, speakers, a mouse and simple Internet facility. The study was, however, unable to determine the impact of these innovations and whether they could be replicated in other developing countries such as Sub-Saharan Africa.

4.10.6 Making a choice of appropriate ICTs to bridge digital divide

Several initiatives are being taken to assist those who may want to adopt ICTs in remote disadvantaged rural environments. The Technical Centre for Tropical Agriculture and Rural Co-operation established an Observatory on ICTs in 1998 for ACP agricultural and rural development (CTA 2003:1). The aim of the Observatory is to study and monitor suitable technologies for use in information and communication management. The main objectives of the Observatory as outlined by CTA (2003:1) are to:

- identify and indicate key ICT issues and strategies relevant to ACP agricultural development and natural resources management;
- improve the common pool of knowledge and expertise available in this area;
- identify relevant projects and expertise that could assist in defining strategies; and
- provide a mechanism for monitoring technical developments which can benefit those working in agriculture, rural development and natural resources management.

On the same note Munyua (2000:7) observes that the International Telecommunication Union (ITU) has created a Global Case Library of reports on on-going projects using ICTs, planned projects using satellite and wireless technologies and examples of equipment adapted for use in remote disadvantaged rural environments. One can access the website through:

- ITU http://www7.itu.int/itudfg7/About/Means_Methods.html
- http://www7.itu.int/itudfg7/fg7/CaseLibrary/Case-Library.html.

Policy makers in the agricultural sector can benefit from the above initiatives and ensure that appropriate ICTs are adopted in the sub-Saharan Africa countries including Kenya, to facilitate communication of agricultural information between agricultural researchers, extension workers, farmers and other actors involved in research and extension. These technologies can enhance the effectiveness and efficiency of delivery of information and promote equitable and sustainable agricultural development.

4.11 Summary

The chapter has reviewed literature related to the study. It has examined the potential of ICTs in enhancing the process of technology transfer and communication among actors involved in research and extension. It is observed that ICTs offer tremendous capabilities to demand driven research and extension by providing effective and efficient means of delivering agricultural information. The advancements of ICTs in Africa is therefore an opportunity to overcome inherent and historical disabilities that have confronted the continent in the past. It is noted that several ICT models have been developed to improve the linkages between agricultural research, extension workers, farmers and other stakeholders. These models include VERCON developed by FAO, RUN developed by the German Centre for Documentation and Information in Agriculture, JAMEX developed by the Jamaica Agricultural Marketing Exchange and MANOBI developed by a private firm in Senegal. These models are being applied in various countries.

The review of literature on information needs and use of ICTs has revealed that the use of ICTs must be centred on availability, access and skills development among the users. In addition, there must be a responsive content to meet the information needs of the users. It is also observed that there is a positive association between the use of ICTs by researchers and their creativity and productivity at work.

Diffusion of ICTs depends on complementary inputs that have been put in place. These include telecommunication and communication infrastructure, electricity and policies to provide an enabling environment and guide the process. It is observed that a complex set of geographic, economic, and social factors must be considered before selecting appropriate ICTs to adopt. It is noted that ICT access is unevenly distributed in Africa often favouring the urban and wealthy residents as opposed to rural populations. This has exacerbated the digital divide within the countries and the most affected are the rural communities. Barriers that contribute to digital divide include lack of physical access, lack of skills and support, cultural and behavioural attitudes and lack of responsive content. The chapter has also reviewed ICT models developed to address the issue of digital divide. There is potential of replicating some of these models in the rural areas of sub-Saharan Africa. An integrated approach can be achieved in initiating ICTs projects to reduce the digital divide if collaborative efforts are made between governments, donors, organisations and the private sector.

The next chapter discusses the research methodology and design applied in the study.

CHAPTER FIVE

RESEARCH METHODOLOGY

5.1 Introduction

The purpose of this chapter is to explain the research design and methodology of the study. To achieve this the chapter is organised into the following sections: introduction, qualitative and quantitative research designs, survey research method, population and sampling, data collection instruments, pilot study, research procedure, data analysis and problems encountered.

Arnon (1989:317) defines research as original and a creative intellectual activity, carried out in the laboratory, the library or the field, which endeavours to discover new facts and to appraise and interpret them properly in the light of previous knowledge. He states that research is the application of human intelligence in a systematic manner to a problem whose solution is not immediately available. Similar views are shared by Weingand (1993:17) who defines research as a careful study and investigation, which seeks to discover facts or information. It is a purposeful, controlled, formal, systematic, critical and intensive activity (Mgenda and Mgenda 1999:1, Keya, Makau, Mani & Omari 1989:1). According to Peritz in Rochester and Vakkari (1998:167) research is an inquiry where the goal is to elicit, by means of a systematic method, new facts, concepts or ideas. A similar view is expressed by Mgenda and Mgenda (1999:2) who assert that the main purpose of research is to discover new knowledge.

Keya, Makau, Mani and Omari (1989:1) describe the philosophy of research design and methodology as a process, which has a continuum of interrelated or interlocked activities and sub-processes, starting with a needs assessment and ending with the way in which results will be utilised for development. Research method is understood as the first step in the way and the means by which a project is implemented and closely related to it is research design, which is the theoretical perspective that specifies how a study is executed in such a way that it answers the research questions (Ikoja-Odongo 2002:184).

In other words research design is a strategic framework for action that serves as a bridge between research questions and the execution or implementation of the research. It involves the structuring of variables in a manner that enables their relations to be determined (Nkpa 1997:40). Research technique, on the other hand, is the approach or the strategy by which research is carried out by use of observation, interview or questionnaire (Keya et al 1989:20).

In this study, research methods, designs and techniques were analysed in close juxtaposition with the objectives of the study. They were examined in terms of appropriateness in implementing the study which investigated diffusion of ICTs in the communication of agricultural information among agricultural researchers and extension workers in Kenya. In particular, the study focused on the Kenya Agricultural Research Institute (KARI) and the Ministry of Agricultural and Rural Development (MoARD). The selected methods, designs and techniques are discussed in the following sections of the chapter.

5.2 Quantitative and Qualitative Research Designs

The study used both qualitative and quantitative research designs. Neuman (2000:122) states that qualitative research design is used to collect data in forms of words, pictures, sounds, visual images, or objects. It is a source of well-grounded rich descriptions and explanations of processes in identifiable contexts (Mgenda and Mgenda 1999:201). Miles and Huberman (1994:10) assert that qualitative research focuses on naturally occurring ordinary events in natural settings reflecting real life situations and data is collected in close proximity to a specific situation. Qualitative researchers are more concerned about issues of richness, texture and feeling of raw data because their inductive approach emphasizes developing insights and generalizations out of data collection (Neuman 2000:122). Qualitative method encompasses use of data collection techniques that include observation, interviews and documentary review (Mgenda and Mgenda 1999:203). This study used in-depth interviews to solicit for information from the key informants of the study. The main data collection instruments (interviews and questionnaire) were supplemented by observations and reviewing of documents relevant to the study. These methods enabled the researcher to collect qualitative data from the respondents. Mgenda and Mgenda (1999:202) observe that in a descriptive research which is typically quantitative a researcher may include open-ended items where respondents are given an opportunity to express their views, thus yielding qualitative data. In the questionnaire therefore, this researcher included some open-ended questions where respondents were expected to freely express themselves using their own words.

According to Neuman (2000:517) quantitative research design is used to collect data in forms of numbers. Weingand (1993:19) is of the opinion that quantitative research tends to deal in large amounts of data, which, through sampling can then be generalised to represent the total target population. These views are shared by Neuman (2000:123) who observes that quantitative researchers are more concerned about issues of design, measurement, and sampling because their deductive approach emphasises detailed planning prior to data collection. This study used quantitative techniques in sampling the population and in data collection. In data collection, a questionnaire was used to solicit information from agricultural researchers and extension workers, while the sampling techniques used to select the respondents were stratified, cluster and random sampling. Before the actual study, the data collection instruments were pre-tested to ascertain their clarity, suitability, reliability and validity. Mgenda and Mgenda (1999:198) argue that data collection techniques used in quantitative research often involve rigorous standardization, utilizing such strategies as pre-tests to demonstrate validity and reliability.

Although qualitative and quantitative research differs in many ways, they complement each other (Weingand 1993, Neuman 2000). One of the differences between the two comes from the nature of the data. Soft data (qualitative), in the form of impressions, words, sentences, photos, symbols, dictate different strategies and data collection techniques than hard data (quantitative), in form of numbers (Neuman 2000:123). The findings in a qualitative research cannot be extended to wider population with the same degree of certainty that quantitative analyses can (Weingand 1993:23). The complementary role is that while quantitative is useful in measuring occurrences in a phenomenon, qualitative research helps to explain the element "why" of the occurrence (Weingand 1993:19). Miles and Huberman (1994:10) state that qualitative data are useful when one needs to supplement, validate, explain, illuminate or reinterpret quantitative data gathered from the same setting. They argue that quantitative and qualitative methods are intertwined, not only at the level of specific data sets but also at the levels of study design and analysis. This study used both methods to enable confirmation and corroboration of data collection via triangulation. The various instruments used for data collection supplemented and complemented one another and enabled the researcher to gather useful information from the respondents. The methods also allowed the researcher to examine the issues being investigated from several angles in order to meet the objectives of the study. The two approaches were used sequentially or simultaneously depending on the circumstances. King, Keohane and Verba (1994:5) conclude by observing that the best research often combines the features of both qualitative and quantitative methods.

5.3 Survey Research Method

A survey research method, comprising of a self-completed questionnaire and interview with the respondents, was utilised to gather data, as a means of investigating diffusion of ICTs in the communication of agricultural information among agricultural researchers and extension workers in Kenya. Neuman (2000:34) states that the survey research method often uses a sample of selected respondents but generalizes results to the entire population being studied. It enables a researcher to gather information about target population without undertaking a complete enumeration (Robson 1997:124). A survey is based on the assumptions that samples from a population can often furnish the same information at much less cost, with greater efficiency, and sometimes greater accuracy (The American Statistical Association 1997:1, Kerlinger in Kimani 2001:75). Wegner (2000:73) is of the opinion that a survey is the most widely used technique in collecting primary data and seeking the beliefs, opinions, attitudes, motivation, expectations, characteristics and behaviour of the respondents. This study, therefore, found the survey method to be appropriate because of various reasons. First, the study sought to find out the perceptions, opinions, expectations, motivation and attitudes of agricultural researchers and extension workers in relation to use of ICTs in communication of agricultural information. Secondly, it was not possible to involve all the respondents due to their large number. The researcher, therefore, sampled the population using appropriate sampling techniques and obtained a representative sample. The techniques used in sampling ensured that each person in the population had a measurable chance of being selected. This way, the results can be reliably projected from the sample to the larger population. Thirdly, the study had many variables to test and survey research method was found to be appropriate. Neuman (2000:250) asserts that survey research allows many variables and multiple hypotheses to be tested.

5.4 Population and Sampling

5.4.1 Area of study

The study focused on the public agricultural sector in Kenya and in particular the Kenya Agricultural Research Institute (KARI) and the Ministry of Agriculture and Rural Development (MoARD). The agricultural researchers were drawn from the twenty-one main KARI research centres distributed in all the eight provinces of Kenya and strategically spread to cater for different agro-ecological zones and socio-economic systems. The centres consisted of fifteen national and six regional research centres respectively. In addition, KARI has twelve sub-centres which are the extension of the national and regional research centres. These centres were not included in the study because they are small centres performing the extension activities of the selected national and regional centres. The study, therefore, purposively involved all the 21 main research centres spread across the country and depicting different level of infrastructure development. Obviously, some centres are located in areas with well developed infrastructure and conducive climate for a variety of agricultural activities. These centres were also likely to serve many farmers and extension workers due to high population in the area. In contrast, some centres are located in the semi-arid areas where the infrastructure is poor and is sparsely populated hence serving fewer farmers and extension workers. In addition, some research centres are located near big towns enabling them to access good communication infrastructure as opposed to those centres located in the rural areas. The spread of the KARI research centres across the country to cater for different agro-ecological zones and socio-economic systems, and depicting different levels of infrastructure development gives a clear indication on the distribution of ICTs in the agricultural sector and provides basis for comparison.

The KARI head office was also included in the study for purposes of consulting key informants of the study who comprised top management staff/policy makers, systems administrator/IT manager, head of information and documentation services, coordinators of research programmes and the Agricultural Technology Information Response Initiative (ATIRI).

The Ministry of Agriculture and Rural Development (MoARD) has agricultural extension offices at provincial, district, and divisional levels. It was not possible to cover all the extension workers who are spread across the country. The researcher therefore used purposive sampling to select one province that has a representation of dense as well as sparse population, depicted different agro-ecological zones as well as various levels of infrastructure development. According to Neuman (2000:198) purposive sampling uses the judgement of an expert in selecting cases with specific purpose in mind. Robson (1997:142) adds that purposive sampling enables a researcher to obtain a sample to satisfy specific needs of the study. The province that met the stipulated criteria was the Rift Valley Province. The province has a total of 18 districts. The cluster sampling technique was used to cluster the districts within the province into two categories as follows:

- Districts with high and medium agricultural potential areas, dense population and relatively good infrastructure and
- Districts in the arid and semi-arid areas, sparse population and relatively poor infrastructure.

According to Keya, Makau, Mani and Omari (1989:30) a cluster sample is used to group the elements of a population according to similar characteristics, which may include ecological zones, villages, and families. Cluster sampling is used when a population is widely dispersed and large, requiring a great deal of effort and travel to get the survey information (Robson 1997:139). In this study, cluster sampling enabled the researcher to group the districts into two categories according to similar characteristics. This reduced the cost of reaching the dispersed population of extension workers. The researcher then purposively selected one district from each of the two clusters/categories. The districts selected were Uasin Gishu district which represented districts in the high and medium potential areas and Baringo district representing districts in the arid and semi-arid land. The extension workers were therefore drawn from the two districts.

Baringo district agricultural office coordinates extension services in 14 divisions namely, Tenges, Sacho, Kabarnet, Kabartonjo, Kipsaraman, Bartabwa, Barwesa, Salawa, Marigat, Mochongoi, Mukutani, Tangulbei, Nginyang and Kolowa. The Uasin Gishu district agricultural office coordinates extension services in six divisions namely, Ainabkoi, Kapsaret, Kesses, Moiben, Soy and Turbo. The extension workers consulted were therefore distributed in all the divisions within the two districts. The Ministry of Agriculture headquarters was included in the study for purposes of consulting the key informants of the study who comprised the top management staff (policy makers), coordinators of various extension programmes, head librarian, and system administrator/ IT manager. The Agricultural Information Centre (AIC) which is a division within the ministry of agriculture participated in the study because of its role of repackaging agricultural information and providing it in print and electronic format and also through the media to farmers, extension workers and interested parties.

The list of the institutions surveyed is provided in Appendix A.

5.4.2 Target Population

Population refers to an entire group of individuals, events or objects having common observable characteristics (Mgenda and Mgenda 1999:9). To define a population, a researcher specifies the unit being sampled, the geographical location and temporal boundaries of populations (Neuman 2000:201). In selecting the target population, notions of appropriateness and practicability should be considered (Keya, Makau, Mani and Omari 1989:27). Appropriateness of the target population refers to its suitability in achieving the objectives of the study (Flicks 1998:41).

The target population of this study consisted of 212 and 96 extension workers in Uasin Gihu and Baringo districts respectively and 382 agricultural researchers distributed among the 21 KARI centres. Various sampling techniques were utilised to select samples from the two categories of respondents. The sample selected consisted of 191 agricultural researchers drawn from the 21 KARI research centres and 154 extension workers drawn from the Uasin Gishu and Baringo districts. Those who completed the questionnaire and returned were 159 agricultural researchers and 138 extension workers. The study also consulted 59 key informants who comprised policy makers, system administrators/IT managers, librarians or information professionals drawn from all the institutions surveyed.

5.4.3 Sample selection procedure

Mgenda and Mgenda (1999:10) define sampling as the process of selecting a number of individuals for a study in such a way that the individuals selected represent the large group from which they were selected. The primary purpose of sampling is to get a representative sample from a much larger population, study it and produce accurate generalizations about the larger group (Neuman 2000:195). Sampling enables one to achieve the same research objectives with reduced resources in terms of personnel, time and costs (Keya, Makau, Mani and Omari 1989:27). The American Statistical

Association (1997:2) is of the view that there is no simple rule for sample size that can be used for all surveys.

In order to obtain an in-depth study and to acquire a demonstrable degree of reliability and validity, the researcher used a variety of sampling techniques in selecting population sample for the study. Both probability and non-probability sampling techniques were used. Probability sampling uses statistical or mathematical process in selecting samples so that each and every member of the population has an equal chance of being selected for the sample (Shao 2002:363). Probability samplings used in this study were stratified, random and cluster sampling techniques. Non-probability sampling is where the researcher is not compelled to determine the sample size in advance (Neuman 2000:196). Examples of non-probability sampling techniques are purposive, snowball, quota, and deviant sampling among others. In this study purposive sampling was used as already mentioned.

At the time of conducting the study, KARI had a total of 382 agricultural researchers distributed in the 21 research centres. Out of this number, a sample of 191 representing 50% was selected for the study. Out of 212 extension workers at Uasin Gishu district, 106 (50%) were selected for the study. While in Baringo district out of 96 extension workers 48 (50%) were selected for the study. The extension workers were distributed in the divisions within the two districts and each division had an agricultural office to coordinate the extension activities. A fifty percent sample size was used given that the agricultural researchers were spread through out the country and that the extension workers were also dispersed within the two districts. The sample size was, therefore, found to be appropriate given the difficulty of reaching all the respondents. Mgenda and Mgenda (1999:43) argue that a 50% sample is large enough and can be used to represent the target population. Neuman (2000:216) suggests that a sample size depend on the purpose of the study, the kind of analysis to be applied and the characteristics of the population.

The researcher obtained personnel data from respective research centres and district agricultural offices and used stratified sampling to categorise agricultural researchers and extension workers into strata according to their departments/section or research areas/activity. Stratified sampling involves dividing the population into a number of groups or strata where members of a group share a particular characteristic or characteristics (Shao 2002:366). The researcher may divide the population into sub-populations (strata) on the basis of supplementary information (Neuman 2000:208). The respondents were placed into strata according to their areas of research and sections, for example plant breeders, animal breeders, pathologists, agronomists, soil scientists, entomologists etc. This guaranteed a representative sample from the target population. A simple random sampling strategy was developed and used to draw sample from each of the stratum. Neuman (2000:208) asserts that after dividing the population into strata, the researcher draws random sample from each sub-population.

Purposive sampling technique was used to select policy makers and top management staff, system administrators, IT managers, librarians and other key informants of the study from the institutions surveyed.

5.5 Data collection instruments

This study used a variety of instruments in data collection which included a self-completed questionnaire, a semi-structured interview, observation and documentary review. The instruments were expected to provide precise and adequate data relevant to the objectives of the study. Keya, Makau, Mani and Omari (1989:31) observe that the choice of data collection instrument is largely based on the efficiency and accuracy with which the information will be collected. The authors are of the view that the method chosen would depend on the extent to which it would provide precise and adequate data on variables the investigator wishes to study. Wegner (2000:70) adds that the choice of the instrument influences the quality, quantity and type of data to be gathered and selection of statistical analyses to be used. The selection of a method is also based on practical considerations such as the need for personnel, skills, time, equipment and other facilities, in relation to what is available (Keya, Mani and Omari 1989:31).

5.5.1 Self-completed questionnaire

The self-completed questionnaire as a data-gathering instrument is a widely used tool in survey research (Mgenda and Mgenda 1999:71). A questionnaire is a formatted set of questions drawn up to meet the objectives or research questions of the study (Neuman 2000:250, Keya et al 1989:32). The key factor in the construction of a questionnaire is the relevance of the questions to the goals of the study and to the individual respondent (Leedy 1997:192). A survey researcher conceptualizes and operationalizes variables as questions and weaves them together so that they flow smoothly and include introductory remarks and instructions for clarification (Neuman 2000:251).

This study used the questionnaire technique to gather information from agricultural researchers and extension workers. The respondents were widely dispersed among the 21 KARI research centres distributed across the country and also within the two districts surveyed. The questionnaire enabled the researcher to collect data from this large number of respondents in a cost-effective manner. Robson (1997:243) asserts that self-completed questionnaires, which respondents fill in for themselves, are very efficient in terms of researcher time and effort. The questionnaire used was semi-structured, thus comprised open-ended (unstructured) and closed-ended (structured) questions. The open-ended questions constituted 15 percent of the total questions and were used to elicit free responses and permitted the respondents to respond in their own words. The closed-ended questions constituted 85 percent of the total questions and were used to capture fixed responses from the respondents. Neuman (2000:260) states that the disadvantages of questionnaire can be reduced by mixing open-ended and closed-ended questions. Mgenda and Mgenda (1999:72) add that, although closed-ended questions can be easier and quicker for respondents to answer, they can be frustrating to the respondents because their desired answer is not among the choices given. On the other hand, although open-ended questions permit unlimited number of possible answers, coding them may be difficult. A blend of the two types of questions was therefore desirable for this study.

The questionnaire was comprised of six major sections (see appendix C). Section I consisted of questions designed to collect demographic data such as the status, position, highest qualifications, age and gender. Some studies have shown that such personal characteristics have influence on the issues being investigated. The characteristics were used in this study to investigate whether they had an influence on use of ICTs among the respondents. Section II of the questionnaire was designed to collect information on the information needs of the respondents. Section III collected information on the availability, access and use of ICT tools and services and measured the distribution of these technologies among the institutions surveyed. Section IV of the questionnaire was designed to asses the respondent's skills and competencies in relation to use of ICT tools and services. Section V of the questionnaire examined the costs and sustainability of ICTs. Finally section VI was comprised of open-ended questions. The first question sought to establish whether ICTs had changed the way the respondents seek information from libraries and information centres. The second question sought to establish whether ICTs had changed the way the respondents communicated agricultural information. The third question asked the respondents their opinions on limitations and constraints affecting the use of ICTs in their institutions. The fourth questions asked the respondents to suggest ways of improving the application and use of ICTs in their institutions.

The researcher was conscious of the limitation of the questionnaire, namely, the low response rate, no opportunity for researcher to clarify questions to the respondents, the lack of satisfactory answers. However, these limitations were minimised by adopting several techniques. The researcher visited the institutions surveyed and personally requested the respondents to complete the questionnaire. Although this was time consuming it paid dividends as the response rate was high. This also provided an opportunity to clarify any question that respondents did not understand. It was not possible to reach one research centre due to bandits and insecurity and the researcher had to get the intervention of the director of KARI in distributing the questionnaires to respondents. In the course of drafting the questionnaire, care was taken to ensure the following:

- that questions were clearly worded, categorical and simple to answer;
- that questions were kept to minimum;
- that attempt was made to avoid ambiguity, confusion, vagueness;
- that appearance and layout of the questionnaire was attractive to ensure ease of reading;
- A polite introductory letter stating the purpose of the study, guaranteeing confidentiality and encouraging the participant to take part in the study was given at the beginning of the questionnaire and that
- the questionnaire was designed on the basis of the study objectives and research questions.

A close liaison was established with the directors of research centres and the District Agricultural, Livestock and Extension Officers (DALEO). Before questionnaires were distributed, meetings were held with the directors of research centres or their deputies and also with the DALEOs. The purpose of the study was explained and research permits and other documents showed. The directors of research centre and DALEOs arranged meetings between the agricultural researchers/ extension workers and the researcher. In some occasions the director requested one senior officer to take the researcher to the departments/sections to meet the respondents. These meetings were very helpful in clarifying issues pertaining to the study and also in soliciting cooperation from agricultural researchers and extension workers respectively. In most cases, the researcher personally hand delivered the questionnaire to the respondents. The secretary in the director's office or one of the research officers was requested to coordinate the collection of completed questionnaires. The researcher went back on the agreed date to collect the questionnaires.

5.5.2 Semi-structured interview

Personal interview was conducted with three categories of key informants of the study who comprised 24 policy makers, 27 librarians/information professionals, and 8 Information Technology (IT) personnel drawn from the institutions surveyed. In addition, the staff of the Agricultural Information Centre (AIC) were also interviewed. They included the director, the radio producer, the video manager, the publications officer, and the documentalist. Shao (2002:185) is of the view that a personal interview involves face-to-face communication between an interviewer and a respondent with the purpose of obtaining information relevant to research problem. The strength of face-to-face interview lies in its flexibility and adaptability, ensuring a high rate of response, control of interview situation, recording of spontaneous and unintended responses and provision of in-depth data to meet specific objectives of the study (Mgenda and Mgenda 1999:84). Well-planned interviews usually produce most useful information as well as supplementary, insightful observations and opinions from the respondents.

Mgenda and Mgenda (1999:86) assert that an interview schedule can have structured, semi-structured and unstructured questions. This study used semi-structured interviews to collect data from the informants of the study. A semi-structured interview, is where the interviewer has worked out a set of questions in advance, but is free to modify their order, based upon his/her perception of what seems most appropriate in the context of the conversation (Robson 1997:231). Three types of semi-structured interview schedules were prepared for the three categories of informants who were comprised of policy makers, librarians/information professionals and IT personnel (see appendix D, E and F). The face-to-face interview suited this category of respondents who were assumed to have vital information on ICT policy, adoption, diffusion and use of ICTs in their respective institutions. The researcher made appointments with this category of respondents before the interviews. During the interviews, it was possible to explore the responses of the interviewees in-depth by following up interesting responses and underlying motives on various issues being investigated (see the Schedules in appendix B). This provided rich and highly illuminating information relevant to the objectives of the study.

During the interviews, the researcher was able to re-phrase and clarify questions when the need arose. The schedules were used purely for guidance purposes and were not followed strictly in the order that the questions appeared. The answer to the first question was used to determine the next question. Some questions were invalidated by previous answers. Non-verbal cues produced by the respondents helped the researcher to understand their verbal response. This method provided the researcher with an opportunity to maintain personal contact with the respondents, a condition that was utilised to satisfy the respondents psychologically as they were made to feel part of the study. This condition enhanced their participation in the interview.

5.5.3 Observation

The observation method was found to be appropriate in supplementing the main data collection instruments in collecting data pertaining to the nature, types and distribution of ICTs among the institutions surveyed. Robson (1997:192) asserts that observation can be used as supportive or supplementary technique to collect data that may complement or set in perspective data obtained by other means. The advantage of observation as a technique of data collection is its directness that permits a researcher to collect data from real situation (Wegner 2000:70). Robson (1997:194) classifies observation into formal and informal gathering techniques. Formal approaches impose a large amount of structure and direction on what is to be observed. While informal approaches are less structured and allow the observer considerable freedom in what information is gathered and how it is recorded. A combination of the two techniques were used. An observation guide was prepared to guide in data collection (see appendix G). During visits to institutions surveyed, the researcher focused mainly on the nature and types of ICTs available and their application, but was also flexible enough to observe any other aspect or phenomenon which was relevant to the study.

In each of the institutions visited the centre director or district agricultural, livestock and extension officer arranged for a tour of the departments/sections. During the tours and visits to the departments and sections, it was possible to note down ICT facilities available and where necessary clarification was sought. In many occasions, the respondents were eager to demonstrate to the researcher how some of the facilities work. For example, at the Agricultural Information Centre (AIC), the radio producer demonstrated how the two studios work. The Observation method, therefore, provided additional information that could not be easily captured by the other methods used. Through this method information was obtained pertaining to ICTs tools and services such as GIS facilities, Radio Studio Equipments, information storage facilities such as the Kenya Agricultural Research Database (KARD), CD-ROM databases, Video facilities, Agro-Meteorology facilities, Email and Internet facilities among others. This information was noted down in a notebook.

5.5.4 Analysis of Documentary Evidence

This technique of data collection also referred to as documentary review entails going through existing documents, which are likely to give useful information for the study. During visits to institutions, the researcher was given documentation about the respective institutions. For example at the KARI headquarters, the director and the public relations officer provided a lot of documentation about KARI. Similarly, other institutions also made their documentation available to the researcher. These documents were carefully studied and notes made out of them, and those which could be taken away were collected for further review. Reviewed documents included, annual reports, strategic plans, and policy documents, project reports on information/information technology and related areas, inventory of IT, brochures, newsletter, organizational charts, and manuals among others. Perusing through these documents provided good insights and background information about the institutions surveyed in terms of their missions, objectives, and core business. For example, information was obtained on the restructuring of KARI and the MoARD to enable the two institutions create an information services division. This was after the realization of the need to improve the flow of information among the actors involved in research and extension. The divisions were, therefore, expected to facilitate the provision of agricultural information. This information was obtained from the Ministry of Agriculture Report on "Assessment of information needs and options for information managements 1997/8" and also from KARI strategic plan document titled "Third medium term plan 2003-2007." The documentary review therefore provided information that could have proved difficult to capture using the other methods employed in the study.

5.6 Pilot Study

A pilot study was undertaken prior to the main study to pre-test the data collection instruments and ascertain their clarity, reliability and validity. This was done using twenty extension workers and agricultural researchers from Kesses division and the Kenya Plant Health Inspectorate Services (KEPHIS), Kitale. These persons were given the questionnaire and requested to complete and also to comment on the clarity and suitability of the instrument. At the time of collecting the questionnaire the researcher held discussions with each of the participants to ascertain areas in the questionnaire that needed improvement. In some questions, the options for choices were limiting. An example is question number ten that was expanded after the pilot study to include more choices on information needs.

The researcher also tested the reliability and validity of the instruments and in particular the questionnaire. Mgenda and Mgenda (1999:95) assert that reliability is a measure of the degree to which research instruments yield consistent results after repeated trials. It suggests that the same thing is repeated or recurs under the identical or very similar conditions. The researcher tested whether the instrument delivered similar outcomes from the twenty participants in the pilot study. This was achieved without much problem.

Validity is an indicator showing whether an instrument is actually capturing the meanings of construct as expected (Neuman 2000:167). In other words, a researcher would test the instrument to find out whether it is eliciting the expected information. The researcher had designed the instrument with the objective of collecting particular information from the respondents. Through the pilot study the instrument was tested to establish whether it elicited valid responses from the participants. Reliability and validity are usually complementary concepts, but in some special situations they conflict each other. For example, a measure can be reliable but invalid. To achieve both reliability and validity, the instrument was pre-tested for clarity, relevance, and shortcomings. Where errors were detected modifications were made prior to the actual study. All the suggestions were incorporated in the final draft of the questionnaire.

5.7 Research Procedure

A research timetable covering the period of research from April 2002-May 2004 was compiled and agreed upon in consultation with the supervisors. This was to guide the researcher in the process of conducting the research. Before going to the field, a research permit was obtained from the Ministry of Education, Science and Technology in Kenya. This is a legal requirement for those who want to conduct research in the country. The Directors of Agriculture and KARI respectively were approached personally and presented with a research clearance permit and a letter of request from the Head of Department of Library and Information Studies, Moi University seeking authority on behalf of the researcher to conduct research at KARI and at the MoARD. The directors showed a lot of interest in the study and granted permission to the researcher to conduct the research. At KARI headquarters, the director asked the public relations officer of the institution to take the researcher on a tour of the institution and introduce him to coordinators of programmes, systems manager and the head of information and documentation unit.

5.7.1 Ethical considerations

Appointments were made with the directors of research centres, the district agricultural, livestock and extension officers of Uasin Gishu and Baringo districts and also with the informants of the study who comprised policy makers, IT personnel and librarians in the institutions surveyed. As soon as the researcher arrived at the institutions surveyed he held introductory talks with the director/officer in charge and explained the purpose of the study. During data collection process, respondents were informed about the objectives and significance of the study and their consent to participate was obtained. They were assured that the information they gave was to be treated with utmost confidentiality and was to be used strictly for purposes of the study.

Data collection took duration of six months starting January to June 2003.

5.8 Data analysis

The completed 297 questionnaires and recorded interviews from 59 informants formed the basis of data analysis and interpretations. The questionnaires were reviewed to determine their usability. Two questionnaires were incomplete and were discarded which reduced the total number of questionnaires to 295 (agricultural researchers 159 and extension workers 138). A coding scheme was developed for closed-ended questions and input into the Statistical Package for Social Sciences (SPSS). Data was then analysed using descriptive statistics where frequencies, percentages, and means were calculated, and data presented accordingly. Relationships among variables were compared and interpretations made.

Open-ended responses and recorded interviews were analysed using content analysis methodology. Mgenda and Mgenda (1999:174) assert that content analysis involves logical groupings of the data with similar messages. Open-ended questions were, therefore, scanned to determine which words or phrases were frequently used by the respondents. An index of all the responses was constructed. The data was then recorded according to the frequency by which the phrases was cited.

5.9 Problems encountered

1. The institutions surveyed were dispersed from one another especially the KARI research centres that are distributed across the country. The researcher had to travel

widely to cover the institutions surveyed. Some KARI centres and divisional agricultural offices could not be reached using public vehicles and this researcher had to use a bicycle taxi commonly known as "boda-boda" in Kenya. This delayed the researcher and he had to keep on calling on cell-phone to assure the respondents that he was still on the way.

2. The study was conducted during planting season in most parts of Kenya and agricultural researchers and extension workers were quite busy. As a result some respondents took long before completing the questionnaires. However, in many instances, the centre director and divisional extension officers were very helpful and facilitated the distribution and completion of the questionnaires. At two research centres, the questionnaires were completed the same day the researcher arrived after the directors requested their staff to assist the researcher who had travelled from far.

3. Due to financial constraints the researcher was not able to hire research assistants. The whole exercise was, therefore, tedious to the researcher who had to travel to all the institutions. However, it was advantageous for the researcher to collect data by himself since this increased its relevancy and validity.

4. The North Eastern Province of Kenya was inaccessible because of insecurity problems caused by bandits. The distance to the province is very far and roads are very poor. Most of the government employees working in the province use chartered planes. KARI has one research centre at Garissa and a sub-centre in Marsabit. The researcher found it difficult to travel to this centre and sought for assistance from KARI headquarters that made arrangement for the despatch of the questionnaires.

5.10 Summary

The chapter has discussed the research methods, designs and techniques applied in the study. The survey research method was utilised in the study. Both qualitative and quantitative research designs were used. The qualitative methods used in data collection included face-to-face interview, observation and documents review. The interview was used to obtain information from the informants of the study. In case of the quantitative method, a self-completed questionnaire was used to solicit for information from agricultural researchers and extension workers.

The agricultural researchers were drawn from the 21 main KARI research centres, while the extension workers were drawn from the Uasin Gishu and Baringo districts. Other institutions surveyed included KARI and the Ministry of Agriculture headquarters and the Agricultural Information Centre (AIC). The key informants of the study were drawn from all the institutions surveyed.

The study used both probability and non-probability sampling techniques. The probability sampling techniques used were stratified, cluster and random, while the non-probability sampling technique used was purposive. The agricultural researchers and extension workers were stratified according to their areas of research. Simple random sampling was used to draw data from each stratum. The purposive sampling method was used to select the key informants of the study who comprised of policy makers, librarians and IT personnel. Completed questionnaires were analysed using Statistical Package for Social Sciences (SPSS) and frequencies, percentages, means and standard deviations were calculated and presented accordingly. Content analysis was used for open-ended responses and recorded interviews.

The next chapter presents and analyses data obtained from the field.

CHAPTER SIX

DATA PRESENTATION AND ANALYSIS

6.1 Introduction

The purpose of this study was to investigate the diffusion of Information and Communication Technologies (ICTs) in communication of agricultural information among agricultural researchers and extension workers in Kenya. The study focused on the public agricultural sector and covered the Kenya Agricultural Research Institute (KARI) and the Ministry of Agriculture and Rural Development. A total of 356 respondents comprising 159 agricultural researchers, 138 extension workers and 59 key informants participated in the study. The completed questionnaires were reviewed to determine their usability. Two questionnaires were discarded because they were incomplete. A total of 295 questionnaires (159 agricultural researchers and 136 extension workers) and 59 recorded interviews were usable. This reduced the total number of respondents to 354.

A survey method was employed to conduct the study. The data collection instruments used were self-completed questionnaire, interview schedule, observation and document review. The questionnaire was used to collect data from agricultural researchers and extension workers while face-to-face interview was used to solicit information from key informants of the study. Information obtained through these instruments provided the basis for data presentation and analysis.

This chapter is divided into two sections. Section I presents data obtained from agricultural researchers and extension workers, while section II present data obtained from the key informants of the study who comprised of policy makers, librarians/information professionals and IT personnel.

Section I

6.2 Data obtained from agricultural researchers and extension workers

6.2.1 Response

At the time of conducting the study, the Kenya Agricultural Research Institute (KARI) had 382 agricultural researchers distributed among the 21 KARI research centres. Fifty percent (191) of the researchers participated in the study. Those who completed the questionnaires and returned were 159 (83.2%).

Out of 212 extension workers in Uasin Gishu District, 50% (106) participated in the study and 90 (85%) completed and returned the questionnaire. Out of 96 extension workers in Baringo District, 50% (48) participated in the study and all (100%) completed and returned the questionnaire. The total number of responses from the two districts was, therefore, 138 (89.6%). Two questionnaires were incomplete and were discarded bringing the total number of usable questionnaires from extension workers to 136.

The overall response for both agricultural researchers and extension workers was 86.1% (297).

6.2.2 Characteristics of Respondents

Agricultural researchers and extension workers were asked to indicate their age, gender, highest qualifications and where obtained, their job titles, level of responsibility and departments where they worked. Tables 1-3 display distribution of the respondents according to their characteristics.

62.2.1 Age

The respondents were asked to indicate their ages. This was necessary so as to understand the distribution of the respondents by age and to establish whether age had any influence on use of ICTs. The following table shows the distributions of the respondents according to their ages.

Table 1
Characteristics of Agricultural Researchers (n=159) and Extension Workers (n=136) by age

	Agricultural Researchers		Extension Workers	
Age	**N**	**%**	**N**	**%**
20 - 29 years	18	11.3	-	-
30 - 39 years	42	26.4	78	57.4
40 - 49 years	78	49.1	58	42.6
over 50 years	21	13.2	-	-
Total	**159**	**100**	**136**	**100**

It can be seen from table 1 that 49.1% of agricultural researchers were between forty and forty nine years of age, 26.4% were between thirty and thirty nine years of age and 13.2% were over 50 years of age. Only 11.3 were between twenty and twenty nine years of age.

Of the extension workers surveyed, 57.4% were between the ages of thirty and thirty nine, while 42.6% were between the ages of forty and forty nine. There was none above 50 years of age and between the ages of twenty and twenty nine. The reason why there were no extension workers between the ages of twenty and twenty nine could be attributed to the fact that the public sector in Kenya, and in particular the Government Ministries, has not been employing all cadres of staff for the last ten years due to rationalization of staff under the Structural Adjustment Programme (SAP). Through this programme a number of staff in public sector were retrenched which may have also contributed to non-availability of extension workers above the age of 50 years. The agricultural researchers were not affected because KARI is a semi-autonomous government parastatal.

6.2.2.2 Gender

The agricultural researchers and extension workers were asked to indicate their gender. The purpose of this question was to find out whether there was gender balance in the two professions. It was also necessary to establish the influence of gender on use of ICTs among the respondents. Many studies have identified women and girls as being disadvantaged in their uptake of ICTs (Hafkin and Odame 2002, Cullen 2001, Ngenge

2000). It has been reported that disparities in use of ICTs are much greater in Africa with the involvement of women being as low as 5% (ECOSOC 2000).

The findings indicate that a significant number (64%) of agricultural researchers were male while 36% were female. Similarly, 71% of extension workers were male, while only 29% were female. The findings suggest that agricultural research and extension work in the public agricultural sector in Kenya is male dominated profession. These findings concur with an earlier study by Ojiambo (1989:74) who reported that 74% of agricultural researchers were male and 26% were female. He further found out that 78.1% of extension workers were male and 21.8% were female. An analysis of data indicates that in a span of 14 years since Ojiambo (1989) carried out his study not much has changed as male still dominate the two professions.

6.2.2.3 Highest qualifications and country where obtained

Five categories of highest qualifications were used to describe the educational characteristics of the respondents. These were certificate and diploma qualifications, bachelors, masters and doctoral degrees. The respondents were further asked to indicate the country where these qualifications were obtained. The aim was to establish whether country of training had any influence on use of ICTs. A study conducted by Ayoo (2001) to evaluate the effectiveness of the Internet as a source of information to industrial researchers in Kenya found out that researchers who trained abroad (in developed countries) made more use of the Internet as compared to those who trained locally in Kenya. Table 2 below indicates the distribution of respondents by their highest qualifications and country where this was obtained.

Table 2

Characteristics of Agricultural Researchers (n=154) and Extension Workers (n=136) by highest qualifications

	Agricultural Researchers		Extension Workers	
Highest qualification and country obtained	**N**	**%**	**N**	**%**
Certificate Kenya	-	-	7	5.1
Diploma Kenya	-	-	28	20.6
Bachelors Kenya	27	17.0	85	62.5
Bachelors USA	3	1.9	-	-
Bachelors India	3	1.9	-	-
Bachelors Denmark	-		4	2.9
Masters Kenya	45	28.3	4	2.9
Masters UK	18	11.3	-	-
Masters Netherlands	6	3.8	-	-
Masters Canada	6	3.8	8	5.9
Masters India	3	1.9	-	-
Masters USA	12	7.5	-	-
Doctoral Kenya	3	1.9	-	-
Doctoral UK	9	5.6	-	-
Doctoral USA	12	7.5	-	-
Doctoral Canada	12	7.5	-	-
	159	**100**	**136**	**100**

The above table shows that 56.6% of agricultural researchers had a master's degree, while 22.5% had doctorate degree and only 20.8% had bachelor's degree. A significant number (52.7%) obtained their qualifications abroad while 47.3% were trained locally in Kenya. Further findings indicate that agricultural researchers are highly qualified for their jobs as 79.1% had masters degrees and above and had been trained in specialised field of agriculture, such as crop sciences, crop pathology, horticulture, animal production, crop pathology, range ecology among others.

Of the extension workers surveyed, 65.4% had a bachelors degree, 20.6% had a diploma qualification, while 8.8% had masters degree. Only 5.1% had a certificate in either agriculture or veterinary sciences. Unlike agricultural researchers, the majority (91.1%) of extension workers were trained in Kenya and only 8.9% were trained abroad. Extension workers had received training in areas such as horticulture, farm management, farm mechanization, and home economics. They were deployed as subject matter specialists at district and divisional agricultural offices. It was found out that the education level of extension workers had improved with a large number (65.4%) having bachelors' degree as opposed to diploma qualifications reported by earlier studies (Ojiambo 1989, Kaniki 1995).

6.2.2.4 Distribution of respondents by Job Titles and Levels of Responsibility

The respondents were asked to state their positions in employment. Table 3 below indicates distribution of respondents by job titles and level of responsibility.

Table 3

Characteristics of Agricultural Researchers (n=159) and Extension Workers (n=136) by Job Titles and Level of Responsibility

	Agricultural Researchers		Extension Workers	
Position	**N**	**%**	**N**	**%**
Centre director	3	1.9	-	-
Deputy centre director	3	1.9	-	-
Chief research officer	15	9.4	-	-
Principal research officer	27	17	-	-
Senior research officer	30	18.9	-	-
Research officer	69	43.4	-	-
Assistant research officer	12	7.5	-	-
District Agric. Lives. Ext. Officer (DALEO)	-	-	2	1.5
District crop officer	-	-	11	8.1
District animal & lives. officer	-	-	10	7.4
District farm mangt. officer	-	-	5	3.7
District Agric. Marketing officer	-	-	4	2.9
District coffee officer	-	-	4	2.9
Agricultural officer	-	-	39	28.7
Assistant agricultural officer	-	-	14	10.3
Divisional extension officer	-	-	11	8.1
Field extension officer	-	-	20	14.7
Veterinary officer	-	-	16	11.8
Total	**159**	**100**	**136**	**100**

Table 3 shows that job titles of agricultural researchers ranged from centre director to assistant research officer. Of the respondents, 43.4% held the job title of research officers, 18.9% were senior research officers, while 17% were principal research officers and 9.4% held positions of chief research officer. At the level of assistant research officer were 7.5% and only 1.9% were at the levels of centre director and deputy centre director respectively. The centre directors and deputy centre directors were categorised as key informants of the study (policy makers) and face-to-face interview was used to solicit information from them. The few who completed the questionnaire were stationed in the

North Eastern Province of Kenya which is several thousands of kilometres away with poor roads and insecurity problems due to bandits. The research centre in the province was, therefore, inaccessible to the researcher and with the intervention of KARI headquarters the questionnaires were sent, completed and returned. The two other directors and their deputies completed the questionnaire after being unavailable when the researcher visited their centres. The questionnaires were left in their offices with a note requesting them to complete.

Table 3 shows that 28.7% of extension workers held job titles of agricultural officers, 14.7% were field officers, while 11.8% were veterinary officers and 10.3% were at the level of assistant agricultural officers. Those who held the positions of district crops officer and divisional extension officer were 8.1% respectively, while 7.4% were district animal and livestock officers, and 3.7% were district farm management officers. Only 2.9% held the job titles of district agricultural marketing officers and district coffee officers respectively and 1.5% were at the level of district agricultural and livestock extension officers.

The respondents were also asked to indicate their departments. This was done to ensure that all the departments were equally represented in the study. The departments/sections varied from one KARI research centre to the other and from one district or divisional extension office to the other as dictated by research and extension mandates. All the departments were proportionately represented in the study.

6.2.3 Information needs of agricultural researchers and extension workers

6.2.3.1 Nature of work

Attempt was made to ascertain the information needs of the respondents and to find out how these needs were met via ICTs. The respondents were first asked to state the nature of their work. Table 4 shows the distribution of respondents by their nature of work.

Table 4
Nature of work of Agricultural Researchers (n=159) and Extension Workers (n=136)

	Agricultural Researchers		Extension Workers	
Nature of work	**N**	**%**	**N**	**%**
Agricultural economist	6	3.8	-	-
Agronomist	27	17	-	-
Animal production	18	11.3	3	2.2
Biometrician/statistician	3	1.9	-	-
Breeder	12	7.5	-	-
Coordinator of programmes	6	3.8	-	-
Documentation	3	1.9	-	
Extension worker	-	-	129	94.9
Gender coordinator	3	1.9	-	-
GIS expert	3	1.9	-	
Horticulturalist	9	5.7	-	-
Pathologist/entomologist	15	9.4	-	-
Public relations	3	1.9	-	
Range ecology	3	1.9	-	
Range management	3	1.9	-	
Social economist	36	22.6	-	-
Soil and water engineer	3	1.9	4	2.9
Soil scientists	6	3.8	-	
Total	**159**	**100**	**136**	**100**

Table 4 shows that 22.6% of agricultural researchers were social economists, 17% were agronomists, while 11.3 % were animal and livestock production officers. Pathologists and entomologists were 9.4%, while 5.7% were horticulturist and 3.8% were coordinators of programmes, agricultural economists and soil scientists respectively. Coordinators of programmes were stationed at the KARI headquarters charged with the responsibility of coordinating research activities in designated centres. Only 1.9% were GIS experts, range management/ecologists, public relations officer, documentalists, gender coordinators, soil and water engineer and biometrician and statisticians respectively.

This study found out that most of the KARI researchers are social-economists. This can be explained by the fact that KARI manages a socio-economics research programme to provide socio-economic input in different programmes. This was after the realization that development, adaptation and adoption of appropriate agricultural technologies cannot be effective without considering socio-economic aspects of the farmers and other stakeholders. These include factors such as output/input prices, domestic and external input-output markets, profitability interventions, existing policies of facilitating institutions and socio-cultural issues (KARI 2002:43). Socio-economist researchers have, therefore, been deployed to all KARI research centres to manage the programme.

Table 4 shows that the core business of extension workers was the provision of extension services to farmers. In other words, the role of an extension worker is to provide relevant information necessary to farmers' conditions. This is indicated by the majority (94.9%) who stated that their nature of work involved extension. Although 2.9% and 2.2% said their work involved soil and water conservation, and animal production respectively, their core work is extension.

6.2.3.2 Identification of information needs

The study sought to establish the information needs of agricultural researchers and extension workers. The respondents were, therefore, provided with a list of 26 items of agricultural information and were asked to tick against those which were applicable. They were further asked to state any additional information need that was not listed. Table 5 summarizes the responses obtained from agricultural researchers and extension workers. Most of the findings represented in the table addresses content information needs related to the line of work of the respondents.

Table 5
Information needs of Agricultural Researchers (n=159) and Extension Workers (n=136)

	Agricultural Researchers		Extension workers	
Information needs	**N**	**%**	**N**	**%**
Agricultural marketing	108	67.9	73	53.7
Agricultural policies	150	94.3	129	94.9
Agroforestry	66	41.5	37	27.2
Agronomy	90	56.6	40	29.4
Animal Production	39	24.5	68	50
Bee Keeping	24	15.1	29	21.3
Credit sources and cooperative	57	35.8	63	46.3
Crop protection	81	50.9	41	30.1
Dairy cattle and goats	51	32.1	69	50.7
Energy conservation	30	18.9	37	27.2
Farm management	15	9.4	55	40.4
Fish farming	15	9.4	35	25.7
Fruit processing	27	17	36	26.4
Gender	87	54.7	80	58.8
Home economics	9	5.7	26	19.1
Horticulture	72	45.3	48	35.3
Indigenous knowledge	15	9.4	44	32.4
Meteorological information	132	83	129	94.9
Plant breeding	54	34	20	14.7
Plant pathology	75	47.2	20	14.7
Post harvesting	69	43.4	41	30.1
Poultry	30	18.9	46	33.8
Range management	48	30.2	32	23.5
Seed technology	66	41.5	42	30.9
Small ruminants	42	26.4	39	28.7
Social sciences	48	30.2	35	25.7
Soil Science	93	58.5	60	44.1
Water harvesting and irrig. and drainage	66	41.5	70	51.5

Note: The table indicate multiple responses

Table 5 indicates that agricultural researchers had various information needs most of which were specific to their particular areas of research. This concurs with the findings of other studies which indicate that researchers have a critical need for, and rely heavily on, information to enable them carry out their research activities (Ayoo 2001, Ojiambo 1995, Costa and Meadow 1999, Kaniki 1995). The majority (94.3%) of agricultural researchers expressed the need for information on agricultural policies and meteorology (83%). This could be explained by the fact that several national and institutional policies have been formulated to regulate research and extension activities in the agricultural sector. Researchers rely heavily on meteorological information when conducting their field trials. The findings revealed that KARI has set up three Agro-meteorological Stations at Njoro, Kiboko and Msabaha research centres to collect weather information in the three regions namely, Western, Eastern and Central. This information is relayed via satellite and other ICTs to respective centres via KARI headquarters and has proved beneficial to the researchers.

Similarly, extension workers expressed a need for information to help them in their day-to-day extension activities. The majority (94.9%) expressed the need for agricultural policy and meteorological information. This information forms an integral part of extension advisory service to farmers. For example, farmers need to be advised on when to plant and on policy issues relating to marketing of their agricultural products.

6.2.3.3 Sources of information consulted first

The respondents were asked to indicate the sources they consulted first whenever they needed information in the course of their day-to-day work. They were provided with a list of sources categorised into five broad areas. Table 6 below summarizes their responses.

Table 6
Sources of information consulted first by Agricultural Researchers (159) and Extension Workers (136)

	Agricultural Researchers		Extension Workers	
Sources consulted first	**N**	**%**	**N**	**%**
Printed sources	144	90.6	136	100
Electronic sources	114	71.7	38	27.9
Colleagues	30	18.9	33	24.3
Conferences/workshops	12	7.5	8	5.9
Mass media	6	3.8	4	2.9

NB: Table indicates multiple responses

It can be seen from the above table that the majority (90.6%) of agricultural researchers consult printed sources. A large number (71.7%) use electronic sources, while 18.9% consult colleagues and experts and only 7.5% reported getting information through conferences and workshops. Those who get information through the mass media were a small number of 3.8%.

Table 6 indicates that all extension workers (100%) consulted printed sources. Those who use electronic sources were 27.9%, while 24.3% consulted colleagues and 5.9% reported getting information through conferences and workshops. Only 2.9% obtained information through the mass media.

The results indicate that printed information sources were the most preferred sources of information by agricultural researchers (90.6%) and extension workers (100%). Further findings indicate that a large number (71.7%) of agricultural researchers made use of electronic sources of information.

6.2.4 Availability, access and utilization of ICTs by agricultural researchers and extension workers

The study sought to investigate the availability, access and use of ICTs by agricultural researchers and extension workers. The data regarding availability, access and use of ICTs was collected from the responses to section III of the questionnaire.

6.2.4.1 Availability of ICTs tools and services

The respondents were asked to indicate the ICTs tools and services available in their respective centres and agricultural offices. They were provided with a list of ICTs tools and services and were asked to tick against those that were available. Table 7 indicates the distribution of ICTs tools and services among agricultural researchers and extension workers in their respective centres and agricultural offices.

Table 7
Availability of ICTs tools and services to Agricultural Researchers (n=159) and Extension Workers (n=136)

	Agricultural Researchers		Extension Workers	
ICTs tools and services	**N**	**%**	**N**	**%**
Computers	159	100	59	34.4
Internet	114	71.7	40	29.4
Email	150	94.3	44	32.4
Electronic journals	54	34.0	8	5.9
CD-ROM databases	105	66.0	12	8.8
Desktop Publishing	78	49.1	11	8.1
Geographical Information Systems (GIS)	72	45.3	4	2.9
Fax	150	94.3	73	53.7
Telephone	159	100	115	84.6
Mobile phone	120	75.5	80	58.9
Television	99	62.7	49	36.0
Radio (Listening groups)	90	56.6	94	69.1
Video machine	105	66.0	56	41.2

Note: Table represents multiple responses

The above table shows that computers and telephones were available to all agricultural researchers (100%) in their respective research centres. A large number (94.3%) indicated availability of email and fax, while 75.5% reported the availability of mobile phones. However, it was established during field visits that mobile phones were personal and each researcher paid for the cost of airtime credit. Internet was available to 71.7%, while 66% had video machines and CD-ROM databases respectively. Television set was available to 62.7%, while radio was available to 56.6% of the respondents. The least available was electronic journals (34%), followed by Geographical Information Systems (45.3%) and desktop publishing (49.1%). The findings further revealed that although GIS is widely used by KARI researchers to asses the suitability of agro-ecological zones to particular variety of crops, the system is still the preserve of few experts.

In regard to extension workers, a large number (84.6%) had telephones in their agricultural offices, while radios and telephone were available to 69.1% and 58.9% of the respondents respectively. Those who indicated the availability of fax were 53.7%, while computers and videos were available to 43.4% and 41.2% of the respondents. The availability of television was indicated by 36%, while email and the Internet were available to 32.4% and 29.4% of the respondents. The least available was GIS (2.9%)

followed by electronic journals (5.9%), desktop publishing (8.1%), and CD-ROM databases (8.8%).

Evidently, the most available ICTs tools and services to agricultural researchers included telephone, computers, email, fax, mobile phone and Internet in that order. In regard to extension workers, the telephone, the radio, the mobile phone and fax were available to the majority. The state and nature of these tools is further discussed in section II of this chapter.

6.2.4.2 Accessibility of ICTs tools and services

The respondents were asked to indicate the level of accessibility of ICTs tools and services in their respective centres and agricultural offices. The aim was to establish the extent to which the available ICTs were accessible to agricultural researchers and extension workers. The respondents were provided with a list of ICTs tools and services and asked to rate them accordingly on the likert scale of 1 (not accessible) through 4 (very accessible). Table 8 summarizes the responses from agricultural researchers and extension workers respectively.

Table 8
Accessibility of ICTs tools and services by Agricultural Researchers (n=159) and Extension Workers (n=136)

		Agricultural Researchers		Extension Workers	
ICTs tools and services	**Category**	**Frequency**	**%**	**Frequency**	**%**
Computers					
	Not accessible	0	0	63	46.3
	Less accessible	12	7.5	24	17.7
	Accessible	48	30.2	25	18.4
	Very accessible	99	62.3	24	17.7
Internet					
	Not accessible	42	26.4	86	63.2
	Less accessible	57	35.8	34	25.0
	Accessible	42	26.4	8	5.9
	Very accessible	18	11.3	8	5.9
Email					
	Not accessible	15	9.4	79	58.1
	Less accessible	33	20.8	29	21.3
	Accessible	69	43.4	20	14.7
	Very accessible	42	26.4	8	5.9
Electronic Journals					
	Not accessible	90	56.6	128	94.1
	Less accessible	36	22.6	4	2.9
	Accessible	24	15.1	4	2.9
	Very accessible	9	5.7	0	0
CD-ROM Databases					
	Not accessible	54	34.0	117	86.0
	Less accessible	24	15.1	15	11.0
	Accessible	48	30.2	0	0
	Very accessible	33	20.8	4	2.9
Desktop publishing					
	Not accessible	90	56.6	111	81.6
	Less accessible	30	18.9	10	7.4
	Accessible	18	11.3	11	8.1
	Very accessible	21	13.2	4	2.9

Table 8 (continued)
Accessibility of ICTs tools and services by Agricultural Researchers (n=159) and Extension Workers (n=136)

		Agricultural Researchers		Extension Workers	
ICTs tools	Category	Frequency	%	Frequency	%
GIS					
	Not accessible	87	54.7	129	94.9
	Less accessible	33	20.8	7	5.1
	Accessible	24	15.1	0	0
	Very accessible	15	9.4	0	0
Fax					
	Not accessible	18	11.3	56	41.2
	Less accessible	36	22.6	37	27.2
	Accessible	57	35.8	23	16.9
	Very accessible	48	30.2	20	14.7
Telephone					
	Not accessible	6	3.8	14	10.3
	Less accessible	27	17.8	22	16.2
	Accessible	60	37.7	43	31.6
	Very accessible	66	41.5	57	41.9
Mobile Phone					
	Not accessible	42	26.4	35	25.7
	Less accessible	12	7.5	29	21.3
	Accessible	39	24.5	19	14.0
	Very accessible	66	41.5	53	39.0
Television					
	Not accessible	57	35.8	42	30.9
	Less accessible	21	13.2	53	39.0
	Accessible	39	24.5	30	22.1
	Very accessible	42	26.4	11	8.1
Radio					
	Not accessible	69	43.4	35	25.7
	Less accessible	18	11.3	50	36.8
	Accessible	18	11.3	26	19.1
	Very accessible	54	34.0	25	18.4
Video Machine					
	Not accessible	54	34.0	67	49.3
	Less accessible	18	11.3	36	26.5
	Accessible	45	28.3	25	18.4
	Very accessible	42	26.4	8	5.9

Table 8 above shows that computers were accessible to the majority (92.5%) of agricultural researchers, while the Internet was less accessible and not accessible to 62.2% of the respondents. Most of the accessible computers were Pentium 1 and 486s which were slow specially when connected to the Internet. Coupled was the low bandwidth and poor infrastructure. The type of Internet connectivity is discussed in section II of this chapter (p.222) The email was accessible to a significant number

(69.8%) of the respondents. It was found out that some centres preferred to subscribe to email services only as it is less costly and does not require high bandwidth.

While electronic journals were not accessible to 56.6% of agricultural researchers, CD-ROM databases were accessible to 51% of the respondents. This may be attributed to the high costs of subscribing to electronic journals. The findings revealed that although KARI is a beneficiary of free access to electronic journals courtesy of the International Access to Scientific Publications (INASP), only few agricultural researchers made use of the journals. This could be attributed to lack of skills which impede the respondents from effectively utilising electronic journals. Free access to electronic journals is further discussed in section II (p.228).

When asked to comment on the level of accessibility of desktop publishing, 56.6% of the respondents indicated that it was not accessible. The findings indicate that most research centres had no desktop publishing units and often took their documents to KARI headquarters for publication. Similarly, 54.7% of agricultural researchers indicated that GIS was not accessible. It was observed that GIS was mostly used by the experts at the Kenya Soil Survey (KSS) which is one of the departments of the National Agricultural Research Laboratory, KARI centre. The KSS is responsible for analysing soil and other land resources throughout the country, thus providing the biophysical information required for multipurpose and specific land use planning. KSS has fully equipped GIS laboratories. The department coordinates the use of GIS at all KARI research centres. Most of the agricultural researchers lacked GIS skills.

Fax and mobile phones were accessible to 66% of agricultural researchers, while the telephone was accessible to 79.2% of the respondents. The findings indicate that despite the costs, the respondents found the mobile phone as a convenient means of communication. It was used to communicate official matters including agricultural information. This concurs with a study by Pigato (2001) which established that users in sub-Saharan Africa and South Asia found the mobile phone to be convenient because of its mobility and Short Message Service (SMS) that reduces airtime costs. It was observed that the management of KARI have facilitated the use of mobile phones by installing four mobile phone lines in their PABX telephone exchange machine at KARI headquarters. Two of the lines belonged to Safaricom mobile provider, while the other two belonged to Kencell mobile provider. Currently, Kenya has three mobile phone service providers. The third one was launched recently in September 2003 as this study was in progress. The mobile phone lines have increased communication between KARI headquarters and the research centres and especially those having problems with their landline telephones. It has also increased communication among researchers and other actors in agricultural research and extension.

The findings indicate that the television was accessible to an average number (50.9%) of agricultural researchers, while the radio was not accessible to 43.4% of the respondents. The video machine was accessible to 54.7% of agricultural researchers. It was observed that television and video were used by the respondents during demonstration and training of farmers and extension workers.

Table 8 shows that, of the extension workers surveyed, 46.3% were of the view that computers were not accessible. Similarly, 63.2% of the respondents reported that the Internet was not accessible. Email was also not accessible to 58.1% of the extension workers. Computers, the Internet and email were therefore not accessible to most of the extension workers. Among the three, the most inaccessible was the Internet, followed by email and computers in that order.

In regard to electronic journals, the majority (94.1%) of the extension workers were of the view that they were not accessible. When asked to comment on of CD-ROM databases, a significant number (86%) also indicated they were not accessible. Similarly, desktop publishing was not accessible to 81.6% of extension workers. Of the respondents 94.9% reported that GIS was not accessible. The findings, therefore, indicate that electronic journals, CD-ROM databases, desktop publishing and GIS were inaccessible to the majority of extension workers. This is attributed to the fact that most of the respondents are based in the rural areas and lacked physical access to ICTs.

When asked to indicate the level of accessibility of fax, 41.2% of the extension workers observed that it was not accessible. In regard to landline telephone, the majority (73.5%) of the respondents said it was accessible, while the mobile phone was accessible to 53% of the extension workers. It was established that landline telephone and mobile phones were accessible to the most of the extension workers as opposed to fax which was inaccessible. It was further observed that the fax was available only to senior agricultural officers stationed at the district headquarters and was used to fax official and vital documents.

The respondents were asked to indicate the level of accessibility of the television, radio and video machine. In regard to the television, 39% were of the view that it was less accessible, while 30.9% indicated that it was not accessible. When asked to comment on the radio, 36.8% of respondents indicated that it was less accessible, while 25.7% reported it was not accessible. Respondents were further asked to comment on the accessibility of video machine, 49.3% were of the view that it was not accessible. The findings indicate that television and radio were less accessible to a significant number of extension workers, while the video was not accessible. The three types of ICTs were less accessible yet extension workers used them more frequently to train the farmers. Furthermore access to television and radio are not a guarantee to access to agricultural information because one has to consider the programming and of course the effectiveness of the broadcasting and reception.

6.2.4.3 Use of ICTs tools and services

The respondents were asked to indicate the purposes for using ICTs tools and services. They were provided with a list of options to choose from and were asked to indicate any other purpose not listed. Table 9 summarizes the responses from agricultural researchers and extension workers.

Table 9
Use of ICTs by Agricultural Researchers (n=159) and Extension Workers (n=136)

	Agricultural Researchers		Extension Workers	
Use of ICTs	**N**	**%**	**N**	**%**
To communicate with agricultural researchers	153	96.2	48	35.3
To communicate with extension	114	71.7	114	83.8
To communicate with farmers	72	45.3	129	94.9
To communicate with friends and relatives	84	52.8	55	40.4
To communicate with colleagues worldwide	102	64.2	12	8.8
To disseminate agricultural information	123	77.4	65	47.8
For research purposes	126	79.2	16	11.8
For educational purposes	93	58.5	44	32.4
For Publishing	78	49.1	16	11.8

Note: Table represents multiple responses

Table 9 indicates that the majority (96.2%) of agricultural researchers reported using ICTs to communicate with fellow colleagues, 79.2% used ICTs for research purposes, while 77.4% used ICTs to disseminate agricultural information. Those who said they used ICTs to communicate with extension workers were 71.7%, while 64.2% used to communicate with colleagues worldwide and 58.5% used for educational purposes. Respondents who used ICTs to communicate with friends and relatives were 52.8%, while 49.1% used for publishing and only 45.3% used to communicate with farmers.

Of the extension workers surveyed, the majority (94.9%) used ICTs to communicate with farmers, 83.8% used to communicate with fellow extension workers and 47.8% used them to disseminate agricultural information. Those who used ICTs to communicate with friends and relatives were 40.4%, while 35.3% used to communicate with agricultural researchers and 32.4% used them for educational purposes. Only 11.8% used ICTs for publishing and research purposes respectively and 8.8% used to communicate with colleagues worldwide.

The findings indicate that most of the agricultural researchers used ICTs to communicate among themselves, for research purposes and to disseminate agricultural information. Although 71.7% of agricultural researchers indicated using ICTs to communicate with extension worker, it was not the same case with extension workers as only 35.3% reported using ICTs to communicate with agricultural researchers. This disparity shows that ICTs are yet to bridge the gap between research and extension. It is evident from the data that the majority of extension workers used ICTs to communicate with the farmers and among themselves.

6.2.5 Effectiveness of ICTs in disseminating agricultural information

The respondents were asked to indicate their views on the level of effectiveness of ICTs in disseminating agricultural information. A list of ICTs tools and services was provided and respondents were asked to rate them accordingly on the likert scale of 1 (not effective) through 4 (very effective). Table 10 summarizes the responses from agricultural researchers and extension workers respectively.

Table 10
Effectiveness of ICTs in disseminating agricultural information among Agricultural Researchers (n=159) and Extension Workers (n=136)

		Agricultural Researchers		Extension Workers	
ICTs	**Effectiveness**	**N**	**%**	**N**	**%**
Internet					
	Not effective	48	30.2	74	54.4
	Less effective	24	15.1	25	18.4
	Effective	30	18.9	23	16.9
	Very effective	57	35.8	14	10.3
Email					
	Not effective	6	3.8	34	25.0
	Less effective	33	20.8	72	52.9
	Effective	51	32.1	19	14.0
	Very effective	69	43.4	11	8.1
Electronic journals					
	Not effective	60	37.7	107	78.7
	Less effective	33	20.8	4	2.9
	Effective	48	30.2	15	11.0
	Very Effective	18	11.3	10	7.4
CD-ROM databases					
	Not effective	60	37.7	117	86.0
	Less effective	36	22.6	11	8.1
	Effective	51	32.1	8	5.9
	Very effective	12	7.5	0	0
Desktop publishing					
	Not Effective	33	20.8	45	33.1
	Less effective	39	24.5	25	18.4
	Effective	39	24.5	30	22.1
	Very Effective	48	30.2	36	26.5
GIS					
	Not Effective	66	41.5	117	86.0
	Less effective	27	19.9	15	11.0
	Effective	42	26.4	4	2.9
	Very Effective	24	15.1	0	0

Table 10 (continued)
Effectiveness of ICTs in disseminating agricultural information among Agricultural Researchers (n=159) and Extension Workers (n=136)

		Agricultural Researchers		Extension Workers	
ICTs	Effectiveness	N	%	N	%
Fax					
	Not effective	39	24.5	56	41.2
	Less effective	45	28.3	47	34.6
	Effective	51	32.1	22	16.2
	Very effective	24	15.1	11	8.1
Telephone					
	Not effective	21	13.2	0	0
	Less effective	45	28.3	89	65.4
	Effective	39	24.5	29	21.3
	Very effective	54	34.0	18	13.2
Mobile Phone					
	Not effective	27	17.0	3	2.2
	Less effective	33	20.8	60	44.1
	Effective	48	30.2	43	31.6
	Very Effective	51	32.1	30	22.1
Radio					
	Not effective	12	7.5	4	2.9
	Less effective	21	13.2	10	7.4
	Effective	42	26.4	66	48.5
	Very effective	84	52.8	56	41.2
Television					
	Not Effective	15	9.4	4	2.9
	Less effective	24	15.1	10	7.4
	Effective	48	30.1	65	47.8
	Very Effective	72	45.3	57	41.9
Video					
	Not Effective	18	11.3	7	5.1
	Less effective	33	20.8	7	5.1
	Effective	51	32.1	61	44.9
	Very Effective	57	35.8	61	44.9

Table 10 indicates that 54.7% of agricultural researchers were of the view that the Internet was effective and very effective in disseminating agricultural information. Similarly, 75.5% of the respondents reported that the email was also effective and very effective. It is reported elsewhere in this study that the email was the most used Internet service in disseminating agricultural information by the respondents. It was noted that the effectiveness of any ICT tool depends on the information to be disseminated and the intended client. For example, the Internet and email may not be effective in disseminating information to farmers who may lack access and skills to use.

When asked to comment on the effectiveness of electronic journals, 58.5% of agricultural researchers indicated that they were not effective and less effective. Similarly, 60.3% of the respondents observed that CD-ROM databases were not effective and less effective. It can be concluded that electronic journals and CD-ROM databases were not effective in disseminating agricultural information among agricultural researchers and also with other actors involved in research and extension.

When asked to comment on the effectiveness of desktop publishing, 54.7% of the respondents indicated that it was effective and very effective. It was observed that KARI headquarters had a well equipped desktop publishing unit that produces handbooks, leaflets, brochures and other materials for disseminating agricultural information. Although handbooks, leaflets and brochures were used frequently by the respondents to disseminate agricultural information it may not be an effective tool as most farmers in Kenya are illiterate. When asked further to comment on GIS, 61.4% of respondents were of the view that it was not effective and less effective. Although GIS was used during demonstration and training of extension workers and farmers, it was limited to a few researchers who had the technical know-how.

In regard to the effectiveness of fax, 52.8% of the respondents indicated less effective and not effective. The fax was found to be limiting due to high costs and unavailability to most of the respondents and may not be a good tool for disseminating agricultural information. It may be effective when used for very urgent official communication. As for the telephone, 58.5% of agricultural researchers indicated that it was effective and very effective. Similarly, 62.3% of the respondents observed that the mobile phone was equally effective. It is evident that agricultural researchers found the land-line telephone and mobile phone as effective means of communicating agricultural information.

The respondents were further asked to rate the effectiveness of the radio, television and video in disseminating agricultural information. With regard to radio, significant number (79.2%) observed that it was effective and very effective. Similarly, 75.4% of the respondents found the television as an effective tool for disseminating agricultural information and a further 67.9% perceived video as equally effective medium. It is evident from the findings that agricultural researchers found the radio, television and video to be effective in disseminating agricultural information especially to farmers. It was established during interview with some of the respondents that the television and video were used mostly in demonstration and training of farmers and extension workers.

The extension workers were asked to indicate the effectiveness of the Internet in disseminating agricultural information. Of the respondents, 54.4% observed that it was not effective. When asked to comment on email, 52.9% said it was less effective. Overall, most of the extension workers perceived the Internet as not effective and the email as less effective in disseminating agricultural information. It was observed during field visits that most of the respondents were not in a position to access Internet and email facilities. This is supported by one respondent who remarked that "Internet and email are not effective as a result of their unavailability and inaccessibility."

When asked to comment on electronic journals, 78.7% of extension workers reported that they were not effective, similarly 86% of the respondents indicated that CD-ROM databases were not effective. It is evident from the findings that extension workers perceived electronic journals and CD-ROM databases as not effective in disseminating agricultural information.

When asked to indicate the effectiveness of desktop publishing, 51.5% of respondents said it was not effective and less effective. It was established that most agricultural offices did not have desktop publishing units and most of their extension materials including brochures, leaflets, handbook, were produced by the Agricultural Information Centre (AIC) located in the capital city, Nairobi. When asked to comment on GIS, 86% of extension workers indicated that it was not effective. It was found out that most of the extension workers do not have access to GIS and lacked the technical know-how.

When asked to comment on the effectiveness of fax, 75.8% of respondents said it was not effective and less effective, while 64.5% observed that telephone was less effective. In regard to mobile phone, 53.7% of respondents indicated it was effective and very effective. It was observed that landline telephones and mobile phones were less effective in disseminating agricultural information. Telephones were less accessible while mobile phones were expensive to sustain because of high tariffs. However, farmers and extension workers often used the Short Message Service (SMS) to communicate because it is cheaper. It was observed that there is a lot of potential on the use of mobile phones to disseminate agricultural information. The recent case in point is the partnership between Safaricom mobile subscriber and the Kenya Agricultural Commodity Exchange (KACE) that launched agricultural commodities market information services. Traders in agricultural products can now check prices of agricultural commodities (Daily Nation 19th August 2003).

Extension workers were further asked to comment on the radio, television and video. The majority (89.7) perceived the radio and television as an effective and very effective medium of disseminating agricultural information particularly to farmers. Similarly 89.8% of the respondents were of the view that video was equally effective and very effective. Overall, the three ICT tools were rated by extension workers as the most effective in disseminating agricultural information. It was observed during the field survey that extension workers used television and videos during demonstrations and training of farmers. An example is the video on gender and agriculture which is used to sensitise extension workers and farmers on gender issues. The radio was used to enhance one of the extension method commonly referred to as "radio listening groups" in which agricultural programmes are broadcast to groups of farmers who come together to listen and participate in the programmes. The radio programmes are produced by the Agricultural Information Centre (AIC) in conjunction with the Kenya Broadcasting Corporation and Private Radio Stations. The listening groups usually converge at the farmers' field schools and at the farmers training centres. The listening groups are facilitated by extension workers.

6.2.5.1 Facilitation of communication of agricultural information

The study sought to find out the extent to which ICTs have facilitated communication of agricultural information among agricultural researchers and extension workers. Respondents were asked to give their views on the likert scale of 1 (strongly disagree) through 5 (strongly agree). Table 11 summarizes the responses from agricultural researchers and extension workers.

Table 11

Use of ICTs to facilitate communication of agricultural information among Agricultural Researchers (n=159) and Extension Workers (n=136)

	Agricultural Researchers		Extension Workers	
Category	**N**	**%**	**N**	**%**
Strongly disagree	0	0	11	8.1
Disagree	3	1.9	0	0
undecided	6	3.8	19	14.0
agree	90	56.6	85	62.5
Strongly agree	60	37.7	21	15.4
Total	**159**	**100**	**136**	**100**

From the above table it can be seen that 56.6% of agricultural researchers were in agreement that ICTs had facilitated communication of agricultural information, while 37.7% strongly agreed, 3.8% were undecided and only 1.9 disagreed. None indicated that they strongly disagreed. The findings indicate that most of the agricultural researchers perceived ICTs as having facilitated communication of agricultural information among all actors involved in agricultural research and extension.

Similarly, most (62.5%) of the extension workers agreed that ICTs had facilitated communication of agricultural information, while 15.4% strongly agreed and 14% were undecided. Only 8.1% strongly disagreed while none indicated disagreed. Overall, significant number of the extension workers were of the view that ICTs had facilitated communication of agricultural information among all actors in agricultural extension service. It was observed that those who were undecided often encountered difficulties in accessing and utilising ICTs. For example, one respondent observed that he or she was "not decided because ICTs are not readily available in all government offices." The

Kenya government is currently networking all the ministries headquarters and this will be carried out at provincial level as well up to district offices. Once this is done it will facilitate communication among the staff of the respective ministries.

6.2.6 Skills, competencies and use of ICTs tools and services

The study sought to find out the respondents skills and competencies in using ICTs tools and services. Section four of the questionnaire asked the respondents to rate their computer and Internet skills on the likert scale of 1 (poor) through 5 (excellent).

6.2.6.1 Computer skills

Table 12 summarizes the responses from agricultural researchers and extension workers on the rating of their computer skills. The data was cross tabulated and presented according to frequency. In order to assess the perceived level of computer and Internet skills by each category of respondents the mean score was calculated on the scale of 1.0 being the lowest through 5.0 being the highest. The mean scores on rating of computer skills by each category of respondents are also presented.

Table 12
Rating of computer skills by Agricultural researchers (n=159) and Extension workers (n=136)

	Agricultural Researchers		Extension Workers	
Rating	**N**	**%**	**N**	**%**
Poor	0	0	53	39.0
Enough to make me work	39	24.5	40	29.4
Good	54	34.0	18	13.2
Very good	45	28.3	11	8.1
Excellent	21	13.2	14	10.3
Total	**159**	**100**	**136**	**100**

It can be seen from table 12 that 34% of agricultural researchers reported that their computer skills were good, 28.3% indicated that they were very good while 24.5% said they were enough to make them work and 13.2% observed that they were excellent. None indicated that they were poor. The analysis of data indicates that the 75.5% of agricultural researchers had good computer skills. This is supported by their mean score of 3.30 (with standard deviation of 0.99), the highest mean score being 5.0 and the lowest being 1.0. If the mean score is more than 2.5 it meant that the respondents were computer literate. This can also be explained by the fact that KARI had organized several in-house staff training on the use of computers, the Internet and electronic sources. KARI has also installed computers in most of the research centres only that they are fewer compared to the number of researchers. It was observed that the nature of work of agricultural researchers compels them to use computers and other ICTs facilities. This is supported by a study conducted by Costa and Meadows (1999) to investigate the impact of computer usage on scholarly communication among social scientists that found out that the nature of work of researchers often influences their level of use of computers. They found out that economists were more active in the use of electronic facilities than sociologists and attribute this to pressures of research community and institutional environment. It is assumed therefore that agricultural researchers were more likely to use ICTs than extension workers due to their nature of work.

Of the extension workers surveyed, 39% said that their computer skills were poor, 29.4% indicated that they were enough to make them work, while 13.2% observed that they were good and 10.3% pointed out that they were excellent. Only 8.1% were of the view that they were very good. Analysis of data indicates that most of the extension workers were not computer literate. This is supported by the mean score of 2.11 (with standard deviation of 1.44) which is below the average mean score of 2.5.

6.2.6.2 Internet skills

The respondents were further asked to rate their internet skills. Table 13 summarizes the responses of agricultural researchers and extension according to frequency. The mean score on the rating of Internet skills by each category of respondents is also presented.

Table 13
Rating of Internet skills by Agricultural researchers (n=159) and Extension workers (n=136)

	Agricultural Researchers		Extension Workers	
Rating	**N**	**%**	**N**	**%**
Poor	36	22.6	71	52.2
Enough to make me work	45	28.3	47	34.6
Good	42	26.4	0	0
Very good	24	15.1	11	8.1
Excellent	12	7.6	7	5.1
Total	**159**	**100**	**136**	**100**

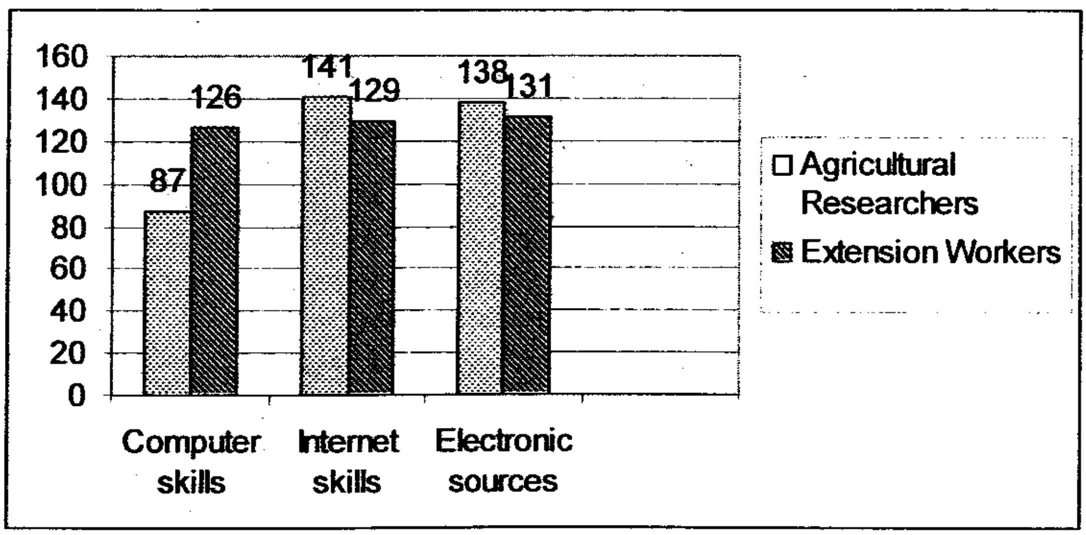
Table 13 indicates that 28.3% of agricultural researchers reported that their Internet skills were just enough to make them work, while 26.4% observed that their Internet skills were good and 22.6% said they were poor. Those who perceived their skills to be good were 15.1% and only 7.5% said they were excellent. Overall, 50% of respondents had good Internet skills. This is supported by the mean score of 2.53 (with standard deviation of 1.27) on the scale of 5.0 being the highest and 1.0 being the lowest. One respondent remarked that " Based on what I learnt during my studies in the university, I feel I have good Internet skills, but we all forget what we know if there is no practice." He further observed that "there is no Internet connectivity in my research centre and I only get access whenever I travel to KARI headquarters which is about 300 kms away." Apparently the research centre of this respondent was located in a semi-arid area. This shows the situation of most researchers based in such research centres. Computer and Internet skills are gained through hands-on experience which require facilities to be physically accessible.

Of extension workers, 52.2% reported that their Internet skills were poor, while 34.6% observed that they were enough to make them work and 8.1% indicated they were very good. Only 5.1% were of the view that they were excellent and none said they were good. The findings indicate that most of the extension workers had poor Internet skills and this is supported by a low mean score of 1.53 (with standard deviation of 1.33), the highest mean score being 5 and the lowest being 1. Most of the extension workers are based in the rural areas and lacked physical access to the Internet.

6.2.6.3 Need for more training on use of ICTs

The study sought to find out whether the respondents needed training on use of computer, the Internet and electronic sources. The respondents were provided with the list of options and asked to indicate against the areas in which they required more training. Figure 4 below summarizes the multiple responses of agricultural researchers and extension workers.

Figure 4
Need for more training on ICT use by Agricultural Researchers (n=159) and Extension Workers (n=136)



- Figure represent multiple responses

Figure 4 shows that the majority (141; 88.7%) of agricultural researchers needed training on use of electronic sources, 86.8% (138) needed training on use of Internet and 54.7% (87) needed training on use of computers. The findings indicate that the majority of agricultural researchers needed more training on the use of computers, Internet and electronic journals. One respondent observed that "there is need for frequent training on use of the Internet and new software coming up in the market so as to acquaint one-self with trends and developments." Another respondent remarked "We require ICTs facilities to be available for self-study."

Similarly, the majority (138; 96.3%) of extension workers indicated the need for training on use of electronic sources, while 94.9% (129) needed training on the use of Internet and 92.6% (126) needed training on the use of computers. It is concluded, therefore, that there is an urgent need to address the training needs of extension workers on use computers, Internet and electronic sources. During field visits it was observed that many do not know how to use computers.

6.2.6.4 How respondents learnt to use computer and the Internet

The study further sought to find out how the respondents learnt to use computers and the Internet. The aim was to establish whether the employers (KARI and MoARD) trained their staff on use of ICTs. Lists of options were provided and respondents were asked to tick against those which were applicable. The following table summarizes the responses of agricultural researchers and extension workers.

Table 14
Learning to use computers and the Internet by Agricultural researchers (n=159) and Extension Workers (n=136)

	Agricultural Researchers		Extension Workers	
Category	**N**	**%**	**N**	**%**
Through self-study	111	69.8	68	50.0
From colleagues	60	37.7	12	8.8
Through in-house course offered by library	15	9.4	0	0
Through in-house course offered by institution	51	32.1	25	18.4
Training abroad	45	28.3	16	11.8
In course offered during studies	27	17.0	19	14.0

Note: Table presents multiple responses

Table 14 indicates that most (69.8%) of the agricultural researchers learnt to use computers and the Internet through self-study, 37.7% said they learnt from colleagues, while 32.1% learnt through in-house courses offered by the institution and 28.3% learnt through training abroad. Only 17% learnt through courses offered during their studies and 9.4% learnt through in-house courses offered by KARI library. The findings show that most of the agricultural researchers learnt to use computers and Internet through self-study and from colleagues. It was noted during field survey that KARI had organized several in-house training for computers and Internet. The training took one to two weeks. However, only 32.1% of respondents reported having benefited from these trainings. The majority of those who benefited were from KARI headquarters and the surrounding research centres as the training took place at the headquarters. Most of the agricultural researchers based at research centres located far from the headquarters had limited knowledge of computer and the Internet.

An average number (50%) of extension workers learnt how to use computers and the Internet through self-study, 18.4% reported learning through in-house courses offered by their institutions, while 14% indicated learning through courses offered during their studies and 11.8% said they learnt while training abroad. Only 8.8% learnt from colleagues and none learnt through courses offered by the library. A number of extension workers were of the view that they were not computer literate and, therefore, were not in a position to respond to this question. One respondent indicated "Not yet literate." There is need for the ministry of agriculture through the Agricultural Information Centre (AIC) to develop appropriate training courses on use of ICTs for extension workers. During field survey, it was established that AIC has already developed a number of training courses which include the following:

- Communication skills for extension workers;
- Extension supervision and management skills;
- Visual aids production;
- Training of trainers;
- Gender issues and agricultural extension management and
- Agricultural extension project development.

The ICT courses if developed will, therefore, fit into the AIC objective of empowering extension workers with skills and information.

6.2.7 Time spent on the Internet

Respondents were asked to indicate the number of hours they spend per week on the Internet for communication and work purposes. The aim was to determine the extent to which the Internet was used for communication and work purposes by agricultural researchers and extension workers. The respondents were provided with options to choose from. Table 15 summarizes the responses from agricultural researchers and extension workers.

Table 15

Time spent on the Internet per week by Agricultural researchers (n=159) and Extension Workers (n=136)

	Agricultural Researchers		Extension Workers	
Number of hours	**N**	**%**	**N**	**%**
None	39	24.5	91	66.9
1-5 hours	108	67.9	38	27.9
6-10 hours	3	1.9	0	0
11-15 hours	0	0	7	5.2
More than 16 hours	9	5.7	0	0
Total	**159**	**100**	**136**	**100**

From the above table, most (67.9%) of agricultural researchers reported spending 1-5 hours per week on the Internet, 24.5% spent none hours per week meaning they do not use the Internet on a weekly basis and 5.7% indicated spending more than 16 hours in a week. Only 1.9% spend 6-10 hours per week and none spent 11-15 hours per week. The findings indicate that a significant number of agricultural researchers spend an average of 5 hours per week on the Internet. It was observed during field survey that the lack of connectivity in some of the KARI centres denied the respondents opportunity to frequently use the Internet. As a result they were compelled to use private internet cafes located in the nearest town centres.

In regard to extension workers, 66.9% indicated spending none hours per week, meaning either they do not use the Internet at all or they use it occasionally. Those who spend 1-5 hours per week were 27.9%, only 5.2% reported spending 11-15 hours per week and none spend 6-10 hours or more than 16 hours per week. The findings indicate that most of the extension workers rarely use the Internet. This could be attributed to lack of skills and physical access to the Internet.

6.2.7.1 Frequency of use of Internet services

The respondents were asked to indicate their frequency of use of the Internet services. List of Internet services were provided and respondents were asked to indicate accordingly on the scale of 1 (never) through 5 (daily). They were also asked to add any other Internet services not listed. Table 16 summarizes the responses of agricultural researchers and extension workers.

Table 16
Frequency of use of the Internet by Agricultural Researchers (n=159) and Extension Workers (n=136)

		Agricultural Researchers		Extension Workers	
Internet service	**Frequency**	**N**	**%**	**N**	**%**
World Wide Web	Daily	9	5.7	0	0
	Weekly	27	17.0	8	5.9
	Monthly	9	5.7	11	8.1
	Occasionally	51	32.1	18	13.2
	Never	63	39.6	99	72.8
Email	Daily	54	34.0	4	2.9
	Weekly	57	35.9	23	16.9
	Monthly	12	7.5	7	5.1
	Occasionally	21	13.2	57	41.9
	Never	15	9.4	45	33.1
Discussion groups					
	Daily	21	13.2	0	0
	Weekly	9	5.7	0	0
	Monthly	18	11.3	11	8.1
	Occasionally	36	22.6	22	16.2
	Never	75	47.2	103	75.7
Library online public access Cat.					
	Daily	3	1.9	0	0
	weekly	15	9.4	4	2.9
	Monthly	12	7.5	4	2.9
	Occasionally	18	11.3	15	11.0
	Never	111	69.8	113	83.1
Agricultural electronic journals					
	Daily	3	1.9	0	0
	Weekly	15	9.4	4	2.9
	Monthly	21	13.2	7	5.1
	Occasionally	45	28.3	12	8.8
	Never	75	47.2	113	83.1
Agricultural information gateways					
	Daily	3	1.9	0	0
	Weekly	18	11.3	4	2.9
	Monthly	6	3.8	4	2.9
	Occasionally	30	18.9	29	21.3
	Never	102	64.2	99	72.8
Mailing lists					
	Daily	6	3.8	0	0
	Weekly	12	7.5	0	0
	Monthly	12	7.5	4	2.9
	Occasionally	45	28.3	43	31.6
	Never	84	52.8	89	65.4
Downloading software					
	Daily	0	0	0	0
	Weekly	18	11.3	4	2.9
	Monthly	0	0	4	2.9
	Occasionally	66	41.5	32	23.5
	Never	75	47.2	96	70.6

Table 16 indicates that 39.6% of agricultural researchers had never used World Wide Web, 32.1% said they used it occasionally, while 28.4% reported using it on daily, weekly and monthly basis. When asked to comment on email, 69.9% of respondents reported using it on daily and weekly basis. The findings indicate that email was the most used Internet service among agricultural researchers. Email offers many advantages to the users ranging from instantaneous response, convenience and satisfaction. This assertion is supported by Rogers (1995:5) who observes that relative advantage of an innovation maybe measured in economics terms, convenience, satisfaction and social prestige. Agricultural researchers therefore found email to be a convenient mode of communication. It was further observed during discussions with a number of respondents that although they occasionally used World Wide Web, most of them were ignorant that they were using it.

When respondents were asked to comment on discussion groups, 47.2% said they had never participated, 22.6% participate occasionally, while 30.2% participated on daily, weekly and monthly basis. Respondents were also asked to comment on the use of Library Online Public Access Catalogue (OPAC) on the Internet, 69.8% said they had never used it. It is evident, therefore, that most of the agricultural researchers were not using discussions groups and OPAC services on the Internet.

In regard to agricultural electronic journals, 47.2% of the respondents had never used the journals, 28.3% used them occasionally, while 24.5% used the journals on daily, weekly and monthly basis. When asked to comment on the use of agricultural information gateways, the majority (64.2%) of respondents said they had never used the service. The findings indicate that most of the agricultural researchers were not using electronic journals and agricultural information gateways. This may be attributed to lack of access and skills.

When asked to comment on the frequency of use of mailing list, 52.8% of the respondents reported not to have used the service. In regard to downloading of software from the Internet, 47.2% had never downloaded, while 41.5% downloaded occasionally and 11.3% does it on weekly basis. The findings show that a significant number of agricultural researchers do not use much of the mailing list and downloading services on the Internet. This could be attributed to lack of adequate access to the Internet services as one respondent remarked "I use the Internet services occasionally when I go to KARI head office where the facilities are available."

Of the extension workers surveyed, 72.8% said they had never used World Wide Web. When asked to comment on email, 44.9% indicated using it occasionally, 33.1% said they had never used it, while 24.9% were using it on daily, weekly and monthly basis. It was observed during field visits that although most of the extension workers lacked access to the Internet at work-place, the majority used private cyber cafés to access email facilities. The email service was, therefore, the most used Internet service by extension workers.

In regard to discussions groups, 75.7% of the respondents had never participated in the discussions. Similarly, 83.1% of the respondents had never used OPAC on the Internet. It can be deduced from the findings that the majority of extension workers were not using OPAC and discussions groups.

When further asked to comment on the frequency of using electronic journals, the majority (83.1%) of respondents indicated that they had never used the journals. Similarly, 72.8% had never used agricultural information gateways. The findings show that the majority of extension workers were not using electronic journals and agricultural information gateways. This could be attributed to lack of skills and physical access to the Internet.

When asked to comment on mailing lists, 65.4% of the respondents said they had never used the service. In regard to downloading of software, 70.6% indicated that they had never downloaded. It can be deduced from the findings that only a small number (2.9%) of extension workers made effective use of the Internet services.

6.2.8 Usefulness of information obtained from Internet and CD-ROM databases

6.2.8.1 Searching of Internet and CD-ROM databases

The study additionally sought to find out whether the respondents were able to conduct independent searches on the Internet and CD-ROM databases. They were provided with options on the likert scale of 1(never) through 4(always) and asked to respond. The mean score was also calculated to provide a general picture of the situation per each category of respondents.

The agricultural researchers who reported that they often conduct independent searches were 35.8%, while 34% said they sometimes do and 17% indicated they always do. Only 13.2% of the respondents had never conducted independent searches. The mean score was calculated to give a general picture of respondents' competencies in conducting independent searches. The score was 2.57, the highest mean score being 4.0 and the lowest being 1.0. The findings indicate that the majority of agricultural researchers were competent enough to conduct independent searches on the Internet and CD-ROM databases. However, limitation of access to these facilities denied the respondents enough practice. For example one respondent observed "I sometimes conduct independent searches but if the Internet and CD-ROM services were available I could do that always."

In regard to extension workers, 59.6% observed that they were not in a position to conduct independent searches, 32.4% reported doing it sometimes, while 8% often and always conducting conducted the searches. The mean score was calculated to give a general picture of the situation of extension workers. The mean score was 1.51 which was below the average mean score of 2.0 indicating that majority of the respondents lacked skills and competencies to conduct independent searches on the Internet and CD-ROM databases.

Respondents were further asked to indicate the frequency in which they sought for assistance to search the Internet and CD-ROM databases. They were provided with options to choose from. The findings indicate that 58.5% of agricultural researchers sometimes ask for assistance, 33.9% often and always do, while 7.5% said they never ask for assistance. It is evident, therefore, that most of the agricultural researchers were able to conduct independent searches and only ask for assistance whenever they were stuck. In an ideal situation, library users only seek assistance whenever they encounter difficulties and cannot proceed with their searches.

In regard to extension workers, 42.6% said they sometimes ask for assistance, while 38.2% never ask and 19.1% often and always do. It was observed that the majority of those who said they had never asked for assistance lacked physical access to the Internet and CD-ROM databases.

6.2.8.2 Frequency of obtaining information on the Internet and CD-ROM databases

Besides, the study sought to find out if the respondents were able to obtain the information they need from the Internet and CD-ROM databases. They were provided with options on the likert scale of 1(never) through 4(always). The mean score for each category of respondents was calculated to give a general picture of the situation on the ground. Table 17 summarizes the responses of agricultural researchers and extension workers.

Table 17
Frequency of getting information by Agricultural Researchers (n=159) and Extension Workers (n=136)

	Agricultural Researchers		Extension workers	
Options	**N**	**%**	**N**	**%**
Never	12	7.5	69	50.7
Sometimes	78	49.1	59	43.4
Often	63	39.6	4	2.9
Always	6	3.8	4	2.9
Total	**159**	**100**	**136**	**100**

Table 17 indicates that 49.1% of agricultural researchers sometimes get the required information, while 43.4% often and always obtain the needed information and 7.5% never get the needed information. The mean score for agricultural researchers was calculated to give a general picture of the situation. The mean score was 2.4, the highest mean score being 4.0 and the lowest being 1.0. The score was above the average score of

2.0 indicating that more than half of the respondents were able to get the required information from the Internet and CD-ROM databases.

In regard to extension workers, an average number (50.7%) said they never get the required information, 43.4% sometimes obtain the information and 2.9% always and often obtain the information. The mean score for extension workers was 1.58 which is below the average of 2.0. It is evident from the findings that most of the extension workers were unable to get the required information from the Internet or CD-ROM databases. These findings corroborate with the earlier findings where the majority of extension workers had indicated having inadequate physical access to ICTs and lacked computer and Internet skills. This hindered them from effectively utilising the Internet and CD-ROM databases to obtain the relevant information needed in their day-to-day work.

6.2.8.3 Usefulness of information obtained from the Internet and CD-ROM databases

The study sought to establish the frequency of usefulness of information obtained by agricultural researchers and extension workers from the Internet and CD-ROM databases. The respondents were provided with options on the likert scale of 1(not useful) through 4(very useful) and were requested to tick against that which was applicable to them. The mean score was calculated to provide a general picture of the situation of each category of respondents. Table 18 summarizes the responses of agricultural researchers and extension workers.

Table 18
Frequency of usefulness of information obtained from Internet and CD-ROM databases by Agricultural Researchers (n=159) and Extension Workers (n=136)

	Agricultural Researchers		Extension workers	
Options	**N**	**%**	**N**	**%**
Not useful	6	3.8	54	39.7
Sometimes useful	39	24.5	43	31.6
Useful	60	37.7	28	20.6
Very useful	54	34.0	11	8.1
Total	**159**	**100**	**136**	**100**

Table 18 shows that most (71.7%) of the agricultural researchers found the information obtained from Internet and CD-ROM databases to be useful and very useful, 24.5% indicated sometimes useful and only 3.8% found the information not useful. The mean score was calculated to indicate the extent to which agricultural researchers obtained useful information. The score was 3.02, highest mean score being 4.0 and lowest score being 1.0. The finding shows that a significant number of agricultural researchers obtained useful information from the Internet and CD-ROM databases.

As for the extension workers, 39.7% found the information obtained not useful, 31.6% reported that it was sometimes useful, while 28.7% said it was useful and very useful. The mean score for extension workers was 1.97, which was slightly below the average score of 2.0. The findings indicate that an average number of extension workers obtained useful information from the Internet and CD-ROM databases. Although the majority lacked computer and Internet skills, they appreciated the usefulness of information contained in these electronic storage devices.

6.2.8.4 Other sources consulted by respondents

The study sought to find out the information sources consulted by the respondents whenever their information needs were not met through ICTs. This was done cautiously bearing in mind that both printed and electronic sources complement one another and it is difficult to draw a line as to when to use one particular source. Respondents were provided with options to choose from and asked to indicate any other source(s) not listed.

The findings indicate that the majority (94.3%) of agricultural researchers used printed sources of information, 66% (105) consulted colleagues, while 39.6% (63) and 24.5% (39) consulted experts and authors respectively. Only 5.7% (9) consulted stockists and traders of agricultural products.

Similarly, 97.1% of extension workers used printed sources, 83.8% (114) consulted colleagues, while 62.5% (85) and 49.3% (67) consulted experts and stockists/ traders of agricultural products respectively. Only 47.1% (64) consulted authors.

The findings indicate that the majority of agricultural researchers and extension workers used printed information sources whenever their information needs were not met via ICTs. It was observed that unavailability and inaccessibility of ICTs and in addition lack of skills contributed to wide use of printed sources of information.

6.2.9 Increase in work productivity and creativity

The study further sought to find out if use of ICTs had increased the respondents' level of research productivity and creativity. A study carried out by Kaminer and Braunstein (1998) on bibliometric analysis of the impact of Internet use on scholarly productivity found out that there is a positive association between the use of the Internet by scholars and their productivity. Lubanski and Mathew (1998) investigated the socio-economic impact of the Internet in the academic research environment and concluded that productivity and creativity increase is related to increase in co-authorship of papers and coordination of research. In line with this perspective, the respondents were provided with options on the likert scale of 1(strongly disagree) through 5(strongly agree). Table 19 summarizes the responses from agricultural researchers and extension workers.

Table 19
ICTs and increase in work productivity and creativity among Agricultural Researchers (n=159) and Extension Workers (n=136)

	Agricultural Researchers		Extension Workers	
Options	**N**	**%**	**N**	**%**
Strongly disagree	0	0	0	0
Disagree	9	5.7	17	12.5
Undecided	21	13.2	67	49.3
Agree	72	45.3	44	32.3
Strongly agree	57	35.8	8	5.9
Total	**159**	**100**	**136**	**100**

Table 19 shows that 45.3% of agricultural researchers were in agreement that use of ICTs had increased their work productivity and creativity, 35.8% strongly agreed, while 13.2% were undecided and only 5.7% disagreed. None strongly disagreed. It is evident from the findings that the majority (81.1%) of agricultural researchers were of the view that the use of ICTs had increased their work productivity and creativity. The findings concur with the earlier studies (Kaminer and Braunstein 1998, Lubanski and Mathew 1998).

In regard to extension workers, 49.3% were undecided as to whether use of ICTs had increased their productivity and creativity, 32.3% agreed that they had, while 12.5% disagreed and 5.9% strongly agreed. None strongly disagreed. The findings indicate that most of the extension workers were undecided as to whether use of ICTs had increased their work productivity and creativity. This is attributed to lack of physical access to ICTs and as such most of them opted to remain non-committal.

6.2.10 Use of Mobile Cellular Phone

The study sought to establish the frequency of use of the mobile cellular phone in communicating agricultural information among the respondents. They were provided with options on the likert scale of 1(never) through 4(quite often) and asked to tick against the option that was applicable. The mean score was calculated to get the general picture of the situation as per each category of respondents. Table 20 summarizes the responses

Table 20
Frequency of use of mobile phone in communicating agricultural information among agricultural researchers (n=159) and Extension Workers (n=136)

	Agricultural Researchers		Extension Workers	
Options	**N**	**%**	**N**	**%**
Never	36	22.6	24	17.6
Sometimes	69	43.4	75	55.1
Often	24	15.1	26	19.1
Quite often	30	18.9	11	8.1
Total	**159**	**100**	**136**	**100**

It can be seen from table 20 that 43.4% of agricultural researchers said they sometimes use their mobile phones to communicate agricultural information, 22.6% never used, while 54% used often and quite often. The mean score was calculated to indicate the level of use of mobile phone by agricultural researchers. The score was 2.2, highest mean score being 4.0 and the lowest score being 1.0. The findings indicate that most of the agricultural researchers found mobile phones as a convenient mode of communicating agricultural information in spite the fact that they were personal and expensive to sustain. These findings corroborate with Pigato (2001) study that investigated the impact of ICT on poverty and development in sub-Saharan Africa and South Asia and found little relationship between the level of mobile penetration and per capita income. Pigato (2001) attributes this to the advantages of the mobile phone which includes the convenient mode of communication with instantaneous response and does not require much skill to use. These sentiments corresponds with the respondents views. For example, one respondent remarked that "though I use the mobile phone to communicate agricultural information the credit is bought by me and not the organization." In addition, Obijifor (1999) observes that mobile technology embraces the African preferred oral communication that provides immediate feedback.

As for the extension workers surveyed, 55.1% said they sometimes used the mobile phones, while 27.2% used quite often and often, and 17.6% never used. The mean score was calculated to indicate level of use of mobile phones by extension workers. The score was 2.2, which is the same as that of agricultural researchers. The findings indicate that although the mobile phones were personal and expensive to maintain, more than average number of extension workers used them to communicate agricultural information to farmers. One respondent observed that "farmers are given mobile phone numbers to call whenever they need our assistance." Most of the extension workers were limited by airtime credit as one respondent thus observed "I use the cell phone quite often but I am limited by lack of phone credit." However, others were sceptical to use their mobile phones as one respondent remarked that "credit for airtime is expensive moreover the mobile phone is a personal property not to be used for official work."

6.2.10.1 Reasons for not using the mobile phone

The respondents who were not using their mobile phones in communicating agricultural information were further asked to indicate the reasons. This question was open-ended and required the respondents to give their responses freely. The question received varied views from the respondents. With the help of content analysis method, the comments were grouped according to frequency of similar phrases. Table 21 summarizes the responses from agricultural researchers and extension workers.

Table 21
Reasons for not using the mobile phone by Agricultural researchers (n=159) and Extension Workers (n=136)

	Agricultural Researchers		Extension Workers	
Reasons	**N**	**%**	**N**	**%**
No reason	42	26.4	22	16.2
Expensive due to high tariffs	75	47.2	84	61.8
Personal/doesn't belong to organization	21	13.2	16	11.8
Organization doesn't provide funds for credit	12	7.5	3	2.2
Lack of network	3	1.9	7	5.1
Do not have one	3	1.9	4	2.9
Don't think waves are safe	3	1.9	0	0
Total	**159**	**100**	**136**	**100**

It can be seen from table 21 that 47.2% of the agricultural researchers reported that mobile phones were expensive due to high tariffs, while 26.4% gave no reason because they often used their mobile phones and 13.2% observed that they were personal. Those who said their employers were not providing funds for credit were 7.5%, while 1.9% indicated lack of network and the same number had no mobile phones. It was interesting to note that 1.9% of the respondents were not using their mobile phones because they believed that waves were not safe. It was found out that most of the agricultural researchers used the SMS facility as it was relatively cheaper than making a call.

Of the extension workers, 61.8% said that mobile phones were expensive due to high tariffs, 16.2% gave no reason as they often used their mobile phones and 11.8% remarked that mobile phones were personal and not the property of the employers. Of the respondents, 5.1% lacked network, while 2.9% had no mobile phones and only 2.2% observed that their employer was not providing funds for credit. None said that waves were unsafe. The findings indicate that although extension workers were of the view that mobile phones were expensive to use, they found them to be a reliable mode of communication compared to landline telephones. Farmers were encouraged to use the SMS facility to reduce on cost of airtime.

6.2.11 Collaboration with TV and Radio Station

This study also sought to find out whether the Ministry of Agriculture and Rural Development (MoARD) and the Kenya Agricultural Research Institute (KARI) collaborated with Radio and TV Stations in disseminating agricultural information to the farming community. It further sought to find out whether this was also happening at the district and divisional agricultural offices and at the KARI research centres. The respondents were, therefore, asked to indicate whether their institutions were collaborating with Radio and TV Stations in disseminating agricultural information. Their responses are summarized below.

Most (73.6%) of the agricultural researchers indicated that their research centres were collaborating with Radio and TV Stations, while 26.4% reported they were not. Similarly, the majority (81.6%) of extension workers said that their agricultural offices were collaborating with Radio and TV Stations, while 18.4% reported that they were not. The findings indicate that KARI research centres and the district and divisional agricultural offices collaborated with Radio and TV Stations to disseminate agricultural information to the farming community.

The respondents were further asked to indicate the names of radio and TV Stations collaborating with their institutions. All (100%) agricultural researchers reported collaborating with the Kenya Broadcasting Corporation (KBC) which is the National Radio and TV Station in Kenya. Collaboration with private Radio and TV Stations was minimal as only 5.1% of respondents indicated Nation and Citizen Radio and TV Stations respectively, while 2.6% mentioned Kenya Television Network (KTN) and Sayare Radio and TV Station respectively.

Similarly, all (100%) the extension workers reported that their agricultural offices were collaborating with KBC which is the National Radio and TV Station, while 47.7% indicated Sayare TV and Radio Station. It was observed that due to liberalization of the airwaves in Kenya, many private Radio and TV Stations were being established in all parts of the country to cater for various needs. They were becoming popular in the rural areas because of using vernacular languages to transmit their programmes. It was found out that the private radio and TV stations charged less in recording and producing radio and TV radio programmes compared to KBC which is the national radio and TV station. As a result the ministry of agriculture and KARI were now collaborating more with the private Radio and TV Stations in disseminating agricultural information to the rural communities. Programmes were also being translated into vernacular to reach a wider audience.

6.2.11.1 Radio and TV programmes

The respondents were further asked to identify the TV and Radio programmes that had been produced to disseminate agricultural information to the farming community. The following programmes were mentioned by the respondents.

Radio programmes broadcast in the national language - Kiswahili

- Sikio la mkulima aired on KBC Radio Station and Private Radio Stations;
- Tembea na majira aired on KBC Radio Station and Private Radio Stations;
- Kahawa wiki hii aired on KBC Radio Station and Private Radio Stations;
- Afya na mifugo wetu aired on KBC Radio Station;
- Bei ya mboga na matunda aired on KBC Radio Station;
- Wadudu wa nafaka aired on KBC Radio Station;
- Mkulima na mazao aired on KBC Radio Station;
- Nipe habari aired on KBC Radio Station;
- Momonyoko wa udongo aired on KBC Radio Station and
- Sauti ya Mkulima aired on KBC Radio Station and Private Radio Station.

Radio programmes broadcast in official language - English

- Farmers' corner aired on KBC Radio Station;
- Feed the nation aired on KBC Radio Station;

TV programmes in official language - English

- Zero grazing shown on KBC TV Station;

- Farmers' journal shown on KBC TV Station;
- Professional view Shown on KBC TV Station;
- Agricultural documentaries Shown on KBC TV and Private TV Stations;
- Boran cattle Shown on KBC TV Station and
- Agricultural shows on KBC and Private TV Stations.

6.2.12 Costs and sustainability of ICTs

6.2.12.1 Costs of ICTs tools and services

The study sought to find out the views of agricultural researchers and extension workers in regard to costs and affordability of ICTs. The respondents were provided with a list of ICTs tools and services and requested to rate them on the likert scale of 1(very costly) through 4(affordable). Table 22 summarizes the responses of agricultural researchers and extension workers.

Table 22
Costs and affordability of ICTs to Agricultural Researchers (n=159) and Extension Workers (n=136)

		Agricultural Researchers		Extension Workers	
ICTs	Category	Frequency	%	Frequency	%
Computers					
	Affordable	18	11.3	19	14.0
	Less costly	30	18.9	4	2.9
	Costly	87	54.7	27	19.9
	Very costly	24	15.1	86	63.2
Internet					
	Affordable	9	5.7	8	5.9
	Less costly	12	7.5	3	2.2
	Costly	69	43.4	43	31.6
	Very costly	69	43.4	82	60.3
Email					
	Affordable	27	17.0	12	8.8
	Less costly	60	37.7	24	17.7
	Costly	57	35.9	37	27.2
	Very costly	15	9.4	63	46.3
Electronic Journals					
	Affordable	3	1.9	4	2.9
	Less costly	18	11.3	7	5.2
	Costly	51	32.1	28	20.6
	Very costly	87	54.7	97	71.3
CD-ROM Databases					
	Affordable	3	1.9	4	2.9
	Less costly	39	24.5	4	2.9
	Costly	60	37.7	31	22.8
	Very costly	57	35.9	97	71.3
Desktop publishing					
	Affordable	24	15.1	4	2.9
	Less costly	42	26.4	7	5.1
	Costly	69	43.4	45	33.1
	Very costly	24	15.1	80	58.8

Table 22 (continued)
Costs and affordability of ICTs to Agricultural Researchers (n=159) and Extension Workers (n=136)

		Agricultural Researchers		Extension Workers	
ICTs	Category	Frequency	%	Frequency	%
Fax					
	Affordable	36	22.6	15	11.0
	Less costly	39	24.5	37	27.2
	Costly	54	34.0	51	37.5
	Very costly	30	18.9	33	24.3
Telephone					
	Affordable	33	20.7	21	15.4
	Less costly	48	30.2	34	25.0
	Costly	51	32.1	77	56.6
	Very costly	27	17.0	4	2.9
Mobile Phone					
	Affordable	21	13.2	21	15.4
	Less costly	15	9.5	3	2.2
	Costly	45	28.3	42	30.9
	Very costly	78	49.0	70	51.5
Radio					
	Affordable	60	37.7	60	44.1
	Less costly	63	39.6	43	31.6
	Costly	21	13.2	22	16.2
	Very costly	15	9.4	11	8.1
Television					
	Affordable	51	32.1	28	20.6
	Less costly	48	30.2	32	23.5
	Costly	48	30.2	54	39.7
	Very costly	12	7.5	22	16.2
Video					
	Affordable	39	24.5	28	20.6
	Less costly	69	43.4	67	49.3
	Costly	42	26.4	26	19.1
	Very costly	9	5.7	15	11.0

Table 22 indicates that 69.8% of agricultural researchers were of the view that computers were costly and very costly. Similarly, 86.8% of the respondents reported that the Internet was costly and very costly. In contrast, 54.7% of the respondents observed that email was less costly and affordable. The findings indicate that most of the agricultural researchers found the Internet and computers to be costly, while email was less costly. It was observed that most KARI research centres had email services only. The argument was that ISPs were located far from the research centres and this increased the costs due to unreliable telecommunication facilities such as low bandwidth. It was, therefore, frustrating to connect to the Internet. This was compounded by the fact that most of the centres had inadequate funding.

Respondents were asked to comment on the cost of electronic journals. The majority (86.8%) said they were costly and very costly. Similarly, 73.8% observed that CD-ROM databases were costly and very costly. The findings indicate that most of the agricultural researchers were of the view that both electronic journals and CD-ROM databases were costly. It was found out that electronic journals were supposed to be available in the fifteen research centres having Internet facility but due to poor connectivity only few were able to access the journals. It was observed that the electronic journals available were those offered freely courtesy of the International Availability of Scientific Publications (INASP) and Blackwell Publishers. Most of the libraries at the research centres had a variety of CD-ROM databases.

In regard to desktop publishing, 58.5% of the respondents observed that it was costly and very costly. Although KARI had centralised the publications of the materials at the headquarters, many research centres had small desktop publishing units that produced in-house publications such as annual reports.

When asked to comment on the cost of fax, 52.9% of the respondents said it was costly and very costly. In regard to telephone, an average number (50.9%) of respondents observed that it was less costly and affordable. When asked further to comment on the cost of mobile phone, 77.3% were of the view that it was costly and very costly. The findings indicate that most of the agricultural researchers felt that mobile phone was very costly, while the fax was costly and telephone was less costly. As mentioned earlier, fax was only used to send vital official documents and was not accessible to most of the respondents. It was observed that despite the costs, most of the respondents used their mobile phones to communicate agricultural information with colleagues, farmers and extension workers.

The respondents were asked to comment on the cost of radio, a large number (77.3%) were of the view that it was less costly and affordable. Similarly, 62.3% of the respondents observed that the television was less costly and affordable. When further asked to comment on the cost of video, 67.9% of the respondents reported less costly and affordable. It is evident from the findings that most of the agricultural researchers' perceived radio and video as less costly, while television was affordable. It was observed that although the radio, video and television were generally affordable, the problem was the high cost of producing radio and TV programmes. One respondent observed that "costs can be reduced if there is more collaboration with stakeholders in the agricultural sector and TV and radio stations." In a study conducted by Odame and Kassam (2002) to investigate the problems that hindered effective linkages and collaboration between agricultural research and radio and TV stations in Africa identified lack of policies procedure as a major constraint. The authors observed that in many instances radio producers often encounter closed-gates of research facilities whenever they want to gather data for agricultural programs. There is need therefore for KARI and radio/TV stations to come up with policies to guide their collaboration and reduce costs of broadcasting agricultural programmes.

Of the extension workers surveyed, 63.2% were of the view that computers were very costly. Similarly, 60.3% observed that the Internet was also very costly. When asked further to comment on the cost of email, 46.3% said they were very costly, while 27.2% indicated costly. It can be deduced from the findings that most of the extension workers were of the view that computers, the Internet and email were very costly. It was observed that the slow pace of diffusion of ICTs among extension workers was associated with costs needed to procure the facilities, to train the respondents and costs for sustainability. These findings concur with Duncombe and Heeks (2002:8) who observe that investments for Internet access are significant in terms of initial capital outlay, running costs, and time and skills.

When asked further to comment on the cost of electronic journals and CD-ROM databases, 71.3% of the respondents reported that they were very costly. It was observed that none of the agricultural offices in the two districts had subscribed to any electronic journal. Although a few CD-ROM databases had been acquired, this was through donor funding.

The respondents were asked to comment on the cost of desktop publishing, 58.8% said they were very costly. It was observed that the Ministry of Agriculture and Rural Development (MoARD) attaches a lot of value to agricultural information for extension service. In this connection it has established the Agricultural Information Centre with the mandate of repackaging agricultural information in print, electronic and through the media. The ministry has, therefore, centralised the production of extension materials. However provincial and district agricultural offices were encouraged to create small desktop publishing units for their in-house publications. It was observed that Baringo and Uasin Gishu district agricultural offices had small desktop units that were used to produce annual reports and other in-house publications.

When asked to comment on the cost of fax, 61.8% of respondents said it was costly. Similarly, 56.6% of the respondents reported that the telephone was costly. In regard to mobile phones, 51.5% said they were very costly and 30.9% indicated costly. The findings indicate that a significant number of extension workers were of the view that fax and telephone were costly while mobile phones were very costly. In the agricultural offices surveyed, the direct telephone line and fax were in the office of the District Agricultural Livestock and Extension officer (DALEO) and could only be used for urgent official matters. It was observed that although mobile phones were expensive to sustain, most of the extension workers had acquired them.

When respondents were asked to comment on the cost of radio, a significant number (75.7%) said it was affordable and less costly. In regard to television, 55.9% were of the view that it was costly. When asked to comment on video, 69.9% of the respondents said it was less costly and affordable. The findings indicate that the majority of extension workers were of the view that radio was affordable, while video and television was less costly and costly respectively. While television and video were used during training, radio was used for radio listening groups. The radio listening group is an extension method where extension workers organize group of farmers to come together and listen to agricultural programmes being broadcast by the national and private radio stations. It has proved popular in disseminating agricultural information. After listening to the programmes, the farmers are encouraged to ask questions and extension workers respond accordingly.

6.2.12.2 Sustainability of ICTs tools and services

The respondents were asked in an open-ended question to comment on the sustainability of ICTs tools and services. The question received varied views from the respondents. With the help of content analysis method, the responses were grouped according to frequency of similar phrases. The following is a summary of the views of agricultural researchers and extension workers.

Table 23
Views of Agricultural Researchers (n=159) and Extension Workers (n=136) on sustainability of ICTs tools and services

	Agricultural Researchers		Extension Workers	
Views of respondents	**N**	**%**	**N**	**%**
Sustainable	12	7.5	-	-
Fairly sustainable if used sparingly	9	5.7	18	13.2
Feasible if each section contributes for costs	3	1.9	-	-
Sustainable as long as donor is there	39	24.5	3	2.2
Not sustainable due to high costs	36	22.6	7	5.2
Can be sustained if properly managed	6	3.8	-	-
Institutions trying to sustain within their means	15	9.4	-	-
Should be commercialized for ease of sustainability	-	-	4	2.9
Limited access to ICTs due to poor infrastructure	3	1.9	21	15.4
Inadequate allocation of funds for sustainability	9	5.7	44	32.4
Funding from central management have ceilings	-	-	8	5.9
Sustainability difficult due to poor infrastructure	-	-	17	12.5
Not sustainable as technical staff are centralized at the Headquarters	6	3.8	3	2.2
Obsolete ICTs not sustainable	9	5.7	-	-
Easy to sustain radio, fax, telephone, computers not Internet	12	7.5	11	8.1
Total	**159**	**100**	**136**	**100**

Table 23 indicates that 24.5% of agricultural researchers were of the view that ICTs were sustainable as long as the donor was there, while 22.6% said they were not easily sustained due to high costs of maintenance. The least mentioned view by 1.9% of respondents was limited access to ICTs due to poor infrastructure. It was observed during field survey that all KARI research centres had donor funded projects. Each project was expected to incorporate an ICT component of telephone, fax, the Internet and email services. The staff also used these services in the absence of a centralised Internet and email services at the research centres. The major problem experienced by all KARI research centres was sustainability of ICTs once the donor project ends. This problem was compounded by inadequate funding. This finding concurs with that of Pigato (2001) who evaluated donor funded ICT initiatives in Uganda, Tanzania, Zambia, and Ethiopia and found out several limitations. The author observed that donor-funded programs have tended to provide initial investment capital rather than maintenance and running costs. KARI should therefore attempt to address the issue of sustainability of donor funded ICT projects. Ironically, the least mentioned problem was inadequate infrastructure. This is a major problem in the country yet few of the agricultural researchers mentioned it. It could be attributed to the fact that most of the KARI research centres are located near urban centres where electricity and telecommunication facilities are available.

Inadequate funding was the most mentioned problem of sustainability by 32.4% of the extension workers. The ministry of agriculture experienced problem of inadequate funding and this affected funding of ICTs. One respondent observed that "our agricultural office use the telephone allocation to buy and maintain computers which is very inadequate." Only 15.4% cited limited access due to poor infrastructure. Most of the extension workers are based in the rural areas where the infrastructure is poor. Some places had no electricity and telephones lines. The least mentioned problem by 2.2% of the respondents was that of sustainable as long as the donor was there. This is because the Ministry of Agriculture had fewer donor-funded ICT projects compared to KARI.

6.2.13 Perceptions of ICTs tools and services

6.2.13.1 Awareness of ICTs tools and services

In view of the sub-heading given above, the study sought to find out the respondents views on the effectiveness of methods used to create awareness of ICTs tools and services. They were provided with options on the likert scale of 1(not effective) through 4(very effective) and requested to tick against that which was applicable. The mean score for each category of respondents was calculated to give a general picture of the situation on the ground.

The findings indicated that 43.4% (69) of agricultural researchers were of the view that the methods were somewhat effective, 26.4% (42) found them effective, while 17% (27) and 13.2% (21) indicated not effective and very effective respectively. The overall picture indicates that most of the agricultural researchers felt that the methods used to create awareness of ICTs in their respective institutions were fairly effective. This is supported by mean score of 2.4, highest mean score being 4.0 and lowest being 1.0. The mean score was, therefore, higher than the average mean score of 2.0.

Of the extension workers surveyed, 31.6% (43) observed that the methods were not effective, while 29.4% (40) and 26.5% (36) reported somewhat effective and effective respectively. Only 12.5% (17) were of the view that they were very effective. The findings indicate that most of the extension workers observed that the methods used to create awareness were fairly effective. This is supported by the mean score of 2.2 which is higher than mean score of 2.0.

6.2.13.2 ICTs and seeking information from libraries and information centres

The study sought to find out whether the use of ICTs had changed the respondents' way of seeking information from libraries and information centres. The question required them to indicate either yes or no. Those who indicated 'yes' were further probed to explain how ICTs had changed their information seeking behaviour. The responses are reported as frequency and percentage.

The majority (81.1%) of agricultural researchers were of the view that the use of ICTs had changed their way of seeking information from libraries and information centres. Of the extension workers surveyed, 54.4% observed that ICTs had changed their way of seeking information from libraries and information centres.

The respondents who indicated that the use of ICTs had changed their information seeking behaviour were asked to explain the factors that had contributed to the change. The question was open-ended and provided the respondents with flexibility of expressing themselves freely. The responses were coded and summarised as follows:

- The libraries and information centres are no longer the sole repositories of information as much of the current information is obtained via the Internet;
- I get much of the information from the Internet without physically visiting the library;
- It is relatively cheaper to access information via ICTs than through conventional libraries;
- ICTs provide a faster means of getting information;
- ICTs are more effective and efficient as opposed to accessing information in libraries;
- ICTs are more convenient to use and easily accessible;
- Use of ICTs saves time of travelling to libraries and information centres;
- ICTs provide enormous information in one pool unlike using more than one library to get the same information;
- ICTs such as the Internet and CD-ROM databases provide access to full-text information;
- It is possible to access up-to-date information via ICTs;
- It is possible to seek specific information via ICTs;
- Can access library catalogues from the web and saves time of searching for information from different libraries;
- ICTs are more user-friendly;
- No need for intermediaries when accessing information via ICTs;
- ICTs ensures integrity of information and
- Emphasis is now on electronic information hence one has to get acquainted with use of ICTs.

The factors that received the highest mention from both agricultural researchers (39.5%) and extension workers (44.3%) were that ICTs are more convenient to use and were easily accessible; ICTs provide a faster means of getting information (agricultural researchers mentioning 30.2% and extension workers mentioning 33.8%); ICTs provide enormous information in one pool (agricultural researchers mentioning 27.9% and extension workers 21.4%). Among the least mentioned factor by agricultural researchers (2.3%) and extension workers (21.4%) was that ICTs provide full-text information.

6.2.14 ICTs and communication of agricultural information

The study sought to find out whether the use of ICTs by agricultural researchers and extension workers had changed the way they communicate agricultural information. The respondents were provided with the options of choosing from either yes or no. Those who indicated 'yes' were further asked to explain how ICTs had changed the way they communicate agricultural information. The responses are reported as frequency and percentages.

Of the agricultural researchers surveyed, the majority (84.9%) were of the view that ICTs had changed the way they communicate agricultural information to others. Similarly, a significant number (69.9%) of extension workers reported that ICTs had also changed the way they communicate agricultural information.

The respondents who reported that ICTs had changed the way they communicate agricultural information were asked to explain the factors contributing to the change. The responses from agricultural researchers and extension workers are summarised as follows:

- Communication via ICTs is not bound by time or space;
- ICTs are faster and provide instantaneous response;
- It is easier to reach a wider coverage of people simultaneously via ICTs;
- ICTs are more efficient and effective in communicating information;
- ICTs allow sharing and exchange of information among many people;

- ICTs make it possible to tailor-made information to specific group of users;
- Possible to publish on the Web;
- ICTs facilitate more collaboration among all actors in the agricultural sector;
- It is possible to send large quantity of information via ICTs at relatively low cost;
- It is possible for one to be able to cross-check information via Internet and CD-ROM databases;
- ICTs provide more forms of presentation;
- ICTs speed up production and dissemination of information;
- ICTs provide current information;
- ICTs are convenient, versatile and
- ICTs facilitate adoption of ideas in a natural setting (seeing is believing).

The factor that received the highest mention from both agricultural researchers (53.3%) and extension workers (64.9%) was that ICTs are faster and provide instantaneous response. Of the agricultural researchers, 28.9% mentioned that it was easier to reach a wider scope of people simultaneously via ICTs. Similarly, 41.5% of extension workers observed that ICTs were more effective and efficient. A number of agricultural researchers (20%) and extension workers (26.6%) mentioned that ICTs allow for the sharing and exchange of information among many people. The factor that received least mention from agricultural researchers (4.4%) was possibility of publishing on the Web. Similarly, the least mentioned factor among extension workers (3.2%) was the efficiency of ICTs in speeding up of production and dissemination of information.

6.2.15 Methods of disseminating information to farming community

The respondents were asked in an open-ended question to outline the methods used in disseminating agricultural information to the farming community. The study's assumption was that ICTs could be used to enhance the efficiency and effectiveness of the dissemination methods. The mentioned methods are summarised below:

- Open/field days;
- Agricultural Shows;
- Workshops, symposium and conferences;

- Field demonstrations;
- Farmers field schools;
- Agricultural Technology Information Response Initiative (ATIRI);
- Dances, songs and drama;
- Mobile cinemas and video shows;
- Radio listening groups;
- Printed material i.e. posters, brochures, calendars, leaflets;
- Farmers' journal and handbook;
- *Chiefs' barazas*;
- Personal advisory to individual farmers;
- Use of Farming groups and associations;
- Field visits;
- Farmers educational tours and exchange visits;
- Farmers research groups;
- On farm participatory trials;
- Through regional research extension liaison stakeholder meetings;
- Liaise with Community Based Organizations (CBO's), church, 4k clubs;
- Use of focal area concept;
- Participatory rural appraisal;
- Farmers visit to research centres and agricultural offices and
- Mother-baby field trials.

The methods that received more mention by agricultural researchers (67.9%) and extension workers (97.1%) include the use of open and field days; agricultural shows (mentioned by 56.6% of agricultural researchers and 100% of extension workers) Field demonstration (mentioned by 73.6% of agricultural researchers and 94.9% of extension workers); Farmers field schools (mentioned by 58.5% of agricultural researchers and 86.8% of extension workers); workshops, seminars, conference (mentioned by 43.4% of agricultural researchers and 86.8% of extension workers). A number of extension workers (69.9) also mentioned the use of *chief's barazas* (meetings called by local chief/headman), while 43.4% of agricultural researchers mentioned use of printed material such as leaflets, brochures etc. Some of the methods have incorporated the use of ICTs. These include among others radio listening groups, use of mobile cinemas, television and video shows. One respondent observed that "ICTs facilitate the adoption of ideas in a natural setting as farmers believe more by seeing."

Informal discussions with extension workers revealed that no single extension approach can be considered appropriate to address the needs of all agro-ecological zones. Specific approaches to be used in a given area will depend on, among other factors, the following: (a) agro-ecological zones; (b) farmer literacy level; (c) enterprise mix; (d) land tenure; (e) farmers' resources; (f) socio-cultural factors; and (g) farmers' needs. However, approaches that emphasize the use of groups rather than individual farmers are recommended because of their relative low cost, particularly in view of the current low staff/farmer ratio in public extension service. ICTs, therefore, have a role to play in enhancing the extension approaches.

6.2.16 Knowledge gaps, constraints and challenges affecting the use of ICTs by agricultural researchers and extension workers

The study sought to establish the knowledge gaps, constraints and challenges affecting use of ICTs by agricultural researchers and extension workers. The respondents were asked in an open-ended question, to indicate the factors that affect the use of ICTs in their research centres and agricultural offices respectively. The question received varied views from the respondents. With the help of content analysis method, the responses were grouped according to frequency of similar phrases. Table 24 summarizes their responses.

Table 24
Constraints affecting use of ICTs by Agricultural Researchers (n=159) and Extension Workers (n=136)

	Agricultural Researchers		Extension Workers	
Constraints	**N**	**%**	**N**	**%**
Inadequate funds	87	54.7	92	67.6
High costs of maintenance of ICTs	30	18.9	36	26.4
High costs of production of TV and radio programmes	3	1.9	-	-
Poor infrastructure in terms of telecommunication and electricity	42	26.4	42	30.9
Lack of support from management	15	9.4	11	8.1
Non-availability of ICTs	66	41.5	109	80.1
Inadequate wide area network	3	1.9	-	-
Lack of awareness of ICTs tools and services	15	9.4	-	-
Lack of technical know-how of ICTs	48	30.2	35	25.7
Lack of comprehensive ICT policy and strategy	12	7.5	-	-
Obsolete hardware and software	12	7.5	9	6.6
ICTs tools and services concentrated in the headquarters	12	7.5	-	-
Frequent breakdown of ICTs	12	7.5	-	-
Lack of technical staff to maintain	6	3.8	14	10.3
High initial installation costs of ICTs	9	3.8	21	15.4
Lack of appropriate content	6	3.8	-	-
Lack of a strategy to sustain ICTs once donor projects ends	12	7.5	-	-
Lack of sound management of ICTs	3	1.9	-	-

Note: Table indicate multiple responses

Table 24 indicates that the factors that received the highest mention from both agricultural researchers and extension workers included the inadequate funding; the non-availability of ICTs; poor infrastructure; and the lack of technical know-how of ICTs.

Inadequate funding was mentioned by 54.7% of agricultural researchers and 67.6% of extension workers. Funding is a major constraint affecting diffusion of ICTs in the agricultural sector in Kenya. It was observed during field survey that agricultural extension offices hardly have any ICT budget. At the Uasin Gishu District Agricultural Office telephone allocation was used to purchase computers and the extension workers had to forgo part of their field allowance to connect the Internet. This is supported by comments of a respondent in charge of the district agricultural office who stated that "I have used our telephone vote to purchase the few computers you are seeing since we don't have an ICT budget." After connecting to the Internet, the staff had to use the facility sparingly due to lack of adequate funds to sustain. In regard to KARI research centres inadequate funding was also a major constraint especially for donor funded projects.

The non-availability of ICTs was mentioned by 41.5% of agricultural researchers and 80.1% of extension workers. The situation was worse for extension workers as the majority were based in the rural areas and lacked physical access to ICTs. Poor infrastructure and lack of funding compounded this problem.

Poor infrastructure was mentioned by 26.4% of agricultural researchers and 30.9% of extension workers. Most of the extension workers were based in the rural areas where basic infrastructure was lacking. Most part of arid and semi-arid areas such as Baringo district lacked electricity and telephone facilities. The network for mobile phone was also inadequate. One respondent remarked that "If you are to talk on your mobile phone you have to climb on top of a tree or a hill." As compared to extension workers, agricultural researchers were relatively better as far as the infrastructure was concerned. Most of the KARI research centres are located near urban centres.

Lack of technical know-how was mentioned by 30.2% of agricultural researchers and 25.7% of extension workers. Ironically, only a few extension workers mentioned this problem. The number does not correspond to those who mentioned that they lacked skills to use the Internet and computers. This may be attributed to the non-availability of ICTs tools and services. One respondent commented that "We cannot talk about skills when we lack computers to use." More agricultural researchers mentioned this factor because the majority had physical access to ICTs but lacked skills of utilising them effectively.

Other factors mentioned by respondents included high costs of maintenance; high costs of production of TV and radio programmes; lack of support from the management; inadequate wide-area network; lack of awareness of ICTs tools and services; lack of comprehensive ICT policy and strategy; obsolete hardware and software; concentration of ICTs tools and services at the headquarters; frequent breakdown of ICTs; lack of technical staff to maintain ICTs; high initial costs to install ICTs; and lack of responsive content.

6.2.17 Suggestions of agricultural researchers and extension workers on how to improve diffusion and use of ICTs

Agricultural researchers and extension workers were asked in an open-ended question to indicate the measures that should be taken to improve diffusion and use of ICTs in their respective institutions. The question received various views from the respondents. With the help of content analysis method, the responses were grouped according to frequency of similar phrases. Their views are summarised below.

- Provision of adequate ICTs tools and services to agricultural researchers, extension workers and other actors in the agricultural sector;
- Need for institutional support in diffusion and use of ICTs;
- Allocation of adequate funding for ICTs in all government departments;
- Need to improve infrastructure i.e. telecommunication and electricity especially in the rural areas;
- Need to impart skills and technical know-how to researchers, extension workers and other actors in the agricultural sector;
- Urgent need to formulate a comprehensive ICT policy and develop a strategy for ICTs diffusion in the country;
- Employ adequate technical staff to maintain ICTs regularly at all government departments;
- The need for regular procurement of latest ICTs;
- Need to re-train policy makers to appreciate use of ICTs;
- Government should reduce taxes on importation of ICTs;
- Institutions should subsidize use of mobile phones by meeting cost of air time credit;
- Need for more collaboration, partnership and networking with all stakeholders in the agricultural sector to enhance diffusion of ICTs;

- Establish telecentres at all farmers training centres in the country;
- Information specialists and IT staff should create awareness of ICTs among agricultural researchers and extension workers;
- ICTs such as radio, TV, video's should be used more in the rural areas where connectivity is poor;
- Need to network all agricultural institutions/organizations to allow more sharing and exchange of agricultural information;
- Commercialize some of the services to sustain use of ICTs;
- Use of satellite technology and VSAT to improve connectivity in the whole country;
- Establish agricultural information centres at national, provincial, district and divisional level;
- More ICTs courses should be taught at school, colleges and universities to pave the way for an information society;
- Institutions should lobby for affordable ICTs services;
- There is need for more sound management of ICTs and the
- Need to identify information needs of agricultural researchers and extension workers in order to provide responsive content via ICTs.

Suggestions that received more mention from agricultural scientists (49.1%) and extension workers (80.9%) was the provision of adequate ICTs tools and services to agricultural researchers, extension workers and all actors in the agricultural sector. It was further mentioned that there was need to impart skills and technical know-how to agricultural researchers and extension workers (mentioned by 50.3% of agricultural researchers and 73.5% of extension workers). The issue of inadequate funding received more mention from the respondents (mentioned by 50.3% of agricultural researchers and 73.5% of extension workers). They suggested that a separate budget should be allocated to ICTs. Other suggestions received less mention ranging from 1.9% to 24.3% of the respondents.

Section II

6.3 Data obtained from the Key Informants of the study

This section presents data obtained from interviews with the key informants of the study who comprised policy makers, IT personnel and librarians. They were drawn from the institutions surveyed and consisted of 8 Information Technology (IT) personnel, 27 librarians and 24 policy makers. The policy makers were those in the management of their respective institutions and they included the director of KARI, the director of agriculture, the director of extension services, district agricultural livestock and extension officers, research centre directors and their deputies among others. The IT personnel targeted were those in charge of ICTs in their respective institutions like the systems administrators. The librarians on the other hand, were those in charge of their respective libraries and information centres.

Three types of interview schedules were used to seek information from the three categories of informants. The schedules sought information relating to nature and types of ICTs, adequacy of IT personnel, infrastructure, training of staff on use of ICTs, ICT policy, provision of library and information services, funding of ICTs, problems encountered in the application and use of ICTs and suggestions for improvement.

6.3.1 Nature and types of ICTs

6.3.1.1 Availability of fax, the Internet, email and computers

The respondents were asked to state the nature and types of ICTs in their respective institutions. The question was targeted to all key informants. They were also asked to indicate the availability of Internet and email services. Their responses are summarised in table 25a and 25b.

Table 25a
Availability of Fax, Internet and email services, and number of computers at each of the KARI research centres

	KARI CENTRE	Fax lines	Internet	ISP Used	Email	No. Of Computers
1	KARI HQs	5	Connected	Kenyaweb	connected	91
2	Kitale research centre	1	Connected	Multitecweb	Connected	22
3	Kibos research centre	1	None	-	None	4
4	Molo research centre	None	None	-	Connected	7
5	Njoro research centre	1	Connected	Africa Online	Connected	25
6	Tigoni research centre	1	None	-	Connected	9
7	Muguga south R. centre	1	Connected	Kenyaweb	Connected	23
8	NARL research centre	1	Connected	Kenyaweb	Connected	46
9	Thika research centre	1	Connected	NairobiNet	Connected	11
10	Mwea Tabere centre	1	Connected	Africa Online	Connected	20
11	Katumani res. centre	1	Connected	Africa Online	Connected	22
12	Muguga North R. centre	1	Connected	Kenyaweb	Connected	19
13	Naivasha res. centre	1	Connected	Africa Online	Connected	17
14	Marsabit res. centre	1	None	-	Connected	3
15	Kiboko res. centre	1	None	-	Connected	10
16	Kakamega res. centre	1	Connected	Africa Online	Connected	13
17	Kisii research centre	1	Connected	NairobiNet	Connected	12
18	Embu research centre	1	Connected	Salpha Net	Connected	35
19	Garissa research centre	1	None	-	Connected	3
20	Mtwapa research centre	1	Connected	Africa Online	Connected	10
21	Perkerra res. centre	1	None	-	Connected	8
22	Lanet res. centre	1	Connected	Wananchi online	Connected	12

Table 25b
Availability of fax, Internet and email services, and number of computers at institutions surveyed in the ministry of agriculture and rural development

Ministry of agriculture and rural development	Fax lines	Internet	ISP Used	Email	No. Of Computers
Ministry of agriculture HQ	15	Connected	African online	connected	700
Agricultural Information Centre	1	None	-	Connected	15
Uasin Gishu district agricultural offices	1	Connected	Multitecweb	Connected	5
Baringo district agricultural office	1	None	-	None	2

Table 25a indicates that the majority of KARI research centres had Internet and email services. Most of these,services were funded through donor projects. The policy of KARI was that each donor project is to include a component of Internet and email services. This enhanced accessibility of the Internet and email services among the agricultural researchers. It was observed that Kibos was the only research centre without the Internet and email services. The centres that had only email services were Tigoni, Marsabit, Kiboko, Garrissa and Perkerra. The number of computers varied from one centre to the other with KARI headquarters having the highest number of 91 computers. Computers were found to be inadequate in most of the research centres. One respondent observed that KARI required an additional of 1,000 computers for it to meet the demands of all the staff at research centres.

Table 25b indicates that the ministry of agriculture head office and Uasin Gishu district agricultural office had Internet and email services, while the Agricultural Information Centre (AIC) had only an email service. Baringo district agricultural office had none of the services and extension workers accessed the services from the neighbouring district development office. The majority of the institutions surveyed had dial-up Internet connection apart from KARI headquarters, which had both dial-up and dedicated line connections.

The ministry of agriculture headquarters had 700 computers. Although this was the highest number, it was inadequate to meet the demand of about 2,000 employees. The Agricultural Information Centre had 15 computers of which 2 were apple Macintosh G4. Uasin Gishu district agricultural office had 5 computers while Baringo had only 2 computers. There were no computers at divisional agricultural offices.

The institutions had a range of proprietary and open-source software. These include Standard Microsoft Office suite, statistical packages such as SPSS, CD-ISIS, WordPerfect, Dbase, oracle, Linux, page-maker, clippers, and in-house developed retrieval software among others. Operating systems included MS DOS, MSS Windows, UNIX, Novell, and Macintosh. A number of GIS software was available at the Kenya soil survey which was used to store, manipulate and present data in spatial (geographical) context. The GIS software was developed to suit agriculture which is the most spatially intensive activity with variation in production conditions driven by climatic, edaphic, biotic and socio-economics factors.

It was found out that the institutions surveyed used different Internet Service Providers (ISPs) depending on the proximity, cost and quality of service. It was observed that KARI had its own ISP called Kenyaweb, which had been installed at KARI headquarters. It was only used by the research centres located near the headquarters. The centres which were far from the headquarters used commercial ISPs.

It was observed further that KARI headquarters had a fully operational Local Area Network (LAN) with email address that enabled the staff to communicate via the network. The staff were also able to access the Internet and email services from their offices. It was found out that the research centres that had installed LAN were Mtwapa, Perkerra, Kisii, Katumani, Thika, Kitale and the National Agricultural Research Laboratory (NARL). The networking software used was Novell NetWare and lines were connected via routers. Unshielded twisted pair was used in cabling and networking the offices, while coax was used to network temporary buildings such as green house. Fibre optic was used for underground cabling.

KARI is a member of Kenya Education Network (KENET) funded by USAID. Currently KENET is networking all the educational and research institutions in Kenya using satellite and Very Small Aperture Technology (VSAT). KARI expects to benefit from this initiative and be able to network all the research centres.

The ministry of agriculture had established a computer resource centre department with only 5 technical staff. The ministry was in the process of networking all the offices at the headquarters at the cost of Kshs 14 million (USD 175,000). At the time of conducting the study, trunking and cabling were already taking place where switchers, routers and fibre optic were used. While Uasin Gishu and Baringo district agricultural offices were not networked and were using stand-alone computers.

6.3.1.2 Availability of radio, video, television and other ICTs tools

The respondents were asked to indicate the availability of radio, video, television, mobile phone and other forms of ICTs in their respective institutions. It was found out that the Agricultural Information Centre (AIC) had a variety of ICTs, which were used, in repackaging agricultural information. The centre had 2 accousted and fully equipped radio studios, editing suites and publishing unit. Among the ICT facilities included mixers, tape recorders, radio cassettes, sound craft, amplifiers, tapes, colour printers, rota printers, scanners, television, VCR, video cameras and editing facilities. It was observed that the ministry of agriculture headquarters also housed a variety of ICTs most of which had been acquired through donations. The ministry had the responsibility of distributing the ICTs to provincial and district agricultural offices. Baringo and Uasin Gishu district agricultural offices had radios, televisions and VCR, and videocassettes. They were used mainly in training the farmers.

It was observed that KARI had a section within the Information Services Division that handled all the audio-visual equipment. It was manned by a professional staff member. The equipment ranged from radios, televisions, overhead projectors, video cameras, VCR, scanners, and copy printers. The research centres had variety of ICTs that had been acquired through donor projects. These ranged from video camera, VCR, colour printers, scanners, television, and radios.

At the KARI headquarters use of the mobile telephony had been enhanced through the incorporation of 4 mobile lines in the PABX system. The lines included two of Safaricom and Kencell mobile subscribers respectively. The KARI PABX system had both analogue and digital configuration. It was noted that the centre directors of Kakamega and Kitale research centres had identified key officers and had made arrangement to purchase mobile phones for them. The officers were also given a monthly allowance of Kshs 2,000 (USD25) to meet the costs of airtime credit. Mobile phones were used to communicate with farmers and other stakeholders.

The findings indicate that KARI had developed a website, while the Ministry of agriculture was in the process of developing one. Similarly, the Kenya Agricultural Commodity Exchange (KACE) was in the process of developing a website for Baringo district agricultural office. The Uasin Gishu district agricultural office was yet to develop a website.

6.3.2 Information Technology (IT) Specialists

The respondents were asked to state the number of IT personnel in their respective institutions. The question was directed to all the informants. The findings indicate that all the IT personnel were centralised at the headquarters of the two institutions. At KARI, the total number of IT personnel was 15 of which 4 were professionally qualified with higher national diplomas and bachelors degrees in computer science and related areas. The remaining 11 were technicians. The IT personnel had the responsibility of maintaining ICTs in all the 21 KARI centres. This was yet to be achieved, as most centres are located far from the headquarters and are widely dispersed from one another. This makes it difficult for the IT personnel to travel to every centre requiring their services. The centre directors interviewed were not happy with the arrangement and emphasised the need to have technicians at their centres to maintain ICT facilities on a daily basis. They observed that maintenance of their facilities was becoming very expensive since they were often compelled to contract private consultants to deal with urgent matters. Many centres had identified researchers who were computer literate and had trained them on basic maintenance of hardware and software. After this they were given the responsibility of overseeing ICT facilities in their respective centres in addition to their research work. The only problem was when these researchers decide to leave for greener pastures. At the Kitale research centre, for example, the researcher who was maintaining ICT facilities secured a better employment and opted to move in spite of the centre director trying to persuade him stay.

Similarly, at the ministry of agriculture, the IT personnel were centralised in the computer resource centre department. At the time of conducting the study the total number of staff in the department was only five. It was found out that two extension workers had been identified to take care of computers and the Internet services at Baringo and Uasin Gishu district agricultural offices respectively. The extension workers had skills and knowledge on use of computers and Internet. They also assisted in producing annual reports and other publications. The district agricultural livestock and extension officers in the two districts argued that the identified extension workers were also expected to perform their extension duties and were not able to dedicate enough time to maintenance of ICTs. They observed that for ICTs to be provided there is need to employ competent IT personnel.

6.3.3 Training of staff on use of ICTs

The policy makers and IT personnel were asked to state whether they trained their staff on use of ICTs. It was established that KARI had conducted training sessions for all the staff including those in senior management positions. The aspects covered during the training included use of CD-ROM databases such as the crop protection compendium and The Essential Electronic Agricultural Library (TEEAL). Training had also been offered on use of the Internet and email services. Staff had also been trained on the use of in-house database called the Kenya Agricultural Research Database (KARD). KARD was developed in 1992 through the funding of the Department for International Development (DFID) and the Netherlands Overseas Development Agency (NUFFIC). It is a database containing research publications emanating from all KARI research centres. All the staff at the headquarters and those in research centres with fully operational Local Area Network (LAN) had also been trained on the use of the network. According to the KARI system administrator, the training had increased network utilization to 90% at KARI headquarters and 50% at the research centres.

It was established that the ministry of agriculture through the computer resource centre was conducting basic training on use of computers for all staff at the headquarters. Staff were encouraged to take extra training sessions on use of software packages by paying a minimal fee. At the Uasin Gishu district agricultural office training on basic use of computers and Internet had been organised for all the extension workers based at the district office. The training was offered by two private computer-training firms namely

Down to Dusk and Alphax. However, it was noted that extension workers at divisional offices did not benefit from the training. At the Baringo district agricultural office no training had been offered by the time of conducting the study.

6.3.4 Provision of Library and Information Services

The librarians were asked to state the nature and types of ICTs in their respective libraries. They were further asked to indicate whether their libraries offered Internet and email services and whether they were automated.

It was observed that KARI library at the headquarters was well stocked with 3,700 books, 51 journal titles, and several electronic journals and CD-ROM databases. The CD-ROM databases included AGRIS, AGRICOLA, Crop Protection Compendium, RURAL and TROPAG among others. The Essential Electronic Agricultural Library (TEEAL) is full-text and has a collection from 141 agricultural journals stored on 172 discs and holding images of 750,000 full text pages with illustrations and diagrams. The TEEAL database is an agricultural library on CD-ROM and is acquired as a complete stand-alone system. The database is a joint project of The Albert Mann Library of Cornell University in collaboration with Rockefeller Foundation and co-operating libraries. The database was developed to fill the information gap of agricultural researchers and educators in developing countries and is available at a subsidised cost of US$10,000. The subjects covered on the TEEAL database include: crop production, plant diseases, farm mechanics, tillage and soils, agricultural economics, natural resources, the environment, food science, animal and human nutrition, forestry, genetic resources and breeding and tropical plants. The database was available in all KARI libraries and the content had proved useful to all agricultural researchers.

The library subscribed to electronic journals through the courtesy of the International Network for the Availability of Scientific Publications (INASP) and Blackwell Synergy. The library had six computers connected to the Internet and provided free Internet and email services. It had a direct telephone line and a fax machine. The library was partially automated using WINISIS and was linked to the local area network. The most commonly used service was the question and answer service sponsored by the Technical Centre for Agriculture and Rural Co-operation (CTA). The service was also offered through other agricultural libraries and information centres. Agricultural researchers, extension workers, farmers and other actors in the agricultural sector made request through the service.

It was found out that KARI centre libraries varied in terms of stock, ICTs tools and services and quality of service. Many donor projects included a component of the library, which was used to purchase books and ICTs tools. It was established that 14 centre libraries had professionally trained librarians. The libraries offered Internet and email services and had a variety of CD-ROM databases. They were partially automated using WINISIS text retrieval software. The libraries were Katumani, Kisii, Thika, Mwea Tebere, Mtwapa, Kitale, Njoro, Kiboko, Embu, Marsabit, Muguga North and South, and Perkerra and KARI headquarters library. It was observed that TEEAL and question and answer services were available in all KARI centre libraries. Some centre libraries did not have computers and it was not possible to access the CD-ROM databases. The libraries without computers included NARL, Naivasha, Molo, and Kibos.

KARI had trained all library staff on various aspects of ICTs. For example in 1998 KARI provided an in-house training to all library staff on use of WINISIS text retrieval software. After the training the library staff were expected to create in-house databases using the package. Training of trainers' course had also been conducted on use of the Internet, TEEAL, and Crop Protection Compendium and on question and answer service. The trained librarians were expected to train agricultural researchers in the respective centres.

The main library at the ministry of agriculture headquarters was partially automated using WINISIS text retrieval software. The library had one computer, which was used to provide OPAC services. It had 28 titles of CD-ROM and had developed two databases for monographs and periodicals. There were no Internet and email services in the library. The library provided access to electronic journals through the courtesy of INASP.

The AIC documentation centre dealt mainly with unpublished agricultural literature. The centre was partially automated using WINISIS. It had 2 computers and several CD-ROM databases. The library provided only email services. Uasin Gishu and Baringo district agricultural offices had no libraries as such but effort had been made to organize available publications and electronic databases in some room. It was found out that a database called District Management Information System (DMIS) had been developed in Baringo agricultural office. The database was used to analyse and monitor crop performance in the district.

6.3.4.1 Creating awareness of ICTs tools and services

The librarians used a variety of methods and techniques to create awareness of new ICTs tools and services. The ministry of agriculture libraries used demonstrations and notices to create awareness of new ICTs tools and services. Whenever there was a new product such as CD-ROM or OPAC, users were invited to a demonstration on how to access the information from the products.

Similarly, KARI libraries used demonstration and training to create awareness among users on new ICTs products and services. Emphasis was on hands-on training as a way of building confidence among the users to effectively use the newly acquired products and services. Short training had also been offered on the use of electronic journals. Other methods used to create awareness include library newsletter, email, notice boards, and meetings.

6.3.5 ICTs Budget

The key informants were asked to state the proportion of ICT budget in relation to the total budget of their respective institutions. The respondents were asked to state if the budget was centralised or decentralised. They were further asked to state whether they had a separate budget for ICTs. They were also asked to state the percentage of hardware, software, training, communication fees and maintenance in the ICT budget.

It was found out that budgets were centralised at KARI and it was only after approval that each research centre was given their allocations. The research centres were expected to prepare a consolidated budget. The budgets were forwarded to KARI headquarters for approval. But before the budgets were approved, the co-ordinators of the various KARI programmes scrutinised them to establish whether all the items were presented correctly. Once the budgets were approved, funds were disbursed to the respective centres.

KARI spent a total of Kshs 5,000,000 (USD 62,500) yearly on ICTs. Fifty percent of this amount was used for communication fees such as telephone and costs of ISPs, while 2% was used for maintenance of ICTs and training of staff respectively. About 46% was used to acquire hardware, software and other forms of ICTs.

Similarly, budgeting of KARI library services was centralised. Each centre library prepared its own budget and forwarded it to the head of information services division at the KARI headquarters. The librarians found it difficult to quantify the allocation for ICTs procurement and maintenance. It was estimated to be about 30% of the total library budget.

Similarly, at the ministry of agriculture, the budget was centralised and each district agricultural office prepared a consolidated budget and forwarded it to the ministry headquarters. Once the budget was approved money was then disbursed to the respective agricultural offices in the country. It was observed that the approved budget was always inadequate to meet the basic requirements. In most cases ICT was given inadequate funds which were used mainly to provide telephone facilities. The computers that were available had been acquired through donations. At the Uasin Gishu district agricultural office the telephone vote had been used to acquire two computers and train staff on basic use of computers. The findings indicate that diffusion of ICTs had been affected by inadequate funds for ICT procurement, adoption and maintenance. These findings concur with a study by Accenture, Markle and UNDP (2001, section 3.1.2) that singled out inadequate funding as a major constraint of ICT diffusion in Africa.

The librarians in the ministry of agriculture found it difficult to quantify the proportion of ICTs allocation in the total library budget. They observed that the budget in the first place was inadequate to cater for basic library services.

6.3.6 ICTs Policy and Regulatory Framework

The respondents were asked to state whether their institutions had an ICT policy and how this policy was related to the government ICT policy. The question was directed to policy makers and systems administrators of the respective institutions.

The Kenya government was yet to formulate a comprehensive ICT policy, although it had appointed a task force to look into the issue. Once the policy is ready it will be enacted through an Act of parliament. It was observed that fragmented ICT policies were in place, example is the policy stipulating the need for all the government ministries to be networked. Each ministry was supposed to establish an IT department. The ministry of agriculture had, therefore, established a computer resource centre within the planning division. The ministry had a policy document on ICT, which outlined its vision. The document stated the need to network all offices at the headquarters, provincial and district agricultural offices (Kenya, Republic of, Ministry of agriculture 1998:24). It stipulated the need to train all the staff in the basic use of computers and the Internet. The ministry had set up an ICT Advisory Committee to implement networking of all the offices at the headquarters. The committee had the responsibility of providing ICTs to provincial and district agricultural offices. It is also expected to make periodic recommendations to the management on issues relating to ICTs diffusion.

It was found out that KARI had an ICT policy, which was pegged to the strategic objectives of the institution. The policy stipulates the need to adopt appropriate ICTs to facilitate dissemination of knowledge and technologies and to catalyse the process of outreach programmes. It also states the need to use ICTs to strengthen the efficiency, effectiveness and sustainability of KARI's institutional capacity (KARI 2003:6). It was observed that implementation of the policy was in progress and it is expected to scale up ICT to all the research centres. Already ten research centres had been networked with the headquarters by the time of conducting the study and attempt was being made to network the others.

6.3.7 Constraints and challenges encountered in the application and use of ICTs

The key informants were asked to state the constraints and challenges they encountered in the application and use of ICTs in their respective work places. They were further asked to comment on the constraints relating to technical staff, infrastructure, enabling environment, ISP, ICT policy, funding, maintenance, and awareness of ICT tools and services. The question was directed to all the key informants. The responses are summarised below.

6.3.7.1 Technical constraints

All the respondents were of the view that diffusion of ICTs had been affected by lack of technical personnel to maintain the hardware and software. The few technical staff were concentrated at the head offices leaving most centres and agricultural offices without a single technician. The respondents also reported that the majority of agricultural researchers and extension workers lacked computer and Internet skills.

6.3.7.2 Lack of training for information providers

It was also reported that there was lack of training for information providers. For example librarians from the ministry of agriculture felt that they needed more training to update their skills on the use of new technology such the Internet and electronic journals.

6.3.7.3 Non-availability of ICTs

The majority of respondents reported the non-availability of ICTs. They observed that computers were very few and that the Internet and email was lacking in some institutions.

6.3.7.4 Funding

Inadequate funding was a major problem encountered by the majority of respondents. At Uasin Gishu district, extension workers had to forgo their allowances in order to raise money to purchase 2 computers. Besides, the telephone allocation was used to connect the Internet and email services.

The centralised system of budgeting was criticised by the majority of respondents who observed that it was a frustrating system. One respondent observed that "It is frustrating when we present our budget proposals to the head office and we receive no response." The respondents further observed that it was difficult and frustrating to manage the small allocation of funds and be able to meet the basic services.

6.3.7.5 Costs of maintenance of ICTs

The respondents reported that maintenance costs for ICTs were considerably high. This situation was made worse by lack of adequate funds. The technical staff were all concentrated at the headquarters and it was difficult for the centres and agricultural offices to maintain their ICTs tools. In some cases private firms were contracted to provide maintenance when this was found to be urgent. But the costs were quite exorbitant.

The respondents further observed that once the donor projects end all the equipment and ICTs were handed over to the respective centres. The problem was on the sustainability and maintenance of the services and facilities.

6.3.7.6 Obsolete technology

The respondents reported of obsolete technology. For example all computers at Baringo agricultural office were the 486 series. They were slow and could not be connected to the Internet and email services. One respondent observed that "technology is moving very fast and we cannot afford to keep pace because of myriad of problems."

It was observed that at the AIC radio and video equipment were installed ten years ago and it was not easy to replace this due to lack of funds. The scale of operation was, therefore, small.

6.3.7.7 Infrastructure

All the respondents observed that poor infrastructure limits the application and use of ICTs. The problem of inadequate telecommunication and low bandwidth made it difficult for KARI centres to be networked. The slow and often congested traffic increased the costs of the Internet and email services. This was more prevalent at research centres located far from the Internet Service Providers (ISP). Most ISPs were located in big towns where business was thriving because of many Internet cafes that had been established to meet the demand of many users.

It was observed that electricity and telephone connection was unavailable in most of the rural areas. This hindered communication among extension workers.

The respondents also pointed out the problem of breakdown and downtimes of Internet and email services. They observed that this was caused mainly by fluctuation of power supply and frequent breakdown of Jambonet, which is the Internet backbone in the country.

It was also established that dial-up connection was expensive because of telephone costs. Policy makers and systems administrators were now opting for dedicated lines.

6.3.7.8 National Co-ordination of ICTs

The respondents pointed out the problem of lack of a ministry to co-ordinate ICTs activities in the country. They observed that it was difficult to know where to channel issues that need to be addressed at the national level as ICTs co-ordination was scattered among the ministries of Education, Transport and Communication, and Tourism and Information.

6.3.7.9 ICT Policy

The respondents expressed the view that the lack of a comprehensive national ICT policy had hindered the scaling up of the technologies. They felt that without such a policy it was difficult to come up with an institutional ICT policy.

6.3.7.10 Attitude of clients

It was found out that public institutions which had commercialised their services so as to generate extra funds for sustainability found it difficult to compete favourably with the private sector. The respondents observed that the attitude of clients towards government institutions was negative due to past experience and have no confidence in their services. They observed that it would take the public sector a while before they could compete favourably with the private sector. In other words, the current situation is that the private sector has monopoly of the market and thus predominates.

6.3.7.11 Enabling environment

While the policy makers said there was an enabling environment, the majority of librarians and IT personnel expressed a different view. They observed that the lack of enabling environment hindered scaling up of ICTs. They complained that policy makers were not appreciating the application and use of ICTs. They blamed them for not supporting ICTs initiative.

6.3.8 Suggestions by key informants on how to improve application and use of ICTs

The key informants were asked to suggest ways in which the application and use of ICTs could be improved. Their views are summarised below.

- More technical staff need to be employed and deployed to all research centres, provincial and district agricultural offices to manage and maintain ICTs;
- More qualified librarians should be employed to manage agricultural libraries and information centres;
- There should be an increase in funding of agricultural services including ICTs;
- Some ICTs services could be commercialised for purposes of sustainability;
- Funding should be decentralisation so as to empower research centres and districts agricultural offices to manage their own funds;

- More ICTs should be acquired to enable each officer to have access to computers. This will facilitate acquisition of computing skills and scaling up of the technology;
- There is a need to harmonise all the IT sections in the ministry of agriculture;
- Each divisional agricultural office should have an agricultural resource centre;
- There is a need for training of information providers and technical staff on new ICTs;
- Policy makers should be re-trained to appreciate the application and use of ICTs;
- All extension workers and agricultural researchers should be trained on basic use of computers and Internet;
- An information day should be set aside to create awareness of information in the country;
- The government needs to formulate a comprehensive ICT policy;
- Satellite and VSAT should be used to facilitate diffusion of ICTs in the rural areas;
- The government should strive to improve telecommunications facilities in the rural areas;
- The ministry of energy requires to scale up rural electrification programme to reach the last mile;
- Portable generator should be used in the rural areas in the absence of electricity and
- The is need for the government to upgrade the Government Information Technology services into a fully fledged ministry with the mandate of managing ICTs adoption and diffusion in the country.

6.4 Summary

This chapter was divided into two sections. The first section presented data obtained from agricultural researchers and extension workers. The characteristics of agricultural researchers and extension workers in relation to age, gender, highest qualifications, their positions and departments where they worked are described. The findings indicate that agricultural researchers were distributed in the ages of twenty and fifty years, while extension workers were concentrated in the ages of thirty and forty nine years. It was found out that agriculture and extension work were male-dominated professions. It was further observed that agricultural researchers and extension workers were professionally trained for their respective work.

The findings indicate that the respondents had a critical need for information to enable them carry out their research and extension work. They needed information on policies and meteorology in addition to information relating to their nature of work. It was found out that ICTs had facilitated communication of agricultural information among the respondents. The most available ICTs tools and services to agricultural researchers were telephones, computers, Internet and email services, mobile phones, television, radio and video. The most available ICT tools to extension workers included the land-line telephone, the mobile phone, television, radio and video.

The most effective ICTs tools and services to agricultural researchers were the email, telephone, mobile phones, television, radio and video, while extension workers found television, radio, and video as effective in communicating agricultural information. Both agricultural researchers and extension workers expressed the need for more training on use of computers, Internet and email services, and electronic sources.

Section two of this chapter presented the data obtained from the key informants of the study. These included policy makers, IT personnel and librarians. They were drawn from all the institutions surveyed. The findings indicate that a variety of ICT tools and services were available in the institutions surveyed. These ranged from computers, the Internet and email services, telephones, fax, fully equipped radio studios, editing suites, tape recorders, radio cassettes, television, VCR, video cameras, sound craft, printers, scanners, mixers among others. It was found out that most of these facilities were acquired through donations and some were now obsolete but lack of funds made it difficult to replace them.

It was also observed that effort had been made to train the staff on use of ICTs, but more training was needed especially in regard to extension workers. The training of staff is hindered by lack of adequate IT personnel. There was also need to re-train policy makers to appreciate the use of ICTs in their respective institutions. Librarians and IT staff required frequent training to keep themselves abreast with ICT trends and developments. It was found out that libraries provided a range of services and that the majority were partially automated using WINISIS text retrieval software. It was, furthermore, observed that the district agricultural offices had no libraries.

The diffusion of ICTs among the institutions surveyed was hindered by lack of a comprehensive ICT policy at both the national and institutional level. Due to the absence of a national policy, co-ordination of ICTs was scattered in the three government ministries. The findings indicate that the myriad of problems facing ICTs diffusion was a result of lack of ICTs policies. Other constraints and challenges affecting the use of ICTs were inadequate funding, non-availability of ICTs, poor infrastructure and lack of technical know-how. It was suggested that all stakeholders in the agricultural sector should collaborate more and try to address the constraints affecting the application and use of ICTs.

The next chapter presents discussions of the findings.

CHAPTER SEVEN

DISCUSSION OF FINDINGS

7.1 Introduction

This chapter discusses the findings obtained through four sets of data collection instruments. This included a questionnaire, the interview schedule, observation and document review. The questionnaire was used to solicit information from agricultural researchers and extension workers, while three types of interview schedules were used to obtain information from the informants of the study. The two main data collection instruments were supplemented by observation and document review. Attempt has been made to collate the findings obtained from these instruments and draw some correlation and comparison in line with the objectives of the study. The discussions include characteristics and information needs of the respondents; nature, types and distribution of ICTs; effectiveness of ICTs; ICTs skills and competencies; training on use of ICTs; ICT policy and regulatory framework; ICT funding and sustainability; and challenges encountered in harnessing ICTs.

7.2 Characteristics of the respondents

Agricultural researchers were distributed in the ages of between twenty and fifty-five years of age, while the extension workers were clustered in the age bracket of thirty to forty-nine years of age. It was established that the ministry of agriculture had been affected by the rationalization of public service staff under the Structural Adjustment Programme (SAP). Consequently, a number of extension workers had been retrenched alongside other public service staff. Since the government had frozen employment of new staff, the ministry was unable to recruit new extension workers. This explains why there were no extension workers in the age bracket of twenty and twenty-nine and at the age of fifty years.

The Kenya Agricultural Research Institute (KARI) being a semi-autonomous institution was less affected by SAP. It was found out that although retrenchment had been done it was confined to the lower cadre of staff, and this did not affect employment of researchers. This explains why agricultural researchers were distributed in the four categories of age brackets.

The findings indicate that agricultural research and extension work in the public agricultural sector in Kenya is a male-dominated profession. Of the agricultural researchers, 64% were male and 36% were female, while 71% of extension workers were male and 29% were female. The findings concur with an earlier study by Ojiambo (1989:74) which found out that among the agricultural researchers, 73.8% were male and 26% were female, while 78.1% of the extension workers were male and 21.8% were female. From the statistics it can be seen that in a span of fourteen years since the study was carried out, the male domination has continued in the two professions. Gender disparity among professions in Kenya is attributed partly to the education system and partly to factors inherent in the society at large (Majanja and Kiplang'at 2003:71). Several studies and policy documents have observed that the majority of the female students in tertiary institutions often opt for arts courses as opposed to science related courses (Kenya, National Development Plan 2002, Mweseli 2001, Olweya 1996). As a result professions such as agricultural research and extension work often end up with fewer female professions.

The agricultural researchers were highly qualified for their jobs as 79.1% had masters and Ph.D. degrees. They were also trained in specialised fields of agriculture, such as crop sciences, crop and animal pathology, horticulture, soil sciences, agronomy, range ecology among others. The findings indicate an improvement in the educational qualifications of the respondents compared to 50.8% who had the same qualifications by 1989 (Ojiambo 1989). Of the respondents, 52.7% obtained their qualifications abroad, while 47.3% were trained locally in Kenya.

Similarly, the education level of extension workers had improved considerably with 65.4% having bachelors degree as opposed to diploma and certificate qualifications reported by an earlier study (Ojiambo 1989). Unlike agricultural researchers, the majority (91.1%) of extension workers were trained in Kenya. The extension workers had received training in diversified areas that include animal production, farm management, home economics, crop production, horticulture, farm machinery and dairy technology among others.

The agricultural researchers held the positions ranging from that of centre director to assistant research officer. On the other hand, the extension workers held positions ranging from District Agricultural Livestock and Extension Officer (DALEO) to frontline extension worker at the locational level. They also worked in various departments in their respective institutions.

The nature of work of the agricultural researchers ranged from agronomist, plant and animal breeder, pathologist, entomologist, soil scientist, horticulturist, social-economist, GIS expert among others. Similarly, extension workers were deployed to district and divisional agricultural offices as subject matter specialists in livestock, poultry, crop production, soil science, horticulture, bee keeping, to home economics, among many others.

7.3 Availability and accessibility of ICT tools and services

It was found out that a variety of ICTs tools and services were available in the institutions surveyed. These ranged from radio, tape recorders, television, video cameras, VCR, computers, Internet and email, telephone, mobile phones, fax among others. The most available ICTs tools and services to agricultural researchers were telephone, computers, email, fax, mobile phone and Internet in that order. It was established that out of 21 KARI research centres, 15 had Internet and email services, 5 had email services only while 1 centre had none of the services. All the centres had telephone services, while fax services were available in all except Molo research centre. Computers were also available in all centres and the number ranged from 3 to 91 per centre. Several initiatives had been made to enhance the use of mobile phones by agricultural researchers. At the KARI headquarters 4 mobile phones lines had been installed in the main PABX telephone system, while a selected key researchers at Kakamega and Kitale research centres, had been given official mobile phones and were getting a monthly allowance for airtime credit.

The fact that ICTs were available was not a guarantee that they were accessible to the respondents. For example, while the Internet was available to 71.7% of agricultural researchers only 37.7% were able to access the facility. Email was available to 94.3% of the respondents but only 69.8% were able to access it. In many instances, therefore, accessibility to ICTs was relatively low compared to the availability. This anomaly was contributed by many factors. Among these are the lack of skills, poor attitude towards ICTs, high costs, low bandwidth, and inaccessibility to ICTs due to bureaucracy. It was observed that poor telecommunication infrastructure often increased the costs and put a lot of pressure on the users. Because of congestion caused by low bandwidth the lines were slow and at times failed to connect. It was further observed that some of the respondents were slow in learning how to use ICTs especially computers, the Internet and email. One respondent posited that "some colleagues have never tried using computer for word-processing leave alone email and the Internet." The findings concur with other studies that have identified lack of skills and poor attitude as the greatest barrier to ICT diffusion (Cullen 2001:5, Pigato 2001:7).

The mobile phone was available to 75.5% of agricultural researchers and was accessible to 66% of the respondents. It is difficult to explain the disparity as most of the respondents had personal mobile phones, while only a few had been given official mobile phones. It suffices to say that physical access includes costs of accessing ICTs. It could be implied therefore that the slight disparity maybe attributed to costs of airtime credit that hindered a number of respondents from using their mobile phones. In other words although the mobile phones were available, a number of respondents were not in a position to use due to costs of airtime credit.

In regard to extension workers, the most available ICTs were the land-line telephone, radio, mobile phone and fax in that order. It was established that the telephone and radio were available and accessible to the majority of the extension workers. Most of the agricultural offices had telephone facilities. Radio was also available and was frequently used to broadcast agricultural programmes to radio listening groups. Mobile phones were reported to be a convenient mode of communication in extension service as indicated by 58% of respondents. The extension workers were required to visit several farmers in a day and often used their mobile phones to make appointments with the farmers. It was observed that farmers frequently used mobile phones to consult extension workers on matters that needed instant response. This is supported by Obijifor (1999:161) who argues that Africans are strongly networked culturally and prefer oral communication that provides immediate feedback. He suggests that the mobile phone could be the technology for the future as it embraces the African mode of communication. Pigato (2001) further observes that the mobile phone has been developing rapidly in spite of the poor physical telecommunications infrastructure in the rural areas. The author is of the view that it has the potential to connect the geographical dispersed population in the rural areas.

Availability and accessibility of land-line telephone and the mobile phone had more or less similar responses from extension workers. The land-line telephone was available to 84.6% of respondents, and accessible to 73.5% of respondents. It was observed that due to high costs of sustaining telephone lines, officers in charge of agricultural offices restricted staff from making unnecessary calls unless they were official and urgent. In regard to mobile phones, 58.9% said they were available, while 53% observe that they were accessible. The radio was available to 69.1% and accessible to 37.5%. Only one radio was available in most of the agricultural offices to be shared among many radio listening groups. One respondent remarked that "radios are now relatively cheap and I do not understand why the office cannot purchase enough to cater for all the listening groups." The fax was available to 53.7% of the respondents and accessible to only 31.6%. Although the fax was available in most of the centres and agricultural offices it was strictly used to send urgent and vital official documents.

It was observed that the Internet and email services were inaccessible to the majority of extension workers. Although the ministry of agriculture headquarters had five Internet access points, they were restricted to only staff working in those offices. At the Uasin

Gishu district agricultural office, the Internet and email was sparingly used due to high costs of sustainability and lack of adequate funds. Besides, the facility was in the office of the District Agricultural Livestock and Extension Officer (DALEO) and this limited accessibility of the service. Baringo district agricultural office had neither the Internet nor email.

Agricultural libraries and information centres in the institutions surveyed had a range of ICTs tools and services including computers, Internet and email services, CD-ROM databases, electronic journals, audio-visual materials, and in-house databases among others. Most of the libraries had partially automated their services using WINISIS text retrieval software. In most cases the libraries worked closely with the Information and Technology (IT) department. For example at KARI, the IT section was part of the Information Services Division headed by a librarian, while at the ministry of agriculture, the computer resource centre shared the same floor with the library and often consulted on issues related to ICTs.

7.4 Information needs of agricultural researchers and extension workers

Both agricultural researchers and extension workers had critical need for information that was specific to the nature of their work. This includes information on agronomy, seed technology, soil science, horticulture, plant pathology, bee keeping, dairy cattle and goats, poultry, agricultural marketing, crop protection, among many others. They also expressed need for information on agricultural policies and meteorology. The agricultural policies were important to researchers and extension workers as they provided guideline on issues affecting research and extension work. For example, the Agricultural input policy ensures that adequate and quality inputs are made available to farmers and that, to the greatest extent possible, they are used at the right time and in correct quantities. The Kenya government has, therefore, formulated various agricultural policies to regulate research and extension work. The policies include Sessional Paper No.2 of 1994 on National Food Policy, Agricultural input policy, the National Agricultural Extension Policy among others.

Meteorological information is quite crucial to agricultural researchers and extension workers. For example, agricultural researchers need information on the climate and weather patterns to assist in planning for their research. Extension workers, on the other hand, need to advise farmers on when to plant. It was observed that KARI attaches a lot of value to meteorological information since research is depended on it. Consequently, it has installed agro-climatological instruments at Njoro, Kiboko and Msabaha research centres to collect weather information from the respective regions. Once the information is collected it is relayed to KARI headquarters via the satellite, which in turn is relayed to all KARI research centres and also to the Kenya Meteorological Department.

7.4.1 Extent to which information needs of the respondents were met through ICTs

Attempt was made to find out whether the information needs of agricultural researchers and extension workers were met through ICTs. A significant number (71.7%) of agricultural researchers were of the view that the Internet and CD-ROM databases provided information relevant to their needs, while most (71.3%) of the extension workers observed that the information was not useful. This contrast is attributed to the level of skills development and physical access to ICTs by the two categories of respondents. While the majority of agricultural researchers were computer literate and had access to the Internet and CD-ROM databases, most of the extension workers lacked basic skills and access. These findings concur with Adupa and Asaba (2003) who investigated the use of electronic agricultural information among the telecentres in Uganda and found out that information retrieval technicalities such as lack of skills and technophobia had hindered the use of the telecentres.

It was observed that KARI was a beneficiary of free access to electronic journals courtesy of the International Access to Scientific Publication (INASP) project through its Programme for the Enhancement of Research Information (PERI). Through this project agricultural researchers were able to access the African Journals Online (AJOL). They were also able to access 600 journals through INASP and Blackwell Synergy project and 5500 full-text journals from EBSCO Host seven databases. The availability of electronic journals enabled the information needs of agricultural researchers to be fulfilled. In addition most KARI research centres provided Internet and email services free of charge. Agricultural researchers had, therefore, unlimited access to these facilities. These factors explain why agricultural researcher's information needs were better fulfilled than those of the extension workers.

KARI also had a variety of CD-ROM databases. The Essential Electronic Library (TEEAL) CD-ROM database had the most relevant content with over 750,000 pages of articles drawn from 141 journals. The database covers a wide range of subjects that include: crop production, plant diseases, farm mechanics, tillage and soils, agricultural economics, natural resources, the environment, food science, animal and human nutrition, forestry, genetic resources and breeding and tropical plants. The content corresponds to the area of research of most agricultural researchers. Crop Protection Compendium which is multimedia encyclopaedic CD-ROM database with information of over 1560 pests on 180 crops had relevant content for agricultural researchers and extension workers. The databases were available in all KARI research centres and its content had proved useful to most of the agricultural researchers.

KARI had also created an in-house database containing researches that had been conducted in Kenya since 1910. The database has more that 50,000 records and is distributed offline to all KARI research centres. The database had information on local content and agricultural researchers found it very useful.

In regard to extension workers, the majority lacked physical access to Internet and CD-ROM databases. They relied mostly (100%) on printed sources of information such as handbooks, pamphlets, newsletters, brochures, leaflets and other extension materials produced by the Agricultural Information Centre (AIC). Informal discussions with the respondents revealed that they also depend on seminars, workshops and monthly consultative meetings. Similarly, agricultural researchers (90.6%) also reported that they used printed sources of information to complement the information they obtain via the Internet and CD-ROM databases. The respondents also obtained their information through the media such as radio, television and newspapers. Recently the Kenya

Agricultural Commodity Exchange (KACE) partnered with Safaricom mobile subscriber to provide marketing information on agricultural products. This is an additional source of information for extension workers especially those based in the rural areas.

7.4.2 ICTs and content

Most (71.7%) of the agricultural researchers were of the view that the Internet and CD-ROM databases had useful content, while significant number (71.3%) of extension workers said it was not useful. This contrast is attributed to the level of skills development and physical access to ICTs by the two groups of respondents. While the majority of agricultural researchers were computer literate and had access to the Internet and CD-ROM databases, the majority of extension workers lacked basic skills and access to these facilities. It can be deduced from the findings that there is a need to generate relevant and useful content in appropriate format and medium for all actors in the agricultural sector. Secondly, is the issue of skills development among the users which is of prime importance if ICTs capabilities are to be leveraged in the agricultural sector.

The ministry of agriculture needs to emulate KARI and create in-house databases containing researches conducted locally in Kenya. KARI and the ministry can then merge their databases to provide a comprehensive content relevant to all actors in the agricultural sector. Caspary (2002:4) gives an example of 'info shops' in Pondicherry, India which had developed responsive local content for farmers. The farmers participated in developing the database which contains information on cost and availability of farm inputs such as seeds, fertilizers, grain; pest management; directory of local veterinarians among other information. As a result of farmers, researchers and extension workers participation, it was possible to create relevant content to agricultural community in Pondicherry. It is, therefore, important for agricultural researchers and extension workers to participate in developing content that is responsive to their information needs.

7.4.3 Use of ICTs tools and services

The majority of agricultural researchers used ICTs to communicate among themselves, for research purposes, and to disseminate agricultural information. A large number

(71.7%) used ICTs to communicate with extension workers. On the other hand, a significant number of extension workers used ICTs to communicate with the farmers and among themselves. Ironically, only 35.3% of extension workers used ICTs to communicate with agricultural researchers. One would have expected ICTs to enhance the communication between agricultural researchers and extension workers. Besides, the two subsystems are supposed to work more closely together in transmitting new knowledge of farm technology to farmers and getting feedback.

During informal discussions with extension workers it was established that other constraints contributed to infrequent communication between extension and research subsystems. These include the following:

- While agricultural researchers had access to the Internet and email services, the majority of extension workers lacked physical access to these services.

- Research centres are usually located at a distance from most extension operations and only those extension workers working around research centres were able to gain frequent contacts with agricultural researchers.

- Agricultural researchers do not often go into the fields where they would meet extension workers.

- Extension workers and agricultural researchers do not meet frequently

- The monthly stakeholders meeting were not providing adequate forum to share knowledge and experiences among extension workers and agricultural researchers

Extension workers were of the view that agricultural researchers often disregard them as inferior and do not involve them in activities where they can contribute. ICTs can only improve communication of agricultural information, if there is a good working relationship between agricultural researchers and extension workers. In essence, ICTs alone cannot transform communication of agricultural information without the interventions and interactions of all the stakeholders in the agricultural sector.

However, agricultural researchers (94.3%) and extension workers (77.9%) perceived ICTs as having facilitated communication of agricultural information among and between all actors in agricultural production. They observed that as a result of using ICTs their work productivity and creativity had increased.

7.5 Effectiveness of ICTs in dissemination of agricultural information

Agricultural researchers found the radio, email, television, video, and mobile phone as very effective in disseminating agricultural information. Equally effective were the telephone, the Internet, and desktop publishing. The least effective were fax mode, GIS, and electronic journals. On the other hand, extension workers found the radio, television and video as very effective in disseminating agricultural information. They also ranked the mobile phone as effective and desktop publishing as less effective. The least effective were the Internet, email, telephone, GIS, fax and electronic journals.

Radio and television were used widely by agricultural researchers and extension workers to disseminate agricultural information to the farming community. A variety of programmes had been recorded in the national language, Kiswahili, and also in vernacular languages. The programmes contained messages on technological and agricultural development issues and were transmitted via the national radio and TV station (KBC) and also through the private radio and TV stations (see chapter 6 section 6.11.1). Among the popular Kiswahili radio and programmes are *sikio la mkulima* and *tembea na majira*, while popular TV programmes are agricultural documentaries and sahiwal cattle.

The radio was ranked high by both agricultural researchers (79.2%) and extension workers (89.7%). It was the most used ICT tool to disseminate agricultural information to the farmers. Besides, the radio is quite cheap and portable and farmers can easily carry it anywhere. It is now common in Kenya for farmers to listen to their radios while working in their farms. Radios do not need electricity as farmers can use transistor battery. With the liberalization of the airwaves and regulatory environment in the country, many rural radio stations have been established in all major towns. The Ministry of agriculture through the Agricultural Information Centre (AIC) has exploited this listernership by using the agricultural radio slot to include technological information and other information concerning agricultural development. This has enabled most of the farmers to access many channels and listen to agricultural and marketing information transmitted in both the national language Kiswahili, and in vernacular. These findings concur with Oguya (2001:78) who observes that private radio and TV stations were mushrooming in Kenya and vernacular languages were being used to broadcast agricultural programmes and this had made it possible for messages to penetrate to the remotest parts of Kenya.

Various methods were used to ensure that agricultural programmes had the relevant content for the farmers. For example, integration of radio and telephone was used during radio talks and interviews with subject matter specialists. During these programmes farmers are encouraged to call and ask questions and subject matter specialists at the studio provide instant response. Another programme is the question and answer sessions where farmers send cheap post cards with questions and subject matter specialists at the studio respond to these questions accordingly. This interaction indicates that the radio has more potential if it is integrated with other ICTs. Odame and Kassam (2002) in their study on linking agricultural researchers and broadcasters identified several advantages of rural radio. Firstly is the sharing of research findings across long distances in languages and terminologies familiar to the audiences. Secondly, live discussions can be held with farmers to obtain their feedback on technologies disseminated to them. Thirdly, the radio can relay disaster preparedness, weather and market information. The only shortcoming of the radio is timing of broadcast which may not be appropriate to all listeners.

Television was also ranked high by both agricultural researchers (75.4%) and extension workers (89.8%). The ministry of agriculture through the Agricultural Information Centre (AIC) has developed many television programmes and has slots in the national and private TV stations for disseminating agricultural information. The programmes usually portray more concrete information in audio-visual form of information and builds solid knowledge among farmers. The farmers have found the programmes to be educative, captivating and lively especially those in form of plays. Most of the farmers in Kenya now own black and white televisions that use car battery (Oguya 2001:79).

The cost of developing radio and TV programmes is high and the ministry of agriculture usually collaborates with agro-chemical industry who sometimes dictates the terms to suit their products. In other words, they sponsor the programmes but take advantage to also market their products negating the spirit of liberalization.

The video was also mentioned by both the agricultural researchers (67.9%) and extension workers (89.8%) as effective in disseminating agricultural information. Many video programmes had been produced by the ministry of agriculture and KARI. The Non Governmental Organizations (NGOs), Community Based Organizations (CBOs), Churches and Agro-Chemical industries participate in the production of agricultural video programmes. Examples of videos produced by the Uasin Gishu district agricultural office in collaboration with a church organization called Goods News Production International Africa are: Wise use of water; Safe cooking stove; Mables' garden secrets; Plant health; new varieties of nutritious vegetables among others. The videos are part of the Church Resource Library Development Series. An NGO called Regional Reach is also collaborating with the ministry of agriculture in distributing and showing agricultural video programmes at market places in the villages. Regional Reach provides television and VCR, while the ministry of agriculture provides the videos and the technical support. It has worked very well and farmers seem to like it. It is said that a picture is worth a thousand words.

Agricultural researchers (62.3%) and extension workers (53.7%) rated the mobile phone as effective in disseminating agricultural information. Use of mobile phones is growing very fast in Kenya. By June 2003 mobile subscribers had reached 2.5 million of the population which is about 20% of the adult population in Kenya. The number of mobile phones is bypassing the landline fixed telephones. It is dominating interpersonal communication in the rural areas and SMS is becoming a favoured niche medium. As already mentioned agricultural researchers and extension workers use mobile phone to communicate among themselves, with the stakeholders and the farmers. Some KARI research centres had made arrangement to purchase mobile phones for the selected key officers. These officers were also given monthly allowances for airtime credit. Similarly, the ministry of agriculture was making arrangements to purchase mobile phones for all the district agricultural extension officers and other key officers at the district level. Companies in the private sector are also supporting the use of mobile phones in one way or the other. As reported earlier, the Kenya Agricultural Commodity Exchange has partnered with Safaricom mobile subscriber to provide agricultural market information. All the subscribers of Safaricom can now access this information from their mobile phones.

A large number (75.5%) of agricultural researchers ranked email as effective in disseminating agricultural information. This corresponds with the findings of the key informants of the study which indicates that out of 21 KARI research centres, 20 had email services. In addition KARI headquarters provided email address in its Local Area Network (LAN). All the staff can access email and Internet from their desk. It was only Kibos research centre that did not have email connection. Email was used for many purposes including: communicating with colleagues; consulting on issues related to the respondents work activities; disseminating agricultural information; and for research purposes through the CTA Question and Answer Service (QAS). The QAS is where users complete a questionnaire requesting information and this is then transmitted electronically to other nodes that may be in a position to provide the information. Email was also found to be a useful tool for collaborative projects among agricultural researchers within ASARECA (Association for Strengthening of Agricultural Research in Eastern and Central Africa) member countries. KARI researchers had also benefited from Africa-link project funded by USAID providing support for dialup Internet and email connections for African researchers.

The extension workers ranked email as less effective in disseminating agricultural information. It was found out that the majority of extension workers were shying away from using the email and Internet because of lack of physical access and requisite skills. The Internet was ranked by agricultural researchers as effective in disseminating agricultural information. It was observed that researchers used the Internet current awareness tools to keep abreast of new trends and developments in their area of research.

Although CD-ROM allows enormous storage of agricultural information which can be disseminated offline, the majority of agricultural researchers and extension workers rated it as not effective. CD-ROM is appropriate for information and knowledge which does not change quickly, and is not frequently consulted. Many agricultural organizations in Kenya are now producing their own CD-ROMs, by capitalizing on the information, knowledge and experience of their staff. The International Livestock Research Institute (ILRI), The World Agro forestry Research Centre (ICRAF) and International Centre for Insect Physiology and Ecology (ICIPE) are among research institutions that have produced CD-ROMs on agricultural information. ICIPE has produced a CD-ROM on pest management, while ILRI has produced several CDs on Livestock health. ICRAF has produced CD-ROM such as TREECD, AGROFORETREE, and Botanical Nomenclature among others. These CD-ROM databases have been widely circulated among the research institutions in the country. The problem is creating awareness and imparting the necessary skills to agricultural researchers and extension workers. It was observed that the majority of respondents lack skills to effectively use CD-ROM databases. During field visit the investigator was requested by one of the agricultural researchers to demonstrate how to use a CD-ROM database. The agricultural researcher often receives CD-ROM databases from various agricultural research institutes but lack the skills to use the databases.

In Kenya, attempt has been made to integrate the different types of ICTs platforms in an effort to enhance the effectiveness of ICTs in disseminating agricultural information. An example is an NGO called DrumNet that provides marketing and financial services for agricultural entrepreneurs through simple, stand-alone facilities called info-kiosks (Groh 2003:3). The info-kiosks cater for clients who require financial, market and technical information in order to make more profitable transactions. Each info-kiosk is equipped with a computer and dial-up connection to the internet and a mobile phone (GSM) to link up with the central hub in Nairobi (capital city). The hub acts as the main server/database and provides an access centre for the storage and retrieval of information. Each kiosk is managed by an 'info-broker', usually a member of the local community, who collects and disseminates information, assists in forming farmer groups, and arranges to buy and sell the deals. This project demonstrates the potential of integrating computers, mobile phone and the Internet in dissemination of agricultural information. It also indicates the participation of the private sector in research and extension activities, which have increased the actors in research and extension and created pluralistic information flows.

The effectiveness of ICTs in dissemination of agricultural information depends on factors such as information to be disseminated, the target audience, the timeliness and use of the information. For example information on early warning and disaster preparedness was best disseminated through radio so as to reach a wider population of farming community. The effectiveness also depended on accessibility and e-readiness levels of each group. For example, a poor illiterate smallholder farmer may be able to only access radio, a literate smallholder a pamphlet and a post card to interact with the radio broadcaster. Likewise access to ICTs is different for each of the categories of extension workers and agricultural researchers. The factors that make each individual or group to choose a particular technology depends on availability, appropriateness and competencies and skills to use.

7.6 ICTs skills and competencies among agricultural researchers and extension workers

The findings indicate that 75.5% of agricultural researchers had good computer skills. This is supported by the mean score of 3.3, the highest mean score being 5.0 and the lowest being 1.0. On the other hand, an average number (50%) of respondents had good Internet skills. This corroborates the findings obtained from the key informants who indicate that KARI had organized several in-house training courses on use of the Internet, email, CD-ROM and in-house developed databases.

It was observed that agricultural researchers who were based in research centres located far from the urban centres were disadvantaged in their exploitation of ICTs. This was due to poor Internet connectivity caused by low bandwidth and unreliable ISP connection. As a result most of the centres had opted to have the email facility only.

Of the extension workers, 39% had poor computer skills. This was supported by the mean score of 2.11, highest mean score being 5.0 and lowest being 1.0. Similarly, over half (52.2%) had poor Internet skills with a mean score of 1.53. The poor skills are attributed to lack of physical access to computers and the internet. Most of those affected were extension workers based at the divisional agricultural offices. None of these offices had computers and the respondents were forced to travel to their respective district agricultural offices whenever they required to use the facilities. It was observed that most of the rural areas had poor infrastructure in terms of roads, telephones and even electricity. This hindered the adoption and use of ICTs. The most affected area was Baringo district which is a semi-arid land.

7.6.1 Gender and ICTs skills

Cullen (2001:5) in her study of the disadvantaged communities in New Zealand established that the interaction of factors such as cost, restricting access to equipment, low educational achievement, culture, age, and gender counteracts against dissemination of computer and technological skills. The present study investigated whether age and gender had any influence on the acquisition of ICT skills by agricultural researchers and extension workers. It further sought to establish whether the country in which the respondents obtained their qualifications influences on the use of ICTs. A Study by Ayoo (2001) found out that researchers who trained abroad (developed countries) were likely to use more of the Internet and email than those trained locally in Kenya.

With regard to gender, 73.7% and 68.4% of female agricultural researchers had good computer and Internet skills respectively. Similarly, 76.5% and 70.6% of male agricultural researchers had good computer and Internet skills respectively. The findings indicate that there was no much disparity in the acquisition of computer and Internet skills among male and female agricultural researchers. The findings disagree with studies that have tended to generalize that women are marginalized in their uptake of ICTs (Ngenge 2002, Hafkin and Odame 2002, Cullen 2001). Although this may be true of rural women, it may not apply to professional women such as agricultural researchers the majority of whom have equal access to ICTs as their male counterparts.

In regard to female extension workers, 82.5% and 84.5% had poor computer and Internet skills respectively. Similarly, 62.5% and 63.6% of male extension workers had poor computer and Internet skills respectively. Evidently, women extension workers seem to be slightly marginalized as compared to their male counterparts in their acquisition of ICT skills. Since most of the extension workers had no access to the Internet in their offices, they depended on commercial Internet cafes in the nearest urban centres. Informal discussions with some of the female extension workers revealed that the majority had no time to visit the cyber cafés, given the multiple and heavy domestic responsibilities. They pointed out that by the time they were through with the farmers it was too late to do any other thing. Besides, they had to rush home to prepare meals for their children and husbands. In contrast, male extension workers had more leisure time and could afford to pass through the cyber cafés to browse. The female extension workers also argued that some cyber cafés were located in places that were not safe to visit in the evening. The findings concur with a study by Hafkin and Odame (2002) which found out that women in the rural areas tend to have less access than men to those ICTs facilities that already exist. The cited authors observed that some rural information centres or cyber cafés are located in places that women may not be comfortable to pass by.

7.6.2 Age and ICTs skills

Concerning age, the findings indicate that an equal number of agricultural researchers (50%) in the age bracket of twenty to twenty nine years had good and poor computer skills respectively. In the age bracket of thirty to thirty nine years, the majority (85.7%) had good computer skills. While in the age bracket of forty and forty nine years, 84.6%

had good computer skills. In contrast, 57.1% of those over fifty years of age had poor computer skills.

Similarly, an equal number (50%) of agricultural researchers in the age bracket of twenty to twenty nine years had good and poor Internet skills respectively. While 55% in the age bracket of thirty and thirty nine years had good Internet skills. In the age bracket of forty to forty nine years 57.7% had good Internet skills. In contrast, 71.4% of those over fifty years had poor Internet skills. The findings indicate that there is a correlation between the age of the respondents and the acquisition of ICT skills. Agricultural researchers who were over fifty years of age had problems in learning and gaining the requisite computer and Internet skills. For example, while the majority of those in the lower age brackets had good computing and Internet skills, most of those who were over fifty years had poor computing and Internet skills. The findings concur with a study by Ayoo (2001) who found out that industrial researchers who had advanced in age had problems in using the Internet because they lacked the basic skills. There is a common phrase that says "it is difficult to teach an old donkey new tricks." People who are advanced in age are more resistant to change because they no longer like things that remove them from the known to unknown.

With the focus on extension workers, 78.2% in the age bracket of thirty to thirty nine years had poor computer skills. Similarly, 71.1% in the age bracket of forty and forty nine years had poor computer skills. In regard to the Internet, most (82.1%) of the extension workers in the age bracket of thirty to thirty nine years had poor Internet skills. Similarly, 83.1% of those who were in the age bracket of forty and forty nine years had poor Internet skills. The extension workers lacked physical access to ICTs and may not provide a clear indication as to whether age had any influence on the acquisition of ICT skills. If the technology is not accessible it is difficult to learn or gain any skills as it depends on hands-on experience.

7.6.3 Country of qualifications and ICTs skills

It was found out that over half (52.7%) of agricultural researchers were trained abroad while 47.7% were trained locally. The majority (86%)of those trained abroad had good computer skills. Similarly, 72% of those trained locally in Kenya had good computing skills. In regard to the Internet, 64% of those trained locally in Kenya had poor Internet skills, in contrast, 60.7% of those trained abroad had good Internet skills. The findings concur with studies by Ayoo (2001) and Mugwisi (2003) that investigated the use of Internet by researchers and academicians in Kenya, Zimbabwe and South Africa respectively and found out that there was a significant difference in ICTs skills among researchers trained abroad (developed countries) and those trained locally in their countries. Those trained abroad exhibited better Internet skills and this was attributed to exposure to adequate Internet facilities at their respective universities abroad (developed Countries).

The majority (91.1%) of extension workers were trained locally in Kenya and out of this 68.5% had poor computer skills. An equal number (50%) of those trained abroad had good and poor computer skills respectively. In regard to the Internet, 78.7% of those trained locally in Kenya had poor Internet skills compared to 66.7% of those trained abroad who had good Internet skills. This strengthens the argument that professionals trained abroad usually exhibit better ICTs skills than those trained locally in their African countries. This is attributed to good exposure to ICT facilities in those countries that enabled them to have adequate hands-on experience.

7.7 Training on use of ICTs

Although KARI had organized several in-house training courses on use of ICTs, most (69.8%) of the agricultural researchers had learnt to use computers and the Internet through self-study. Only 32.1% and 9.4% learnt through in-house courses offered by the institution and the library respectively. The respondents argued that the in-house training had not catered for all the researchers especially those based in research centres that were located far away from the headquarters. On the other hand, the Ministry of Agriculture through the computer resource department was offering in-house training on use of ICTs to their staff at the headquarters. It was noted that the training suffered from poor coordination and was lacking in focus. At the district level, it was only at the Uasin Gishu district agricultural office where training had been organized for the extension workers. This was done through the efforts of the District Agricultural and Livestock Extension Officer (DALEO) who used very scarce resources not only to train the staff but also to buy computers and connect to the Internet. Because of lack of adequate funds training was confined to extension workers at the district agricultural office leaving out those at the divisional offices. The extension workers at the district agricultural office opted to forgo their allowances to subsidize the cost of training. Private consultants were contracted to offer the training. This is a clear indication of the willingness and cooperation of policy makers and their staff in finding solutions to problems that hinder them from adopting and using ICTs.

Overall, the majority (96%) of extension workers expressed the desire for in-house training on use of ICTs. They observed that this should be organized for all the staff at divisional agricultural offices. They needed basic skills to use almost all types of ICTs ranging from computers, electronic sources, and the Internet. There is an urgent need, therefore, for the ministry of agriculture to address the training needs of extension workers. The few extension workers and the majority of agricultural researchers who already had some basic computing and Internet skills observed that they needed more training to uplift their skills and keep abreast with new technological changes. For example (88.7%) of agricultural researchers 88.7% needed training on use of electronic sources and the Internet respectively.

7.8 ICT Policy and Regulatory Framework

The Kenya government is a member of the African Information Society Initiative (AISI) established in 1996 with a mandate of providing connectivity and electro access to information for all citizens of Africa (Zongo 2001:5). Through this initiative the government has started the design and implementation of the National Information and Communication Infrastructure (NICI) and has set up a task force to prepare a comprehensive national ICT policy. The Government recognizes, therefore, that full benefits and gains of ICTs can be realized if there is a comprehensive ICT policy to govern the orderly development of the sector (Kenya, Republic of 2002:110). Such a policy will also address among others, issues concerning technological convergence.

It was noted that the ICT sector in Kenya had witnessed several reforms over the last few years. Key amongst them is the liberalization, privatization and tariff reform. In the 2003 budget the government waived all taxes on importation of computers and their accessories in an effort to improve diffusion of ICTs in the country.

It was observed that the government had started decentralizing the Government Information Technology Department located at the Ministry of Finance and charged with the responsibility of coordinating ICT development in all the government ministries. The staff have been deployed to all ministries including the Ministry of Agriculture to facilitate the establishment of IT department/section.

It was found out that fragmented policies existed at the institutional levels. The Ministry of Agriculture and KARI had ICT policies that guided the diffusion of ICTs in the two institutions. However, implementation of these policies were yet to be effective. This is attributed to lack of a back-up from a national policy and to some extent the lack of commitment by policy makers especially those at the ministry of agriculture. The argument is that a comprehensive national ICT policy is needed to guide in the development of basic infrastructure and create an enabling environment for ICT diffusion (Soltane 2002:7). It was found out that although significant progress had been made in the expansion and modernization of the country's information sector, substantial demands for basic services remain unmet and the disparity in the distribution of communication facilities between the rural and urban areas continues to widen (Kenya, Republic 2002). It was observed that the research centres and agricultural offices in the rural areas often lacked communication facilities to harness ICTs. It can be said, therefore, that lack of basic infrastructure is a major hindrance to the country's full participation in the information society.

It was noted that the government had come up with a policy to provide guidelines in the liberalization of the airwaves which have led to the proliferation of radio and television services in the media sector. This has diversified products in the print media including several radio broadcasting and television stations and a wide range of newspapers and magazines. As a result a wide variety of channels are now available for the dissemination of agricultural information to the farming community in Kenya.

The establishment of a countrywide 2MB Internet backbone popularly known as Jambonet with a hub in Nairobi and extending to all major towns including Mombasa, Kisumu, Nakuru, Eldoret, Nyeri has helped to facilitate points of presence in most parts of the country (Kenya, Republic of, National Development Plan 2002-2008:107). The district agricultural offices and KARI research centres situated near the major towns had no problem in connecting to the Internet. However, those located in small towns and in the rural areas had poor connectivity to the Internet and email. The government, therefore, needs to extend the backbone to smaller towns if it is to achieve universal access in the country.

It was found that both the national and institutional ICT policies were lacking in addressing the over-reliance on donor funded projects leading to low levels of sustainability. It was observed that a large percentage of ICTs initiative at KARI was supported by donor funding and it was difficult to sustain the services once the donor projects ended.

The existing policies had also failed to address the issue of human capacity building and training of the staff. For ICTs to be leveraged in the agricultural sector there is need for skill development among agricultural researchers and extension workers. As mentioned earlier, most of the agricultural researchers and extension workers need more training on use of ICTs. It was noted with concern that the few IT personnel were all stationed at the headquarters of KARI and the Ministry of Agriculture. None were at the research centres, district or divisional agricultural offices and maintenance of ICT facilities suffered considerably. These findings concurs with the research carried out by Pigato (2001:25) to investigate diffusion of ICTs in sub-Saharan Africa and South Asia, which found out that many locations outside capital cities lack technical support and often result in a significant amount of downtime when technical problems arise.

The policies at KARI and the Ministry of agriculture needed to bring about some institutional changes. Far greater tasks than putting in computers are the changes that need to occur within the research and extension service to strengthen and improve the function of the institution as a whole. For this to be realized there is need to understand the application and use of ICTs. To some extent KARI has tried to re-organize the services by installing a Local Area Network (LAN) and by re-training the staff on how to utilize the services effectively. This had worked well and improved the utilization of LAN to 90% at the headquarters and 50% at research centres where the network had been installed. This concurs with O'Farrell's (2003:26) observation that ICTs are transforming the way organizations interact with the employees and their clients and this adjustment of roles and responsibilities requires careful planning and an acceptance that the old ways have changed. On the other hand, the Ministry of agriculture was in the process of networking its offices at the headquarters and was trying to reorganize its services to suit the impending changes brought about by the new technology.

7.9 ICTs funding and sustainability

Despite the efforts to expand and modernize ICTs in the agricultural sector, its growth had been hampered by inadequate funding. This has slowed down the diffusion of ICTs among agricultural researchers and extension workers. Consequently, KARI and the Ministry of Agriculture had to contend with several constraints including inadequate ICT training and skills development, over-reliance of donor projects leading to low level of sustainability and inadequate ICTs tools and services. These findings concur with Pigato (2001:iii) who cautions that even when ICTs initiatives are successful and have brought measurable benefits, there remain issues of financial sustainability and how to ascertain what value "users" attach to services provided.

The centralized budgeting system at KARI and the Ministry of Agriculture was also a contributing factor towards inadequate funding. More often than not the budgets approved were a fraction of what had been presented. This meant that the research centres and agricultural offices had to contend with the basic provision of services. The ICT budget was usually the most affected as it was always reduced to a bare minimum to cater for only telephone services. Due to inadequate funding it was not possible to keep pace with the technology that was changing very fast. Obsolescence of ICTs was the order of the day. It was observed that the majority of computers and ICT equipment had been acquired through donor funding and most of them were now obsolete and needed to be replaced. An example of this, is the case of some of the equipment at the Agricultural Information Centre (AIC) which had been acquired ten years ago through donor funding and needed to be replaced. However, due to inadequate funds it was not possible to replace and the institution had to contend with minimal scale of operation.

The majority of agricultural researchers and extension workers felt that the computers, the Internet, email, electronic journals, CD-ROM, desktop publishing, fax and telephones were costly to acquire and maintain. The informants of the study also expressed the same views and observed further that there was need for a separate ICT budget to meet the high costs of acquisition and the fluctuating cost of maintenance and sustainability of the facilities. Agricultural researchers and extension workers felt that policy makers were not appreciating the use of ICTs and were the source for inadequate funding. They observed that the policy makers need to be re-trained so as to appreciate the efficiency and effectiveness of ICTs tools and services. This would instill awareness and motivate the policy makers to source for adequate funds for ICT development. In the long run this would hopefully create an enabling environment for ICTs diffusion.

The problem of sustainability was repeatedly mentioned by all categories of respondents. This was attributed to inadequate funding and lack of planning especially for donor funded projects. Once the donor projects end, there was often lack of commitment by the respective institutions to continue sustaining the services. Those managing the donor funded projects felt that their research centres often back off when the projects end leaving no option but to terminate the ICTs services. On the other hand, the policy makers argued that it was easier to sustain projects that had been initiated by the institution because of commitment to accomplish them. They observe that it was difficult to sustain the donor funded projects because often they were initiated without local demand and at times they were not given ample time to decide what was good for their institutions. Thus the policy makers lacked commitment to support some of the donor funded initiatives once they come to an end. These findings concur with those of Pigato (2001:24) and Munyua (2002:7) who observe that donor funded programs have tended to provide initial investment capital rather than maintenance and running costs and in most cases lacked local demand for ICT-based information. This corresponds with the findings of many donor funded projects at KARI and the ministry of agriculture which provided initial investment capital without giving much thought to sustainability of these projects. As a result the recurrent costs associated with maintenance have remained largely unmet.

7.10 Challenges encountered in harnessing ICTs

The respondents mentioned several constraints and challenges that affected diffusion of ICTs in the agricultural sector. Among the most mentioned was the inadequate funding that had also contributed to the non-availability of ICTs among agricultural researchers and extension workers. It was noted that ICT facilities were expensive and most of the institutions surveyed were often unable to meet the initial costs of acquiring some of the facilities. The institutions were, therefore, left at the mercy of willing donors to purchase the required facilities.

The lack of skills by the majority of respondents was a major constraint in harnessing ICTs in the agricultural sector. For the respondents to effectively use the ICT tools and services, they require hands-on experience which was not possible due to inadequate facilities. The most affected were the frontline extension workers at the divisional agricultural offices. In comparison, the majority of agricultural researchers were relatively better as they had a number of computers in their respective research centres.

Maintenance of ICTs was also mentioned as a constraint due to inadequate IT personnel. The few who had been employed were stationed at the headquarters of KARI and the Ministry of agriculture. This created a problem as the research centres and agricultural offices could not afford to contract private consultants to maintain their ICT facilities. Many computers and equipment which had broken down and could not be repaired were, therefore, rendered obsolete. It was noted further that in the absence of IT personnel it was difficult to have computer literate staff.

The government, on the other hand, needs to improve the infrastructure in the rural areas. This requires the collaboration of the private sector and other stakeholders. There is need for a national ICT policy to address the gaps and facilitate collaboration and participation of the public and private sector in improving ICT infrastructure in the country. The government needs to privatize the Telkom Kenya and to expand telecommunications services, reduce unit costs and inject management expertise to improve efficiency. In essence, this would enhance the diffusion of ICTs in the rural areas and communication of agricultural information would be facilitated. For example, some research centres and agricultural offices were not able to connect to the Internet due to low bandwidth and unreliable telecommunication lines and had to contend with only email services. This problem can be reduced with the expansion of telecommunication services in the rural areas.

7.11 Summary

The chapter has discussed the findings obtained through four sets of data collection instruments. The findings indicate that agricultural researchers were distributed in the ages of between twenty and fifty-five years of age, while the extension workers were clustered in the age bracket of thirty to forty-nine years of age. Both agricultural research and extension were still male dominated profession. It was found out that the professional education of the respondents had improved significantly. The respondents also had critical need for information that was specific to the nature of their work. It was established that a variety of ICTs tools and services were available in the institutions surveyed. However, availability was not a guarantee to accessibility. In many instances accessibility was lower compared to availability. The findings indicate that the effectiveness of ICTs was relative and often depended on the information to be disseminated, the target audience and the timeliness and use of the information. There was not much significance on the influence of gender on use of ICTs except for female extension workers based in the rural areas. The findings furthermore indicate that there is a correlation between ages of respondents and the acquisition of ICT skills. Those who were over fifty years of age were slow in learning and gaining requisite ICT skills. It was found that the respondents who were trained abroad exhibited better ICTs skills due to exposure of adequate facilities in their learning environment abroad. It was furthermore established that fragmented ICT policy existed both at the national and institutional levels. The findings indicate that the root cause of most problems that hindered effective diffusion of ICTs was inadequate funding.

The next chapter outlines a summary of the study, conclusions drawn from the findings and recommendations suggested for improving diffusion of ICTs in the agricultural sector in Kenya.

CHAPTER EIGHT

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

8.1 Introduction

This chapter summarizes the findings of the study in relation to the research objectives. It gives conclusions, suggests and recommends measures to be taken into account in improving the diffusion of Information and Communications Technologies (ICTs) in the agricultural sector. Suggestions for further research have also been given.

The purpose of this study was to investigate the diffusion of ICTs in the communication of agricultural information among agricultural researchers and extension workers in Kenya. This was done by establishing the nature, types and distribution of ICTs in the *institutions surveyed and finding out the extent to which they were used in* communication of agricultural information by the respondents. Specifically, the study attempted to address the following objectives:

1. Mapping and auditing of ICTs in the agricultural sector in Kenya, to establish their nature, types and distribution and motivation behind the adoption.
2. Explore government and institutional ICT policies and their effect on adoption and diffusion of ICTs in the agricultural sector in Kenya.
3. Examine the information literacy programmes available in the institutions surveyed and how such programmes contribute towards the use of ICTs among agricultural researchers and extension workers.
4. Investigate the extent to which information needs of agricultural researchers and extension workers are met through ICTs.
5. Assess the demand and use of ICTs by agricultural researchers and extension workers in their knowledge acquisition and knowledge dissemination process.
6. Investigate the impact of ICTs use on communication of agricultural information among agricultural researchers and extension workers in the agricultural sector in Kenya.

7. Establish knowledge gaps, drawbacks, and limitations that hinder effective use of ICTs by agricultural researchers and extension workers.
8. Assess the funding, maintenance and sustainability of ICTs in the agricultural sector in Kenya.
9. Establish the constraints and challenges encountered in diffusion of ICTs in the agricultural sector in Kenya.
10. Suggest and recommend measures to be taken into account in improving diffusion and use of ICTs in the agricultural sector in Kenya.

A total of 356 respondents comprising 159 agricultural researchers, 138 extension workers and 59 key informants participated in this study. While the agricultural researchers were drawn from the 21 KARI research centres, the extension workers were drawn from Uasin Gishu and Baringo districts. Other institutions surveyed included the headquarters of the Ministry of Agriculture and KARI and the Agricultural Information Centre (AIC). The informants of the study were drawn from the institutions surveyed.

A survey research method was employed to conduct the study. Data was gathered by use of questionnaire and structured interview technique. This was supplemented by observation and document review. A questionnaire was used to solicit information from agricultural researchers and extension workers while the face to face interview was used to obtain information from the key informants of the study.

The questionnaire was developed for both the agricultural researchers and extension workers. In addition to demographic data, the questionnaire collected information on the information needs of respondents. It sought information on the availability, access and use of ICTs tools and services by the respondents. It also assessed the respondents' skills and competencies in using ICTs. Information was obtained on the perceived usefulness of ICTs tools and services in communicating agricultural information and also on the funding, maintenance and sustainability of ICTs. Open-ended questions examined the constraints and challenges affecting the adoption and use of ICTs and measures that could be taken to improve the situation. The respondents were also asked to indicate the extension methods used in communicating agricultural information to the farmers.

Three types of interview schedules were used to solicit information from the three categories of informants who were comprised of policy makers, IT personnel and librarians. Through the interview information was obtained on the nature, types and distribution of ICTs among the institutions surveyed and the extent to which they were used to communicate agricultural information. The respondents were asked to explain the information literacy programmes offered by their institutions and to state the number of IT personnel employed. The librarians gave information on the provision of electronic information services and the level of automation in their respective libraries and information centres. Information was also obtained on policies, funding and sustainability of ICTs. Finally the constraints and challenges encountered in the application and use of ICTs and the measures that could be taken to improve the situation was also sought.

The data collection instruments were pre-tested using twenty extension workers and agricultural researchers from Kesses division and the Kenya Plant Health Inspectorate Services (KEPHIS), Kitale. All the comments provided by the respondents were incorporated by making the necessary changes and revision of the questionnaire.

The completed questionnaires were reviewed to determine their usability. Two questionnaires were discarded because they were incomplete. A total of 295 questionnaires (159 agricultural researchers and 136 extension workers) and 59 recorded interviews were usable. This brought the total number of respondents to 354.

Analysis of data was done using the Statistical Package for the Social Science (SPSS) and Excel as presented in chapter six and seven. Descriptive statistics were used and data analyzed by frequencies, cross tabulations, percentages, means and standard deviation.

8.2 Summary of the findings

8.2.1 Characteristics of respondents

The male domination in agricultural research and extension professions had reduced as a result of the Kenya Government taking measures to ensure gender equity at all levels of education and development. For example, the male domination in agricultural research had declined from 73.8% in 1989 to 64% in the year 2003, while that of the extension workers had reduced from 78.1% to 71%. The majority of agricultural researchers (75.5%) were between the ages of thirty and forty-nine years, while the extension workers were clustered in the same age bracket. Implicit in the age distribution is that extension workers were younger than agricultural researchers as a significant number (57.4%) were between thirty and thirty nine years of age.

The agricultural researchers were highly qualified for their jobs. For example, 79.1% had masters and Ph.D. degrees and were trained in specialised fields in agriculture and related disciplines. The figure (79.1%) represents 28.3% more than the educational qualifications of agricultural researchers (50.8%) reported by Ojiambo (1989) fourteen years ago. Similarly, the education level of extension workers had improved considerably with the majority (65%) having bachelors' degree, as opposed to diploma and certificate qualifications (82.1%) reported in earlier studies (Ojiambo 1989, Kaniki 1995). It was further noted that while the majority of agricultural researchers (52.7%) obtained their qualifications abroad, the majority of extension workers (91.1%) were trained locally in Kenya.

The nature of work of the agricultural researchers ranged from agronomists, plant and animal breeders, pathologists, entomologists, soil scientists, horticulturists, social-economists, GIS expert amongst others. Extension workers were deployed to district and divisional agricultural offices as subject matter specialists in livestock production, poultry, crop production, soil science, horticulture, bee keeping, farm management, farm mechanization, and home economics, amongst others. The agricultural researchers held the positions ranging from centre director to assistant research officer. On the other hand, the extension workers held positions ranging from District Agricultural Livestock and Extension Officer (DALEO) to frontline extension worker at the locational level.

8.2.2 Summary of the findings by the research objectives

This section summarizes the findings on the ten research objectives and corresponding questions used in guiding the investigation of this study.

8.2.2.1 Objective one

Mapping and auditing of ICTs in the agricultural sector in Kenya, to establish their nature, types and distribution and motivation for adoption.

The corresponding research question was:

What are the nature, types and distribution of ICTs in the agricultural sector in Kenya? What motivation is behind ICTs application and use in the agricultural sector?

A wide variety of ICTs tools and services exist among the institutions surveyed. These included the ICTs based largely on analogue information waves that ranged from radio cassettes, tape recorders, television, video cameras, VCR, television, telephone, mobile phones, fax (both analogue and digital), among others. ICTs based on digital information included computers, Internet, email, scanners, digital cameras amongst others.

The Agricultural Information Centre (AIC) with a mandate of repackaging agricultural information had a modern radio studio equipped with professional sound recording for both field and studio recording. It also had modern recording equipment and editing suites amongst a variety of other video production facilities. A range of audio-visual facilities also existed in most institutions surveyed.

Out of 21 KARI research centres, 15 had Internet and email services, 5 had email services only, while 1 centre had none of the services. All the centres had telephone services, while fax services were available in all except Molo research centre. The number of computers varied from one centre to the other with KARI headquarters having the highest number of 91 computers. However, the computers were found to be inadequate in most of the research centres. Several initiatives had been made to enhance the use of mobile phones by agricultural researchers. At the KARI headquarters 4 mobile phone lines had been installed in the main PABX telephone system. Selected key researchers at Kakamega and Kitale research centres had also been given official mobile phones and were getting a monthly allowance for airtime credit.

The Ministry of Agriculture headquarters and Uasin Gishu district agricultural office had Internet and email services, while the Agricultural Information Centre (AIC) had email services only. Baringo district agricultural office had none of the services and arrangement had been made for extension workers to access the services from the neighbouring district development office. The number of computers varied from one agricultural office to the other with the ministry of agriculture headquarters having the highest number of 700 computers. It was observed that all the districts agricultural offices had computers, but none was available at the divisional agricultural offices. It was noted that whenever the frontline extension officers needed to use computers they travelled to their respective district agricultural offices.

Most of the institutions surveyed had dial up Internet connection apart from KARI headquarters, which had both dial-up and dedicated line connections. The institutions had a range of proprietary and open-source software. These include Standard Microsoft Office suite, statistical packages such as SPSS, lotus, CD-ISIS, WordPerfect, Dbase, Oracle, Linux, Page-maker, and clippers. Operating systems included MS DOS, MSS Windows, UNIX, Novell, and Macintosh. A number of GIS software were also available.

The libraries and information centres in the institutions surveyed had variety of electronic information sources including CD-ROM databases, electronic journals and in-house databases. The CD-ROM databases provided information in bibliographic, full-text and multi-media format. An example of a popular full-text CD-ROM database is The Essential Electronic Agricultural Library (TEEAL) which has a collection from 141 agricultural journals stored on 172 discs and holding images of 750,000 full text pages with illustrations and diagrams. This database is popular and provides a wide range of agricultural information relevant to the needs of agricultural researchers. The database was not accessible to the majority of extension workers unless they travelled to the nearest KARI research centre or to the Ministry of Agriculture library at the headquarters.

KARI had its own ISP called Kenya Web which had been installed at the headquarters and was used by only research centres in close proximity to the headquarters. The rest of the centres including the Ministry of Agriculture headquarters, provincial and the district agricultural offices used commercial ISPs chosen depending on the proximity, cost and quality of service.

KARI headquarters had a fully operational Local Area Network (LAN) with email address that enabled the staff to communicate via the network and access the Internet and email services. Other research centres that had installed LAN were Mtwapa, Perkerra, Kisii, Katumani, Thika, Kitale and the National Agricultural Research Laboratory (NARL). The networking software used was Novell NetWare and lines were connected via routers. Unshielded twisted pair was used in cabling and networking the offices, while coax was used to network temporary buildings such as green houses. Fibre optic was used for underground cabling. KARI is expecting to benefit from the Kenya Education Network (KENET) initiative funded by USAID. The initiative uses satellite and Very Small Aperture Technology (VSAT) to network all research and educational institutions in the country. The Ministry of Agriculture was in the process of networking all the offices at the headquarters at the cost of Kshs 14 million (USD 175,000). Cabling of offices had already been done using switchers, routers and fibre optic. The provincial and district agricultural offices were yet to be networked.

The motivation behind the adoption and use of ICTs among the institutions surveyed was to improve the efficiency and effectiveness of delivering agricultural information among all actors involved in agriculture. It became clear that whereas the institutions were generating useful information and technologies that were beneficial to diverse groups within and outside the institutions, there was no organised mechanism of packaging, storing and disseminating this information. In particular KARI realised that its scientists were not receiving adequate support in terms of accessing reference materials, including scientific journals and databases relevant to their programmes (KARI 2002:46).

8.2.2.2 Objective two

Explore government and institutional ICT policies and their effect on adoption and diffusion of ICTs in the agricultural sector in Kenya.

The corresponding research question was:

Are there government and institutional ICT policies in Kenya? If so, what are there effects on adoption and diffusion of ICTs in the agricultural sector?

The Kenya Government is in the process of preparing a comprehensive ICT policy to govern the orderly development of the ICT sector and once the policy is ready it will be enacted through an Act of Parliament. It was observed that the government had already formulated policies to provide guidelines on liberalization, privatization and tariff reform in the country. The policies have provided guidance in the restructuring of the public sector and involving more of the private sector in various development projects. For example, by liberalizing the airwaves more private radio and television services have been established in the media sector. This has diversified products and services and increased the channels for disseminating agricultural information to the farming community. The government has also instituted several measures to reduce tariffs. In the budget speech of 2003/2004 financial year, the government waived all taxes on importation of computers and their accessories in an effort of scaling up application and use of ICTs in the country.

It was noted that the government was yet to privatize Telkom Kenya Limited which is the sole provider of fixed public telephone service in the country. It is envisaged that once Telkom is privatized and more service providers are enlisted, it will improve tele-density in rural and urban areas which currently stands at 0.16 per 100 people and 4 telephone lines per 100 people respectively.

The Ministry of Agriculture had an ICT policy that guided the networking of all agricultural offices starting from the headquarters to provincial and district levels.

Similarly, KARI had an ICT policy pegged to the strategic objective of the institution. The policy stipulated the need to adopt appropriate ICTs to facilitate dissemination of knowledge and technologies and to catalyze the process of outreach programmes. However, implementations of these policies were not effective due to lack of funds, commitment and to some extent lack of guideline at the national level.

Both the national and institutional ICT policies were lacking in addressing the over-reliance on donor funded projects leading to low levels of sustainability. The institutional policies had not squarely addressed the issue of capacity building and skill development among the staff. The policies needed to bring about some institutional changes. Far greater tasks than putting in computers are the changes that need to occur within the research and extension service to strengthen and improve the function of the institution as a whole. For ICTs to be leveraged in the agricultural sector there is need for policies to address the above mentioned issues.

8.2.2.3 Objective three

To examine the information literacy programmes available in the institutions surveyed and how such programmes contribute towards use of ICTs among agricultural researchers and extension workers.

The corresponding research question was

What information literacy programmes exist in the institutions surveyed and how do they contribute to use of ICTs among agricultural researchers and extension workers?

The information literacy programmes were offered by the institutions surveyed albeit at different levels and continuity. At KARI, several training sessions on use of ICTs had been conducted and all staff including those in senior management participated. The aspects covered during the training include the use of CD-ROM databases such as the crop protection compendium and TEAL, the use of the Internet and email services. Staff had also been trained on the use of an in-house database called the Kenya Agricultural Research Database (KARD). All the staff at the headquarters and those based at Mtwapa, Perkerra, Kisii, Katumani, Thika, Kitale and NARL research centres had received training on use the Local Area Network (LAN) which had been installed at the centres. According to KARI system manager the training had increased utilization of the network to 90% at the headquarters and 50% at the research centres.

The ministry of agriculture through the computer resource centre was conducting basic training on use of computers to all staff at the headquarters. The staff were also encouraged to take extra training sessions by paying a minimal fee. At the Uasin Gishu district agricultural office training on basic use of computers and Internet had been organised for all the extension workers based at the district office. The training was offered by two private computer-training firms namely, Down to Dusk and Alphax. The front line extension workers at divisional offices did not benefit from the training. At the Baringo district agricultural office there was no training that had been offered at the time of conducting the study.

The library staff had also benefited from in-house training on use of ICTs. Both the Ministry of Agriculture and KARI had trained their library staff on the use of WINISIS text retrieval software. Training of a trainers' course had been conducted by KARI on use of the Internet, TEAL, and Crop Protection Compendium and CTA Question and Answer Service (QAS). The librarians involved were expected to train agricultural researchers at their respective research centres.

It was observed that librarians used a variety of methods and techniques to create awareness of new ICTs tools and services. For example, users were invited to a demonstration of new products and services such as CD-ROM database, OPAC, and electronic journals. Emphasis was on hands on training as a way of building confidence among the users so that they could effectively use the newly acquired products and services. Other methods used included the library newsletter, the email, notice boards, and meetings.

Most of the agricultural researchers (83%) had benefited from information literacy programmes compared to only 39% of extension workers. The programmes had enhanced skill development among the respondents consequently leading to an increase in ICTs utilization. The majority of agricultural researchers (75.5%) had good computer skills, while an average number (50%) had good Internet skills. Most of the extension workers had poor computer and Internet skills due to lack of training opportunities. Suffice to say that the information literacy programmes were not adequate as most of the agricultural researchers (69.8%) and average number of extension workers (50%) sought for additional training opportunities to improve their ICTs skills. Besides, a large number of agricultural researchers (88%) needed more training on use of Internet and electronic sources, while over 90% of extension workers needed training on use of computers, Internet and electronic sources of information.

8.2.2.4 Objective Four

Investigate the extent to which information needs of agricultural researchers and extension workers are fulfilled by use of ICTs.

The corresponding research question was:

To what extent are the information needs of agricultural researchers and extension workers being met through ICTs?

The findings indicate that both agricultural researchers and extension workers had a critical need for information that was specific to the nature of their work. This included information on agronomy, seed technology, soil science, horticulture, plant pathology, bee keeping, dairy cattle and goats, poultry, agricultural marketing, crop protection, amongst others. They also expressed need for information on agricultural policies and meteorology. The agricultural policies are important to researchers and extension workers as they provide guideline on issues affecting research and extension work. For example, the Agricultural Input Policy ensures that adequate and quality inputs are made available to farmers and that, to a greatest extent, they are used at the right time and in correct quantities. On the other hand, meteorological information is quite crucial to agricultural researchers and extension workers. Agricultural researchers need information on the climate and weather patterns to assist in planning for their research, while extension workers need to advise farmers on when to plant. Besides, this information helps in forecasting production of food crops and livestock. It is the responsibility of agricultural researchers and extension workers to synthesize interpret and disseminate this meteorological information in a timely and effective manner to the farmers.

The majority of agricultural researchers (71.7%) were of the view that the Internet and CD-ROM databases provided information that was relevant to their needs, while most of the extension workers (71.3%) observed that the information was not useful. This contrast is attributed to the level of skills development and physical access to ICTs by the two categories of respondents. While the majority of agricultural researchers were computer literate and had access to the Internet and CD-ROM databases, most of the extension workers lacked basic skills and physical access. KARI was a beneficiary of free access to electronic journals courtesy of the International Availability to Scientific Publication (INASP) project through its Programme for the Enhancement of Research Information (PERI). Through this project agricultural researchers were able to access the African Journals Online (AJOL). They were also able to access 600 journals through INASP and Blackwell Synergy project and 5500 full-text journals from the EBSCO Host seven databases. It was observed that most KARI research centres had made arrangement for agricultural researchers to access the Internet and email services free of charge. The costs were subsidized through the donor projects. At the Uasin Gishu district agricultural office extension workers also accessed Internet and email free of charge but the services were used sparingly because of costs. The institutions were also contemplating charging a minimal fee to sustain the services.

Among the CD-ROM databases having the most relevant content was the TEEAL with over 750,000 pages of articles drawn from 141 journals. The database covers a wide range of subjects that include: crop production, plant diseases, farm mechanics, tillage and soils, agricultural economics, natural resources, the environment, food science, animal and human nutrition, forestry, genetic resources and breeding and tropical plants. The content corresponded to the needs of agricultural researchers and extension workers. Crop Protection Compendium which is multimedia encyclopaedic CD-ROM database with information of over 1560 pests on 180 crops had relevant content for agricultural researchers and extension workers. The database was available in all KARI research centres and also at the ministry of agriculture library at the headquarters.

KARI had also created an in-house database containing all researches that had been conducted since the establishment of the institute. The database has more that 50,000 records and was distributed offline to all KARI research centres. The database had information on local content and agricultural researchers found it very useful.

Most of the extension workers lacked requisite skills and physical access to the Internet and CD-ROM databases. They relied mostly (100%) on printed sources of information such as handbooks, pamphlets, newsletters, brochures, leaflets and other extension materials produced by the Agricultural Information Centre (AIC). Informal discussions with them revealed that they also depend on seminars, workshops and monthly consultative meetings. Similarly, agricultural researchers (90.6%) also reported that they used printed sources of information to complement the information they obtain via the Internet and CD-ROM databases. The respondents also obtained their information through the radio, television and newspapers. Recently the Kenya Agricultural Commodity Exchange (KACE) partnered with Safaricom mobile subscriber to provide marketing information on agricultural products. This is an additional source of information to the respondents and especially extension workers based in the rural areas.

The majority of agricultural researchers (81.1%) and extension workers (54.4%) were of the view that ICTs had changed their way of seeking information from libraries and information centres. Among the reasons given was that ICTs were convenient, effective and efficient and provide enormous pool of information in one sitting without traveling to libraries and information centres.

8.2.2.5 Objective Five

Assess the demand and use of ICTs by agricultural researchers and extension workers in their knowledge acquisition and knowledge dissemination process.

The corresponding research question was:

To what extent are ICTs used by agricultural researchers and extension workers in their research and extension activities? How have ICTs affected the productivity and creativity of agricultural researchers and extension workers?

The majority of agricultural researchers used ICTs to communicate among themselves (96.6%), for research purposes (79.2%), and for disseminating agricultural information (77.4%). A large number (71.7%) used ICTs to communicate with extension workers. On the other hand, the majority of extension workers used ICTs to communicate with the farmers and among themselves.

A significant number (73.5%) of agricultural researchers and a relatively smaller number (36.8%) of extension workers used the Internet in their research and extension work. A large number of the respondents spent an average of 5 hours per week surfing the Internet. Among the most used Internet service was the email. It was used for consultation purposes, for communicating agricultural information, and for research through the CTA Question and Answer Service (QAS). It was mostly the agricultural researchers who used the QAS. In QAS the users completed a questionnaire requesting for information after which it was transmitted electronically to other nodes that may be in a position to provide the information. It was established that the email was a useful tool for collaborative projects among agricultural researchers within ASARECA (Association for Strengthening of Agricultural Research in Eastern and Central Africa) member countries and also at global level. KARI researchers had also benefited from Africa-link project funded by USAID that provide support for dialup Internet and email connections for African researchers.

Radio and television were used widely by agricultural researchers and extension workers to disseminate agricultural information to the farming community. A variety of programmes had been recorded in the national language, Kiswahili, and also in vernacular languages. The programmes contained messages on technological and agricultural development issues and were transmitted via the national radio and TV station (KBC) and also through the private radio and TV stations (see chapter 6 section 6.2.11.1). Among the popular Kiswahili radio programmes were *sikio la mkulima* (an ear of the farmer) and *tembea na majira* (move with the times), while popular TV programmes included agricultural documentaries and sahiwal cattle. Videos were also widely used to repackage technological messages for extension workers and farmers. They were found to be effective in disseminating agricultural information as a picture is worth a thousand words. Many video programmes had been produced by the ministry of agriculture and KARI. The Non Governmental Organizations (NGOs), Community Based Organizations (CBOs), Churches and Agro-Chemical industries also participated in the production of agricultural video programmes.

The mobile phone was used by the respondents to communicate among themselves, with the stakeholders and the farmers. Some KARI research centres had made arrangements to purchase mobile phones for the selected key officers. These officers were also given monthly allowances for airtime credit. Similarly, the ministry of agriculture was making arrangements to purchase mobile phones for all the district agricultural extension officers and other key officers at the district level. Companies in the private sector are also supporting the use of mobile phones. For example, the Kenya Agricultural Commodity Exchange had partnered with Safaricom mobile subscriber to provide agricultural market information. All the subscribers of Safaricom can now access this information from their mobile phones. The majority of the respondents observed that the SMS mode of communication was becoming a favoured niche medium.

A large number (81.1%) of agricultural researchers observed that use of ICTs had increased their work productivity and creativity, while 61.8% of extension workers were either undecided or disagreed. This is attributed to lack of skills and physical access to ICTs.

8.2.2.6 Objective Six

Investigate the impact of ICTs use on communication of agricultural information among agricultural researchers and extension workers in the agricultural sector in Kenya.

The corresponding research question was:

What is the impact of ICTs on communication of agricultural information among agricultural researchers and extension workers?

The majority of agricultural researchers (94.3%) and extension workers (77.9%) observed that ICTs had facilitated communication of agricultural information among all actors involved in research and extension. A large number of agricultural researchers (71.7%) used ICTs to communicate with extension workers. Ironically, only 35.3% of the extension workers used ICTs to communicate with agricultural researchers. One would have expected ICTs to enhance the communication between agricultural researchers and extension workers. Besides, the two subsystems are supposed to work more closely together in transmitting new knowledge of farm technology to farmers and also getting feedback from farmers. Among the constraints that contributed to infrequent communication between extension and research subsystems include the following:

- While agricultural researchers had access to the Internet and email services, the majority of extension workers lacked physical access to these services.

- Research centres are usually located at a distance from most extension operations and only those extension workers working around research centres were able to have frequent contacts with agricultural researchers.

- Agricultural researchers do not often go into the fields where they would meet extension workers.

- Extension workers and agricultural researchers do not meet frequently

- The monthly stakeholders meetings did not provide adequate forum to share knowledge and experiences among extension workers and agricultural researchers

Extension workers were of the view that agricultural researchers have tended to treat the extension personnel as inferior rather than equals and often do not involve them in agricultural activities that required their input. It was observed that while extension and research have unique and different needs, their destinies are closely intertwined. It was noted that ICTs can only improve communication of agricultural information if there is a good working relationship between agricultural researchers, extension workers and all actors involved in research and extension. In essence, ICTs alone cannot transform communication of agricultural information without the interventions and interactions of all the stakeholders in the agricultural sector.

A large number of agricultural researchers (84.9%) and extension workers (69.1%) were of the view that ICTs had changed the way they communicate agricultural information by providing an effective and efficient delivery system. They noted that ICTs were faster and provided instantaneous response. It was easier for the respondents to reach a wider scope of people simultaneously via ICTs. They observed that ICTs allow for the sharing and exchange of information among all actors involved in research and extension. They noted that use of ICTs had enhanced production and dissemination of extension materials to suit different target groups ranging from the illiterate to literate farmers.

8.2.2.7 Objective Seven

Establish knowledge gaps, drawbacks, and limitations that hinder effective use of ICTs by agricultural researchers and extension workers.

The corresponding research question was:

What knowledge gaps and drawbacks impede agricultural researchers and extension workers from effectively exploiting ICTs potential?

The lack of computer and Internet skills by the majority of respondents was a major constraint to use of ICTs. While most of the agricultural researchers had good computer and Internet skills, the majority (88%) needed more training on use of Internet, electronic journals and CD-ROM databases. A large number (68.4%) of extension workers had poor skills and over 90% needed training in all aspects of ICTs. Related to this constraint was the non-availability of ICTs among the respondents. The most vulnerable group was the extension workers whom over 65% had no access to computers, Internet, email, CD-ROM databases and electronic journals. The most affected were the frontline extension workers based at the divisional agricultural offices. The few extension workers who had acquired some computer skills through self-study lacked the hands-on experience and often relapsed into computer illiteracy.

Associated with the above problems were inadequate funds to acquire and sustain ICT tools and services. The extension workers at the Uasin-Gishu district agricultural office had to forgo their field allowances to supplement the inadequate funds set aside to purchase computers and train the staff. This exemplifies the willingness and enthusiasm among the respondents in learning how to use ICTs.

The ICTs facilities were poorly maintained due to lack of IT personnel and also the high costs involved. The IT personnel employed were stationed at the headquarters of the Ministry of Agriculture and KARI. Due to lack of maintenance there was high rate of non-functional and obsolete computers. It was observed that in the absence of IT personnel it was difficult to have a computer literate staff.

The poor infrastructure in the rural areas affected diffusion of ICTs among the respondents. A number of research centres and agricultural offices were unable to connect to the Internet due to low bandwidth and had to contend with email services that do not require a high bandwidth. Coupled with this was the fact that most ISPs were in big towns and because of distance there was often poor connectivity to the Internet and email services. Frequent down-time of the Internet and email frustrated the respondents from effectively using the services. It was noted that the problem can be reduced with the expansion of telecommunication services in the rural areas.

8.2.2.8 Objective Eight

Examine the funding, maintenance and sustainability of ICTs in the agricultural sector in Kenya.

The corresponding research question was:

How is the funding, maintenance and sustainability of ICTs in the agricultural sector in Kenya?

Despite the efforts to expand and modernize ICTs in the agricultural sector, its growth has been hampered by inadequate funding. This has slowed down the diffusion of ICTs among agricultural researchers and extension workers. Consequently, KARI and the Ministry of Agriculture had to contend with several constraints including inadequate ICT training and skills development, over-reliance on donor projects leading to the low level of sustainability and inadequate ICTs tools and services.

The centralized budgeting system at KARI and the Ministry of Agriculture was blamed for contributing towards inadequate funding. More often than not the budgets approved were a fraction of what had been requested. The most affected were the district agricultural offices that had to contend with the basic provision of services. KARI research centres were relatively better off because of the alternatives sources of funds through donor projects. At the two district agricultural offices ICT budget was usually the most affected and in most cases it was reduced to bare minimum to cater for only telephone services. Despite the constraints the respondents were enthusiastic in keeping pace with the technological advances as portrayed by the extension workers at the Uasin Gishu district agricultural office. They had to forgo their field allowances to subsidize funds set aside for the purchase of computers and training costs. In the end there was surplus money to cater for the cost of connecting to the Internet.

The other problem was the high costs of maintenance which was aggravated by lack of IT personnel at the research centres and district agricultural offices. The few IT personnel employed were all stationed at the headquarters of KARI and the Ministry of Agriculture. Due to inadequate funds the research centres and agricultural offices could not afford to contract private consultants to maintain their facilities. As a result many computers that broke down could not be repaired and were rendered obsolete.

Sustainability of ICTs was affected by inadequate funding and lack of planning especially for donor funded projects. Although on paper KARI usually commits itself to sustain the donor funded projects once they end, this was not always fulfilled because the many such projects that had been initially commenced. Those managing the donor funded projects felt that their institutions often retreat when the projects end leaving no option but to terminate the ICTs services. On the other hand, the policy makers argued that many projects could end at the same time making it difficult to sustain given the limited funds available. They further observed that in some cases the donor funded projects were pushed into their throats without giving them ample time to decide what was good for their institutions. It was observed that these projects had tended to provide initial investment capital rather than maintenance and running costs. As a result the recurrent costs associated with maintenance have remained largely unmet.

8.2.2.9 Objective Nine

Establish the constraints and challenges encountered in diffusion of ICTs in the agricultural sector in Kenya.

The corresponding research question was:

What constraints and challenges are encountered in diffusion of ICTs in the agricultural sector in Kenya?

A number of constraints and challenges had affected the diffusion of ICTs in the agricultural sector. These included inadequate funding, poor infrastructure, inadequate skill development, lack of comprehensive national and institutional ICT policies, lack of monitoring and evaluation system for ICTs projects, inadequate provision of ICTs tools and services, and poor maintenance. Due to inadequate funding the institutions surveyed were unable to acquire adequate ICT tools and services for their staff. In addition, the information literacy programmes were not frequently offered and respondents were unable to update their skills. Most of the training programmes that had been conducted were funded by the donor community. Due to inadequate skills the respondents were unable to effectively use the available ICTs tools and services.

There were many donor funded projects in the agricultural sector and in particular at KARI. While the potential benefits of such ICTs projects cannot be overemphasised, it suffices to say most followed the top-down approach and were often technology-driven rather than needs driven. Once the projects came to an end they suffered from lack of follow-up costs. Many had, therefore, stalled because of lack of funds for continuity.

The poor economic performance in the country over the last decade had slowed down development of infrastructure particularly in the rural areas thereby impeding growth in use of ICT and related services in the agricultural sector. Most of the rural areas lack electricity, and the most affected being the semi-arid areas such as Baringo district. This was an impediment in the application and use of ICTs by the respondents. Related to poor infrastructure was the lack of robust telecommunication facilities in the rural areas. While some areas lacked fixed public telephone service, others had insufficient bandwidth to connect to the Internet thus affecting the diffusion of ICTs in the agricultural sector.

There was poor maintenance and sustainability of ICTs tools and services among the institutions surveyed due to lack of IT personnel. Consequently, most of the institutions found it difficult to develop capacity for ICT absorption and utilization without the IT personnel. The problem was partly attributed to failure to attract skilled professionals to the public sector and partly to lack of appreciation of ICTs by policy makers.

Lack of comprehensive national and institutional policy on ICTs was also mentioned as a constraint to diffusion of ICTs in the agricultural sector. This has been discussed under objective 2 of the study. Lack of monitoring and evaluation system made it difficult to know the performance, effectiveness and efficiency of the adopted ICTs and whether they were sustainable in the long run. Many ICTs projects needed to be rejuvenated to meet the changing needs of the respondents.

8.2.2.10 Objective ten

Suggest and recommend measures to be taken into account in improving diffusion and use of ICTs in the agricultural sector in Kenya.

The corresponding research question was:

What measures should be taken into account to ensure that there is effective diffusion of ICTs in the agricultural sector in Kenya and that agricultural researchers and extension workers are served most effectively by these ICTs?

This objective has been dealt with after conclusions of the study. Suggestions given by the respondents have also been incorporated.

8.3 Conclusions

It is concluded that despite the constraints and challenges encountered in the application and use of ICTs in the agricultural sector, a wide range of ICTs had been adopted to facilitate information sharing and exchange among agricultural researchers and extension workers. This ranged from modern ICTs such as the Internet, email, electronic sources to traditional media such as radio, television and video. The variety of ICTs diversified the channels for disseminating agricultural information among agricultural researchers, extension workers, farmers and also between actors involved in research and extension. Interpreted in light of the diffusion of innovation theory (Rogers 1995), the findings indicate that ICTs that were perceived by the respondents as having relative advantage and were more compatible with their existing values, past experiences and needs were adopted faster. For example, mobile phones had a faster rate of diffusion among the agricultural researchers and extension workers despite the high tariffs.

KARI and the ministry of agriculture were motivated to adopt ICTs in an effort to provide an efficient and effective delivery system of agricultural information. It suffices to say that ICTs have even a greater role to play in the context of the changing paradigms in agricultural research and extension, where linear information flows are being replaced by pluralistic information flows and new actors are emerging to form "community information spaces" (Ajit 2003:3) This development will be enhanced by the availability and accessibility of ICTs.

An attempt had been made to formulate institutional ICT policies to guide the diffusion of ICTs at KARI and the Ministry of Agriculture. Implementation of these policies had been hampered by lack of adequate funds, poor infrastructure and lack of commitment by some of the policy makers. The policies had also failed to address the over-reliance of donor funded projects, capacity building and skill development and to bring institutional changes. The Kenya Government had formulated policies to guide liberalization, privatization and tariff reform. These policies had been implemented to a greater extent and had paved the way for the involvement of the private sector in the development of the various sectors of economy in the country. The government was in the process of formulating a comprehensive national ICT policy to provide guidelines in the ICT sector.

The information literacy programmes were taking place in the institutions surveyed although at different levels of intensity and continuity. Through the programme the majority of respondents had improved their skills on use of computer, the Internet, email and electronic sources. The programmes were better coordinated and managed at KARI than the Ministry of agriculture. As a result, more agricultural researchers had benefited compared to extension workers. The programmes should be offered on a continuous basis as technology is always changing.

Agricultural researchers and extension workers had a critical need for information that was specific to the nature of their work. In addition, they needed information on agricultural policies and meteorology. Most information needs of the respondents were met via ICTs. Agricultural researchers obtained useful information from the Internet and CD-ROM databases with TEAL database having the most useful information, while the Kenya Agricultural Research Database (KARD) database provided useful information on local content. The respondents also obtained useful information from electronic journals. Extension workers were disadvantaged as the majority lacked skills and physical access to ICTs. Their information needs were, therefore, mostly met through use of printed sources of information.

The majority of the respondents used ICTs to communicate among themselves and also with actors involved in research and extension. The Internet and email was used for consultation purposes, for communicating agricultural information, for research purposes and for collaborative projects with other colleagues. The radio, television and video were used in disseminating agricultural information to the farming community, while mobile phones were found to be convenient in communicating short messages. Use of ICTs had increased the respondents' work productivity and creativity.

Although ICTs had facilitated communication of agricultural information among all actors involved in research and extension, there was still room for improvement. For ICTs to be leveraged in the agricultural sector, the agricultural researchers and extension workers should work more closely as their activities are interrelated. Each group should play their roles in the multi-faceted process of transmitting new knowledge of farm technology to farmers and getting their feedback. ICTs will only transform communication of agricultural information with the interventions and interactions of all the stakeholders.

Despite efforts to expand and modernize ICTs in the agricultural sector, its growth had been hampered by a number of constraints and challenges. Among them include the inadequate funding, poor infrastructure, inadequate skill development, lack of comprehensive national and institutional ICT policies, lack of monitoring and evaluation system, inadequate provision of ICTs tools and services, poor maintenance, and over-reliance of donor funded projects leading to low level of sustainability. While a number of constraints could be addressed at the institutional level, others may need to be addressed at the national level. There is an urgent need to address these problems so as to enhance diffusion of ICTs in the agricultural sector. This requires the intervention and interaction of all stakeholders in the agricultural sector and also in the ICT sector.

The next section suggests and recommends measures to be taken into account in improving diffusion and use of ICTs in the agricultural sector.

8.4 Recommendations

The recommendations emerging as a result of this study are addressed to the Ministry of Agriculture and Rural Development and the Kenya Agricultural Research Institute, the ministries concerned with ICTs, scholars and interested persons. These recommendations could be addressed at institutional and national level. They provide practical implications and suggestions for further research.

8.4.1 Infrastructure

An enabling infrastructure is a prerequisite to effective diffusion of ICTs in the country. Such an infrastructure should have good telecommunication facilities, a stable supply of electricity and other communication links such as satellite. However, it emerged from this study (see 8.2.2.9 and also chapter six, section 6.2.16 and 6.3.7.7) that poor infrastructure is a major constraint to diffusion of ICTs in the agricultural sector in Kenya. The respondents mentioned inadequate telecommunication infrastructure and lack of electricity in many parts of rural areas as an impediment to adoption and use of ICTs. It was noted that although the Kenya Government is expanding and improving ICT systems, the current state of infrastructure is still a major hindrance to the country's full participation in the information society. Substantial demands for basic services remain unmet and the disparity in the distribution of communication facilities between rural and urban areas continues to widen. For example, the tele-density in rural and urban areas currently stands at 0.16 per 100 people and 4 telephone lines per 100 people respectively. The telephone bandwidth is low causing Internet and email to be slow and unstable, the telephone services are expensive due to monopoly by the state-owned corporation - Telkom Kenya Limited. Besides, only 3% of the rural population is covered by the Rural Electrification Projects (REP) in the country. The study, therefore, recommends the following measures to be taken to enhance diffusion of ICTs in the agricultural sector and in the country in general.

8.4.1.1 Telecommunication infrastructure

As a matter of urgency the Government should privatize Telkom Kenya Limited and increase participation of the private sector in the provision of fixed public telephone services. The proceeds from the sale of Telkom Kenya could be used to finance modernization, rehabilitation, diversification and expansion of telephone services in the country. Involvement of private companies in providing telephone services would allow for rapid increase of telephone lines, hopefully reduce unit costs and inject management expertise that will improve efficiency and lower tariffs. This would also improve service penetration levels and tele-density in the rural and urban areas. The government could easily achieve the envisaged tele-density of 1 telephone line per 100 people and 20 telephone lines per 100 people in the rural and urban areas respectively by the year 2010.

The government should also improve the efficiency of Internet backbone popularly known as JamboNet with a hub in Nairobi and extending to all major towns in the country. To enhance access and facilitate points of presence in most parts of the country, JamboNet should be extended to all districts headquarters. This would provide an enabling environment for Internet Service Providers (ISPs) to extend their services to these towns and subsequently increase Internet connectivity in the rural areas. KARI centres located in small towns would benefit so would the district agricultural offices. It is expected that an enabling infrastructure would enhance diffusion of ICTs among agricultural researchers and extension workers.

The government is slowly allowing satellite operators in the country, but is yet to open up fully because of monopoly by Telkom which regulates all satellite applications and use in the country. It is proposed that once the government privatizes Telkom and allows more private companies to offer the services at competitive rates, it would be possible to use VSAT to connect most of the rural areas to the rest of the country and also globally. The government should also work closely with Regional African Satellite Communication (RASCOM). RASCOM is an intergovernmental organization established with a mandate to rationalize existing satellite use by African countries, and obtain better rates for its member countries. Other international institutions where Kenya could get assistance for improvement of its telecommunications infrastructure and capacity include World Bank (through the InfoDev programme), The International Telecommunication Union (ITU-through WordTel) and UNDP (through the Small Island States Network).

8.4.1.2 Rural Electrification

The Government should accelerate the implementation of the Rural Electricity Projects (REP) in the country. This can be done by strengthening the management and resource base of these projects in order to improve the performance and impact of rural electrification. To further encourage diffusion of ICT services among the population, the

Government should seek alternative sources of energy such as installing stand-alone generators in areas away from the grid network to serve communities not connected to grid system. The Government should also offer tariff incentives to users of alternative energy sources. This would pave the way for application and use of ICTs in disseminating agricultural information for rural development.

8.4.2 Policy Framework

It was established that one of the major constraints to diffusion of ICTs among agricultural researchers and extension workers was the lack of comprehensive national and institutional policies (see 8.2.2.2 , 6.3.6 and 7.8). The Institutional and national policies that were in place were fragmented and lacked enforcement in their implementations. It was observed that the overall objective of ICT sector in Kenya is to optimize its contribution to the development of the economy and poverty reduction by ensuring the availability of efficient, reliable and affordable services throughout the country (Kenya, Republic of, National Development Plan 2002-2008:110). The Government, therefore, recognizes that full benefits and gains from ICT sector can only be realized if there is a comprehensive policy to govern the orderly development of the sector. In this connection the Government is currently preparing a national ICT policy. It has already formulated policies to address issues on liberalization, privatization and tariff reforms and implementations of these policies are in progress. The following suggestions are proposed to be incorporated in the national and institutional ICT policies.

8.4.2.1 National ICT Policy

Once the national policy is formulated and enacted through an Act of Parliament, it should play a significant role as part of an overall national strategy for development. The policy should be an enabler of social-economic development and should provide guidelines in the adoption of holistic, cross-sector strategies aimed at harnessing the potential of ICT to accelerate a wider development process in the country. The policy should focus on the following interrelated areas for strategic intervention:

Infrastructure – deploying a core ICT network infrastructure, achieving relative ubiquity of access, and investing in strategically-focused capacity to support high development priorities, address the disparity in the distribution of communication facilities in rural and urban areas.

Human Capacity – building a critical mass of knowledge workers, increasing technical skills among users and strengthening local entrepreneurial and managerial capabilities.

Policy – supporting a transparent and inclusive policy process, promoting fair and open competition, and strengthening institutional capacity to implement and enforce policies in institutions such as the Ministry of Agriculture and KARI.

Enterprise – improving access to financial capital, facilitating access to global and local markets, enforcing appropriate tax and property rights regimes, enabling efficient business processes and stimulating domestic demand for ICT.

Content and Applications – providing demand-driven information which is relevant to the needs and conditions experienced by local people.

The proposed strategic framework can form the core of the national ICT policy. It should also spell out a holistic approach on the implementation of the five strategic areas . It is important to secure the participation and commitment of the key stakeholders such as NGO's, CBO's, private sector, and multinational institutions. The national ICT policy would therefore guide diffusion of ICTs in all sectors of economy including the agricultural sector. The proposed framework could also form the basis for formulating a comprehensive ICT policy for KARI and the Ministry of Agriculture.

8.4.2.2 Institutional ICT policy

The Ministry of Agriculture and KARI had institutional policies drawn from the core objectives of the institutions. These policies were not and are not comprehensive to address issues on funding and sustainability, availability and access of ICTs, skill development and over-reliance on donor funded projects (see sections 8.2.2.2 and 7.8). It is recommended, therefore, that the institutions revise their ICT policies in line with the above mentioned strategic framework for national ICT policy. An ICT Advisory Board should be established and given the mandate of revising the policies. Members of the Board should include but not limited to: The deputy director of KARI/agriculture, the financial director, the system administrator, the librarian in charge, chief planning officer, and representatives from KARI centres/district agricultural offices among others. ICTs should form the core institutional strategy for disseminating agricultural technologies and networking with collaborators. The weaknesses of the existing ICT policies should be addressed. Once the new policies are in place and are implemented they would guide diffusion of ICTs at institutional level.

8.4.3 ICT Funding

The problem of inadequate funding was repeatedly mentioned as the root cause of many problems affecting diffusion of ICTs in the agricultural sector in Kenya (See sections 8.2.2.8, 6.2.12.2, 6.3.7.4 and 7.9). Due to inadequate funds the Ministry of Agriculture and Rural Development and the Kenya Agricultural Research Institute had to contend with several constraints including inadequate ICT training, over-reliance on donor projects, inadequate ICT tools and services among others. It was observed that the Ministry of Agriculture and KARI are funded through budgetary provision by the Government of Kenya (GOK) and supported by development partners and collaborators. The two institutions rely mainly on the GOK's budgetary resources, particularly as they relate to recurrent personnel, maintenance and operating expenses. The support from development partners is subject to changes as dictated by factors beyond the control of the two institutions. Over the last twelve years the economic performance of the country has been declining due to a number of factors. Consequently, the exchequer had to reduce budgetary allocation to the ministries and government departments. This affected provision of services including the application and use of ICTs.

In July 2001, the Government published a policy paper, 'A Strategy for Performance Improvement in the Public Service', that called upon the public research institutions in

Kenya to explore possibilities of commercializing research and other services and improve efforts at increasing their internally generated incomes and revenues (KARI 2002:51). It is in this regard that the study recommends that the Ministry of Agriculture and KARI explore alternative sources of funding. A task force should be set up to come up with a proposal that could be tabled at the Ministerial (applies to ministry of agriculture) and Institute Board of Management (applies to KARI) respectively. The document should explore services that could be commercialized to generate income. A holding should be established to oversee this activity. Such a holding may be called Agricultural Research Investments and Services for KARI or Agricultural Extension Investment Services for the Ministry of Agriculture. The alternative sustainable funding mechanisms should be implemented across the Ministry of Agriculture and KARI. It should include all commercially viable services.

The ICT department/section should form an integral part of this holding and help in generating revenue through the provision of ICTs services. These services may include training, maintenance, and consultancies. It would be advisable for the Ministry of Agriculture and KARI to employ IT personnel and deploy them to all KARI centres and district agricultural offices to facilitate the process. The revenue generated through the services can be ploughed back to improve and expand the ICTs services, especially purchasing more computers and sustaining Internet and email services. It is suggested further that staff could pay a small fee to access Internet and email facilities. This would contribute towards sustainability of ICTs services.

8.4.4 Employment of Information Technology (IT) Personnel

It was found out that the application, use and maintenance of ICTs is constrained by inadequate IT personnel as the few who had been employed were all stationed at the Ministry of Agriculture and KARI headquarters. This left the KARI centres, district and divisional agricultural offices without any IT personnel (See sections 8.2.2.7, 8.2.2.9, 6.2.16, and 6.3.2). It was observed that the public sector has failed to attract skilled IT professionals because of poor pay and working conditions. The government through the Structural Adjustment Programme (SAP) has rationalized staff in the public service and has recommended a competitive salary scale. The improved salary scale alone may not attract IT professionals who may still prefer to work in the private sector. It is recommended that the Ministry of Agriculture and KARI find ways of motivating IT professionals by giving incentives emanating from the income generated funds. This is already happening in institutions of higher learning and they have managed to retain IT professionals. The two institutions should employ adequate IT professionals and deploy to all their centres and district agricultural offices. At the divisional agricultural offices a lower cadre of IT professional having certificate qualifications may be employed. With adequate IT staff it would be possible to generate income from commercialized ICTs services. The technical staff would maintain the ICTs tools and services and also provide information literacy programmes for all cadres of staff.

8.4.5 Skill Development Strategies

The lack of skills among agricultural researchers and extension workers was a major constraint to the application and use of ICTs in the agricultural sector in Kenya (see sections 8.2.2.7, 6.2.6, 6.2.16, 7.6 and 7.10). There is need, therefore, to impart the necessary skills to the respondents. This should be approached from a national and institutional point of view.

8.4.5.1 Skill development at national level

To ensure development of a sustainable human capacity that effectively addresses the current digital divide both within the country and internationally, there is need to mainstream information and communication technology education and training in the national curricula and training programmes. To this effect the government has made effort to make ICT an intrinsic and integral part of learning through establishment of a computer specialization unit at the Ministry of Education and preparations of syllabuses by the Kenya Institute of Education(KIE) and Kenya National Examination Council (KNEC). The curriculum is currently being implemented in primary and secondary schools but with difficulties due to poor infrastructure and inadequate computers. It is suggested that since primary education is now free, the government should look for willing donors and development partners to assist in providing computers, while parents should attempt to meet the cost of purchasing computers at secondary schools. The government should also provide incentive to stakeholders in ICT and education so as to encourage dispersion of technology to schools in the rural areas. Such incentives may include lowering of tariffs. It is recommended that the tertiary institutions increase the number of ICT courses for diploma and degree programmes. This would ensure that school and college leavers and young professionals including those joining agricultural research and extension have relevant ICT knowledge, skills and attitudes.

The government needs to streamline many mushrooming computer colleges in the country. While some are offering quality training, others are exploiting the common man by offering sub-standard training. The government should, therefore, establish a body to review the present accreditation of all ICT training institutions in the country. This would ensure that citizens get quality training on use of ICTs.

8.4.6 Training at Institutional level

Although effort had been made to train agricultural researchers and extension workers on use of ICTs, this has not been effective as the majority of the respondents lacked ICT skills (see sections 8.2.3, 6.3.3, 6.3.4, 7.6, and 7.7). The Ministry of Agriculture and KARI should, therefore, have an integrated information literacy programme with the objective of developing an ICT literate staff through retraining and skills building progression. The programme should be conducted jointly by the library staff and IT personnel. It should be offered on a continuous basis and emphasis should be placed on hands-on experience to enable staff gains skills and confidence to use a variety of ICTs. The literacy programme should be offered progressively starting from the very basic skills of using computers, for example, to advanced skills of using Internet search engines. This would allow staff to put the gained skills into practice before advancing further. The information literacy programmes should cover all aspects of ICT use. Training on use of Internet for example, should cover use of search engines and various Internet services including communication via email and fax. Staff should also be trained on repackaging of agricultural information using media such as radio and television. It is expected that the skills gained would go a long way in creating confidence among agricultural researchers and extension workers and making them to be more capable and comfortable in using a variety of ICTs.

8.4.7 Reduction of taxes on ICT tools and services

The study found out that costs for acquisition and maintenance of ICTs tools were quite expensive due to high tarriffs (see sections 8.2.2.8, 6.10.1, 6.2.12, and 6.3.7.5). It was observed that the Kenya Government recently removed taxes on the importation of computers and their accessories in an effort of enhancing diffusion of ICTs in the country. But the same government increased tariffs on mobile phones despite the fact that this technology has proved to be the most used means of communication by all categories of citizens. Kenya being a member of the East African Community was prevailed upon by member countries to increase the tariffs so that it is the same across the East African countries. This may bring down the rate of use of mobile phones in the country. The high rates of taxation on telecommunications equipment have also impacted negatively on the cost of delivery of ICT services to consumers thus compromising the objective of universal access. It is suggested that the government should come up with an optimal tariff policy that would make cost of all imported ICTs equipment affordable to all citizens. This is expected to reduce the high rates of communication through telephones and subsequently reducing the cost of email, the Internet and even fax. In return this is expected to facilitate diffusion of ICTs among the population including those in the agricultural sector.

As already mentioned the government should encourage competitiveness through further liberalization as a way of encouraging participation of the private sector in provision of telephone services. This would be one means of bringing down the cost of telecommunication and enhancing application and use of ICTs in all sectors of economy including the agricultural sector.

8.4.8 Development of responsive content

It was found that although effort had been made by KARI and the Ministry of Agriculture to create local content that was responsive to the needs of agricultural researchers and extension workers, there was need for improvement (see sections 8.2.2.4, and 7.4.2). KARI had developed a database containing all research that has been conducted since the institution was established during colonial days. The database is called the Kenya Agricultural Research Database (KARD) and contains about 50,000 records. The findings indicated that the database has not been updated. There is a need to update the database and circulate it among the research centres as it provides content that is grounded in the reality of local context and has been very useful to researchers. It is also suggested that the database is made available on KARI Website to allow more people to access and also for collaborative purposes.

The Ministry of Agriculture has also developed an in-house database containing researchers done by the ministry staff. However, the scope is limiting as it contained only research publications based at the headquarters. The researcher recommends, therefore, that the database should be expanded to include research findings at provincial and district agricultural offices.

It is further recommended that the KARI and Ministry of Agriculture databases can be merged to form one database which can be posted on the Internet so that it is available internationally and also locally to many interested parties. The two institutions can also develop an intranet to allow their databases to be available for sharing among their staff and also to the outside world. Individual researchers and extension workers are also encouraged to join Internet discussions groups and post articles on topical issues. By doing this they would be contributing and sharing some of their findings globally.

8.4.9 Monitoring and Evaluation of ICTs projects

The problem of sustainability of many ICT projects at KARI and the Ministry of agriculture was attributed to poor planning and management (see sections 8.2.2.8, 6.2.16, 6.2.12 and 7.9). It is recommended, therefore, that KARI and the Ministry of Agriculture develop a monitoring and evaluation system for ICTs projects funded by institutions and also by donor community. Such a system would help in evaluating the viability and sustainability of all ICT projects. The following criteria could form the basis for developing the system namely, relevance, sustainability, performance, effectiveness and efficiency.

Relevance will determine the degree to which the objectives of the intended ICT project fit into the organizational objectives. In evaluating an on-going project, the degree to which the objectives remain valid will be determined. Sustainability will determine whether the project is sustainable in the long run. The institutions would, therefore, develop mechanisms for sustaining both the locally and donor funded projects. This would reduce the number of stalled projects especially those funded by donors. The projects should also be evaluated in terms of effectiveness which measures the extent to which the desired objectives can be met. For example a question and answer service maybe evaluated to find out whether the respondents are getting the desired information in the most effective way. The last criterion is efficiency which determines the speed with which inputs can be transformed to outputs in a timely manner.

The impact assessment method can also be used to assess the achievements of the project in terms of the changes brought about by the project. The centre directors/district agricultural officers or project coordinators can also provide quarterly reports indicating progress in implementation of the project and supporting activities such as the training of staff. The reports should be submitted to the Advisory committee on ICTs of the respective institutions.

The above is a guide that could help institutions develop their own monitoring and evaluation systems for their ICT projects. The system would be useful in evaluating new and on-going projects.

8.4.10 Improvement in communication between agricultural researchers and extension workers

It was observed that ICTs were yet to cement the linkage between agricultural researchers and extension workers which is crucial in the communication of agricultural information (see 8.2.2.6 and 7.4.3). A cordial and good working relationship among agricultural researchers and extension workers is a prerequisite to effective communication of agricultural technologies to the farmers. This may also enhance frequent use of ICTs in communication between and among the two groups of respondents. In this connection, regular forums facilitating interaction between agricultural researchers and extension workers should be intensified. Such forums include: 1) monthly workshops between agricultural researchers and extension workers at the district level; 2) conferences and workshops, 3) joint committees on research planning and evaluation; and 4) joint ICT training at the district level. The Ministry of Agriculture and KARI could also approach development partners to support ICT models that can enhance communication among agricultural researchers and extension workers. Such interactions may improve relationship and mutual respect among the respondents subsequently increasing the frequency of communication.

8.4.11 Networking and collaboration

The non-availability of ICT tools and services in most of the district and divisional agricultural offices and also in some of the research centres made it difficult for agricultural researchers, extension workers and other actors to network and collaborate (see sections 8.2.2.4, 8.2.2.7, 6.2.4, 6.3.7.3, and 7.10). KARI centres and district agricultural offices including the researchers and extension workers need to be increasingly linked to all important research and development institutions engaged in similar issues. Networking within the institutions should be improved so that email and Internet facilities are available to all researchers and extension workers. With the availability and access of Internet and email services researchers and extension workers would be able to communicate more frequently locally and internationally.

There is need for increased collaborative linkages between KARI and the Ministry of Agriculture and also with all actors involved in agricultural research and extension. The actors include NGO's, CBO's, Agro-chemical industries, stockists and traders, farmers association, universities, mass and print media and donor community among others. It is suggested that representatives of these organizations/institutions could be appointed to form a committee which could initiate the whole process of collaboration by coming up with a Memorandum Of Understanding (MOU). The MOU would stipulate the areas of collaborative linkages among the actors. The linkages may be categorized broadly to include: 1) research linkages; 2) extension and training linkages; 3) knowledge-seeking linkages; 4) service seeking/providing linkages; and 5) marketing linkages among others.

Studies (Ndungu, Nkonge and Rees 2000:8) have also shown that when actors do not collaborate they tend to provide information to farmers independent from one another. Such information may be overwhelmingly huge for the farmers and may end up confusing rather than helping them. Collaborative linkages would, therefore, ensure that farming community gets relevant and timely information in appropriate formats. In other words, all actors would participate in the process of catalyzing the adaptation and adoption of agricultural technologies and knowledge among the farming community. Such collaboration may also enhance development of appropriate ICT models for research and extension. The end result would be an improvement in agricultural production in the country.

8.4.12 Virtual Extension, Research and Communication Network (VERCON)

It was observed that ICTs were yet to bridge the gap between agricultural researchers and extension workers (see sections 8.2.2.6 and 7.4.3). It was further established that no effort has been made to develop a computer-based system that can link KARI and the Ministry of Agriculture and also agricultural researchers and extension workers. It is, therefore, recommended that KARI and the Ministry of Agriculture adopt VERCON system developed by FAO as a joint project between the Research, Extension and Training Division (SDR) and the World Agricultural Information Centre (WAICENT). According to O'Farrell (2003), VERCON is an Internet-based ICT system providing a potentially powerful tool for improving communication between research, extension and farmers. She observes that VERCON employs this potential to establish and strengthen linkages among and within the human and institutional elements of agricultural research and extension systems. She argues that the VERCON's innovative nature is its capability to achieve effective linkages by connecting geographically dispersed people and enhance a two-way communication process, managing large volumes of data, and rapidly collecting, processing and dispersing information in a variety of way. The system does this through two fully integrated and interdependent components – the human and technological. On the one hand, the human component is a network (of e.g. staff of research and extension institutions, faculties of agricultural education, NGOs and CBO's workers, agricultural producers) committed to strengthening collaboration, communicating, sharing information and supporting improved agricultural production. On the other hand, the technological component is a tool which allows members of the network to communicate and develop, share, store and retrieve information.

Collaborative linkages between KARI and Ministry of agriculture often occur at higher administrative levels. Agricultural researchers and extension workers at research centres, district and divisional agricultural offices have few opportunities for communicating with one another. Information flow within the institutions and between the staff is still largely dependent upon face to face meetings and infrequent use of ICTs such as telephone and email with supply of limited extension publications and audio-visual materials reaching frontline extension worker. It is recommended, therefore, that VERCON be adopted to improve linkages between research and extension in four pilot centres as the basis for creating a national electronic agricultural knowledge and information network. Initial discussion by this researcher with Clare O'Farrell from FAO indicate a likelihood of FAO funding part of the project.

The project will use Internet-based information and communication technologies to strengthen the national agricultural research and extension system and in particular to close the gap between researchers and extension workers by improving the generation, flow and sharing and collaborative use of agricultural knowledge and information. The network would help overcome the physical, administrative, knowledge and communication barriers that hinder interactions between researchers and extension workers, limit their ability to share competence, and ultimately reduce their impact on improving agricultural productivity and increasing farm incomes. The project is directed at human capacity building through improved and expanded access to agricultural knowledge and information. The VERCON project will specifically address the needs of small-scale farmers through the continuous flow of information from agricultural research through extension and ultimately to the end-users, farmers themselves.

8.4.13 Establishment of the Ministry of Information and Communication Technology

It was observed that many issues that need to be addressed at the national level have failed because of lack of a ministry to co-ordinate ICTs activities in the country (see sections 8.2.2.9 and 6.3.7.8). There is an urgent need, therefore, for the Kenya Government to think seriously of establishing a Ministry of Information and Communication Technology to coordinate the development of the ICT sector in the country. Currently this coordination is fragmented under the docket of multiplicity of ministries that include the Ministry of Tourism and Information, Ministry of Transport and Communication, Ministry of Panning and National Development, Ministry of Education, Science and Technology and the Ministry of Finance. This has made coordination of ICT sector to be poor and lacking in focus as many actors are implementing different things which are not harmonized. Without a ministry to coordinate the activities it would be difficult to implement the new national ICT policy once it is enacted. The role of the ministry would be to harmonize all the ICT activities in the country and coordinate development of the ICT sector.

8.5 Suggestions for further research

1. This study investigated diffusion of ICTs in communication of agricultural information among agricultural researchers and extension workers in the public agricultural sector in Kenya. It is suggested that another study should be conducted, focusing on agricultural researchers and extension workers in the private sector and the international organizations.

2. The present study investigated diffusion of ICTs among agricultural researchers and extension workers but left out farmers. A study thus needs to be conducted to investigate the use of ICTs, such as the radio and television in communication of agricultural information among the farming community.

3. Although this study investigated the use of the Internet by agricultural researchers and extension workers it did not evaluate its effectiveness. It is suggested therefore that a study be conducted to evaluate the effectiveness of the Internet as a source of information for agricultural researchers and extension workers.

4. It is furthermore suggested that a study should be conducted to focus on the dissemination of a particular agricultural innovation from generation to adoption by the farming community and evaluate the channels used at different phases of dissemination.

5. In the light of the above, a study should be also be conducted to asses and compare the application and use of ICTs among female and male in research and extension professions.

5. Finally, a study should be conducted to investigate diffusion of ICTs in the communication of agricultural information among rural women in Kenya.

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	Activity	WORKPLAN											
	Year 2002	Jan	Feb	Mar	Apr	May	Jun	Jul	Agu	Sep	Oct	Nov	Dec
1	**Proposal development and defence**				■	■							
2	**Chap. 1: Introduction and background Inform.**						■						
3	**Chap. 2: Agricultural Knowledge & Inform. Syst**							■					
4	**Chap. 3: Theoretical Framework**								■				
5	**Chap. 4: Literature Review**									■			
6	**Chap. 5: Research Design & Methodology**										■		
7	**Development of Research Instruments**											■	
8	**Pilot study**												■
	Year 2003												
8	**Field Work**	■	■	■	■	■	■						
9	**Chap. 6: Data analysis and Presentation**							■	■				
10	**Chap. 7: Discussions and Findings**									■	■		
11	**Chap. 8: Summary, Conclusions and Recomm.**											■	
12	**Thesis collation & Submission**												■
	Year 2004												
12	**Thesis collation & Submission**	■											
13	**Thesis Examination**		■	■									
14	**Thesis Correction and Binding**				■								
15	**Graduation**					■							

APPENDICES

Appendix A

A LIST OF INSTITUTIONS WHICH PARTICIPATED IN THE STUDY

Ministry of Agriculture and Rural Development
Kilimo House, Catheral Road
P.O. Box 320028
Nairobi.

The Agricultural Information Resource Centre
Waiyaki Way
P.O. Box 66730
Westlands, Nairobi.

Baringo District Agricultural, Livestock and Extension,
P. O. Box 4
Kabarnet.

Uasin Gishu District Agricultural, Livestock and Extension
P.O. Box 64
Eldoret.

The Kenya Agricultural Research Institute (KARI) head office
P.O. Box 57811
Nairobi, Kenya.

KARI National Agricultural Research Laboratories (NARL), Kabete
P.O. Box 14733
Nairobi.

KARI, National Dryland Farming Research Centre, Katumani
P.O. Box 340
Machakos.

KARI National Agricultural Research Centre,
P.O. Box 450
Kitale.

KARI National Veterinary Research centre, Muguga
P.O. Box 30148
Nairobi.

KARI National Agricultural Research Centre, Muguga
P.O. 30148
Nairobi.

KARI National Horticultural Research Centre, Thika
P.O. Box 220
Thika.

KARI National Range Research Centre, Kiboko
P.O. Box 12
Makindu.

KARI National Husbandry Research Centre, Naivasha
P.O. Box 25
Naivasha.

KARI National Fibre Research centre, Mwea Tebere
P.O. Box 298
Kerugoya.

KARI National Plant Breeding Research Centre, Njoro
Private Bag Njoro.

KARI National Potato Research Centre, Tigoni
P.O. Box 338
Limuru.

KARI National Pyrethrum Research Centre, Molo
P.O. Box 100
Molo.

National Sugar Research Centre, Kibos
P.O. Box 1221
Kisumu.

National Beef Research Centre, Lanet
P.O. Box 1679
Nakuru.

National Arid Lands Research Centre, Marsabit
P.O Private Bag
Marsabit.

KARI Regional Research Centre, Mtwapa
P.O. Box 16 Kikambala.

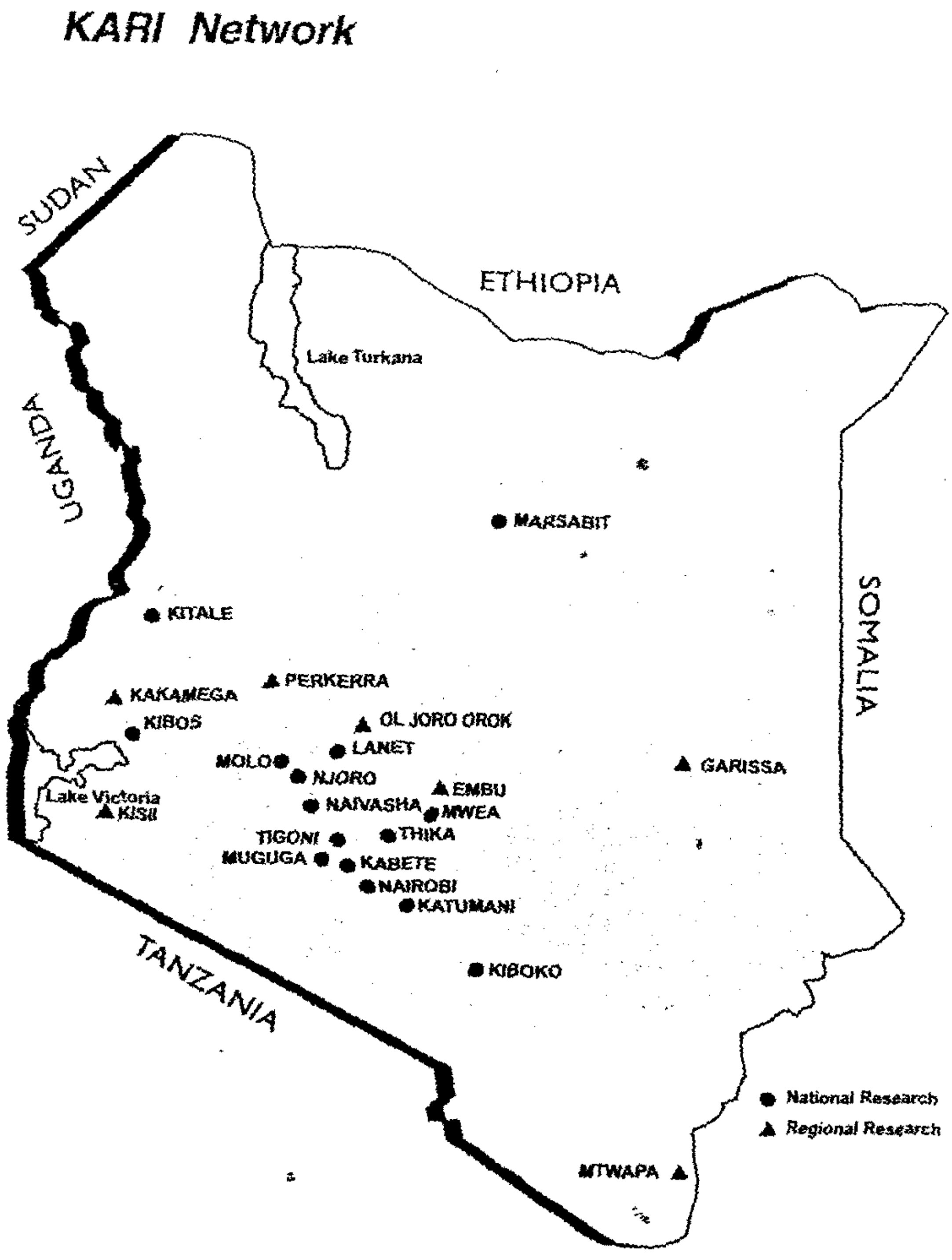
KARI Regional Research Centre, Kakamega
P.O. Box 169
Kakamega.

KARI Regional Research Centre, Kisii
P.O. Box 523
Kisii.

KARI Regional Research Centre, Perkerra
P.O. Private Bag,
Marigat.

Regional Research Centre, Garrissa
P.O. Private Bag
Garissa.

Appendix B


KARI Network
SUDAN
ETHIOPIA
UGANDA
SOMALIA
TANZANIA
Lake Turkana
Lake Victoria
MARSABIT
KITALE
PERKERRA
KAKAMEGA
KIBOS
OL JORO OROK
LANET
MOLO
NJORO
GARISSA
EMBU
KISII
NAIVASHA
MWEA
TIGONI
THIKA
MUGUGA
KABETE
NAIROBI
KATUMANI
KIBOKO
MTWAPA
National Research
Regional Research

Appendix C

JOSEPH KIPLANG'AT,
MOI UNIVERSITY,
FACULTY OF INFORMATION SCIENCE,
P.O. BOX 3900,
ELDORET.

EMAIL ADDRESS: jkngetich@yahoo.co.uk
TELEPHONE NO: 0321-43720
MOBILE PHONE: 0722-223-872
FAX NO: (0) 321-43047

Dear Respondent,

RE: QUESTIONNAIRE ADMINISTRATION

I am a lecturer in the Faculty of Information Science, at Moi University, Eldoret and currently a registered Ph.D. student at the University of Zululand, South Africa. I am conducting a study on 'Diffusion of Information and Communication Technologies (ICTs) in the communication of agricultural information among agricultural researchers and extension workers in Kenya.' This research is for doctoral studies. The findings of this study are expected to indicate the level of adoption, diffusion and use of ICTs in the agricultural sector. The study endeavours to come up with suggestions for improving adoption and use of ICTs in communication of agricultural information in the agricultural sector in Kenya.

In view of your knowledge, involvement and interest in agricultural field and activities, you have been identified to participate in the study. I am, therefore, kindly requesting you to spare some 15 minutes from your busy schedule and respond, as best as you can, to the items in the questionnaire. Most questions require you to simply tick the answers, while a few require short answers based on your views. The information provided will be treated with utmost confidentiality and will be used only for purposes of this study.

Thank you very much for your participation.

Yours faithfully,

Joseph Kiplangat

QUESTIONNAIRE FOR AGRICULTURAL RESEARCHERS AND EXTENSION WORKERS.

Most questions require you to tick the answers. Only a few require short answers to be filled. No names should be provided. The information you provide will be treated with utmost confidentiality.

SECTION ONE: PERSONAL INFORMATION

1. State the name of your research centre, district or/and divisional agricultural office:

....

2.Department/Section:..

3. Status: Agricultural researcher [ ]
Agricultural extension worker [ ]
Others, please specify...

4. Position:..

5. *Highest qualifications:* — country where qualifications were obtained

Certificate	[ ]	....
Diploma	[ ]	....
Bachelor's degree	[ ]	....
Post-graduate diploma	[ ]	....
Masters degree	[ ]	....
Doctoral degree	[ ]	....

Others, please specify ....

6. Age:
20-29 years [ ]
30-39 years [ ]
40-49years [ ]
over 50 years [ ]

8. Gender: Male [ ] Female [ ]

SECTION TWO: INFORMATION NEEDS

9. What is the nature of your work (E.g. plant breeder; agronomist)? ....
....

10. What kind of information would you need in your research/extension work (you can select more than one).

Agronomy	[ ]	Bee keeping	[ ]
Seed technology	[ ]	Poultry development	[ ]
Soil science	[ ]	Agroforestry	[ ]
Plant breeding	[ ]	Water harvesting	[ ]
Plant pathology	[ ]	Irrigation and drainage	[ ]
Horticulture	[ ]	Dairy cattle	[ ]
Crop protection	[ ]	Dairy goats	[ ]
Agricultural marketing	[ ]	Fruit processing	[ ]
Credit sources and cooperatives	[ ]	Post harvesting	[ ]
Animal breeding	[ ]	Range management	[ ]
Animal health	[ ]	Small ruminants	[ ]
Fish farming	[ ]	Energy conservation	[ ]

Others, please specify:...

11. Whenever you need information what sources do you consult first.

Printed sources (E.g. books and periodicals) [ ]
Electronic sources on CD-ROM [ ]
Electronic sources via Internet [ ]
Others, please specify: ....

SECTION THREE: AVAILABILITY, ACCESS AND USE OF ICTs TOOLS AND SERVICES

12. Which of the following ICTs tools and services are available to you in your institution/organization.

ICTs tools and services	Available	Not Available
Computers		
Internet		
Email		
Electronic journals		
CD-ROM databases		
Desktop publishing		
Geographic Information systems (GIS)		
Fax		
Telephone		
Mobile phone		
Television		
Video		
Radio		

Others, please specify: ....

13. How do you rate the accessibility of ICTs tools and services in your institution?

ICTs tools and services	Very accessible	Accessible	Less accessible	Not accessible
Computers				
Internet				
Email				
Electronic journals				
CD-ROM databases				
Desktop publishing				
Geographic Information Systems				
Fax				
Telephone				
Mobile phone				
Television				
Radio				
Video				

Others, please specify: ....

14. For what purposes do you use the above ICTs tools and services (you may select more than one)
To communicate with agricultural researchers [ ]
To communicate with extension workers [ ]
To communicate with Farmers [ ]
To communicate with friends and relatives [ ]
To collaborate with colleagues world-wide [ ]

To disseminate agricultural information [ ]
For research purposes [ ]
For educational purposes [ ]
For publishing [ ]
Others, please specify: ....

15. Which of these ICTs tools/services do you consider effective in disseminating agricultural information.

ICTs tools and services	Very effective	Effective	Less effective	Not effective
Internet				
Email				
Electronic journals				
CD-ROM databases				
Desktop publishing				
Geographic Information systems				
Fax				
Telephone				
Mobile phone				
Radio				
Television				
Video				

Others, please specify: ....

16. Do you think the use of ICTs tools and services has facilitated communication of agricultural information?

Strongly agree [ ]
Agree [ ]
Undecided [ ]
Disagree [ ]
Strongly disagree [ ]

SECTION FOUR: SKILLS, COMPETENCIES AND USE OF ICTS TOOLS AND SERVICES

17. How do you rate your computer skills?
Excellent [ ]
Very good [ ]
Good [ ]
Enough to make me work [ ]
Poor [ ]
None [ ]

18. How do you rate your Internet skills?
Excellent [ ]
Very good [ ]
Good [ ]
Enough to make me work [ ]
Poor [ ]
None [ ]

19. Do you need more training in (you may select more than one)
Computer skills [ ]
Internet skills [ ]
None [ ]

To disseminate agricultural information [ ]
For research purposes [ ]
For educational purposes [ ]
For publishing [ ]
Others, please specify: ....

15. Which of these ICTs tools/services do you consider effective in disseminating agricultural information.

ICTs tools and services	Very effective	Effective	Less effective	Not effective
Internet				
Email				
Electronic journals				
CD-ROM databases				
Desktop publishing				
Geographic Information systems				
Fax				
Telephone				
Mobile phone				
Radio				
Television				
Video				

Others, please specify: ....

16. Do you think the use of ICTs tools and services has facilitated communication of agricultural information?

Strongly agree [ ]
Agree [ ]
Undecided [ ]
Disagree [ ]
Strongly disagree [ ]

SECTION FOUR: SKILLS, COMPETENCIES AND USE OF ICTS TOOLS AND SERVICES

17. How do you rate your computer skills?
Excellent [ ]
Very good [ ]
Good [ ]
Enough to make me work [ ]
Poor [ ]
None [ ]

18. How do you rate your Internet skills?
Excellent [ ]
Very good [ ]
Good [ ]
Enough to make me work [ ]
Poor [ ]
None [ ]

19. Do you need more training in (you may select more than one)
Computer skills [ ]
Internet skills [ ]
None [ ]

20. How did you learn to use computer and the Internet?

Self-study [ ]
From colleagues [ ]
In-house course offered by the institution [ ]
In-house course offered by the library [ ]
Training abroad [ ]
Other, please specify...

21. How much time do you spend on the Internet for work and communication purposes per week?

None [ ]
1-5 hours [ ]
6-10 hours [ ]
11-15 hours [ ]
More than 16 hours [ ]

22. How often do you use the following Internet services?
5=daily, 4=weekly, 3=monthly, 2=occasionally, 1=never

Internet service	Daily	Weekly	Monthly	Sometimes	Never
World Wide Web					
Email					
Discussion groups					
Library online public access catalogue					
Agricultural electronic journals					
Agricultural on-line databases					
Agricultural based information gateways					
Mailing lists					
Downloading software					
Others (specify)					

23. Are you able to get the information you need from the Internet and CD-ROM databases?

Always [ ]
Often [ ]
Sometimes [ ]
Never [ ]

24. How useful to your work is the electronic information you obtain from the Internet and CD-ROM databases?

Very useful [ ]
Useful [ ]
Sometimes useful [ ]
Not useful [ ]

25. If your information needs are not met via ICTs (E.g. the Internet), what other sources do you consult?

Printed information (e.g. periodicals, books) [ ]
Colleagues [ ]
Experts [ ]
Others, please specify...

26. Are you able to search for information independently from the Internet and CD-ROM databases?

Always [ ]
Often [ ]
Sometimes [ ]

Never [ ]

27. How often do you seek for assistance to search the Internet and CD-ROM databases either from systems administrator, librarian or colleagues?
    Always [ ]
    Often [ ]
    Sometimes [ ]
    Never [ ]
28. Do you think Internet and other forms of ICTs have increased your work productivity and creativity?
    Strongly agree [ ]
    Agree [ ]
    Undecided [ ]
    Disagree [ ]
    Strongly disagree [ ]

29. How often do you use mobile phone in communicating agricultural information?
    Quite often [ ]
    Often [ ]
    Sometimes [ ]
    Never [ ]

30. If you do not use your mobile phone, what are the reasons? ....
....
....
31. Does your institution/organization collaborate with any TV or Radio station in disseminating agricultural information to the farming community? Yes [ ] No [ ]

32. If your answer to above question is Yes, outline the name(s) of the TV and/or Radio stations and the agricultural programmes they broadcast ....
....
....

Sustainability and Costs of ICTs
33. How do you rate the cost/affordability of the following ICTs tools and services in communicating agricultural information?

ICTs tools and services	Very costly	Costly	Less costly	Affordable
Computers				
Internet				
Email				
Electronic journals				
CD-ROM databases				
Desktop publishing				
Fax				
Telephone				
Mobile phone				
Radio				
Television				
Video				

Others, please specify: ....

34. Comment on sustainability of ICTs tools and services in your institution..................................
....
....

Perception of ICTs tools and services

35. How do you rate the effectiveness of methods/techniques used to create awareness of new ICTs tools and services in your institution.
    Very effective [ ]
    Effective [ ]
    Somewhat effective [ ]
    Not effective [ ]

36. Have ICTs changed the way you seek for information from libraries and information centres?
    Yes [ ] No [ ]

37. If yes, please indicate how...
....
....

38. Have ICTs changed the way you communicate agricultural information to others?
    Yes [ ]
    No [ ]

39. If yes, please explain how...
....
....

40. In your opinion, what limitations (constraints) affect the use of ICTs in your institution/organization?
....
....
....
....
....

41. What recommendations do you propose to improve the application and use of ICTs in your institution/organization? (you may use back of this page for additional information).
....
....
....
....
....
....
....
....
....
....
....

42. Outline other methods/modes of communicating agricultural information to farming community (e.g. Field days, Demonstration, ASK shows etc.) ....

....

....

....

....

....

THANK YOU VERY MUCH FOR PARTICIPATING AND COMPLETING THE QUESTIONNAIRE

Appendix D.

INTERVIEW SCHEDULE IT MANAGERS/ SYSTEMS ADMINISTRATORS

1.General information
   i) Name of the institution
   ii) Name of the person being interviewed (optional)
   iii) Position (designation)

2. What type of ICT infrastructure does your institution have?
   Stand alone computers (number and ratio per staff)
   Local area networks
   Types and characteristics of Modems, routers
   Multimedia technology
   Others, please specify

3.. When did your institution adopt the use of ICTs?

4. How were staff prepared to use the new technology?

5. How do you plan to spread the adoption and use of ICTs by agricultural researchers and extension workers?

6. What type of carrier technology is being used?
   VSAT
   Wireless technology
   Fiber-optic
   Unshielded twisted pair
   Coax etc.
   Others, please specify

7. Provide a complete list of operating systems with their version available in your institution.

8. Provide a complete list of all applications programs available in your institution.

9. Does your institution have email services?

10. Does your institution have Internet services?

11. What type of Internet connectivity does your institution have? e.g.
   -Dedicated line connection
   - Dial up connection
   - Satellite connection
   - Radio connection

12. Is your institution connected to regional or international networks (E.g. CGIAR)?

13. Comment on the quality and use of Internet in your institution.

14. What is the average number of hours per week on use of the Internet for each of your staff?

15. What is the number of user's accounts?

16. State the average number of times the Internet is down per week?

17. What are the causes of down times?

18. What type of PABX is used in your institution (digital or analogue)?

19. Does your institution provide staff with cellular phones (Mobile) and other radio links for communicating agricultural information?

20. What is the number of telephone and fax lines in your institution?

21. How many television sets and radios do you have in your institution? For what purpose are they used?

22. Explain the areas where ICTs are applied in your institution (e.g. research, personnel records, finance, internal and external communication, communication of agricultural information).

23. Does your institution have enough IT specialist staff?

24. Does your institution have a separate ICT budget available?

25. How does the ICT budget take into account the following:
    - Hardware and software acquisition (percentage %)
    - Hardware and software maintenance (percentage %)
    - Software license (percentage %)
    - ICT user training (percentage %)
    - Communication fees (ISP connectivity, telephone)

26. Is your ICT budget decentralised per research centre/department or is it centralised?

27. State the approximate percentage of your institution budget on ICT (2002, 2001, and 1999)

28. What are the problems in the application and use of ICTs in your institution? In terms of:
    Technical constraints
    Telecommunication and other relevant infrastructure
    Bandwidth
    Electricity supply
    Human resources development and sustainability
    Enabling environment
    ISP
    Telecommunication and ICTs policy
    Funding
    Costs of maintenance
    Resistance
    Awareness of ICTs tools and services
    Others, specify

29. What recommendations do you propose to improve ICTs application and use in your institution?

Appendix E

INTERVIEW SCHEDULE FOR POLICY MAKERS

1.General information
- i) Name of the institution
- ii) Name of the person being interviewed (optional)
- iii) Position (designation)
- iv) Nature of research/activities of the institution
- v) Number of staff
- vi) Departments

2. Explain the nature and types of ICTs in your institution?

3. When did you adopt the use of ICTs in your institution?

4. What were the reasons for adopting ICT use in your institution? Do you think adopted ICTs are fulfilling their intended objectives?

5. How was funding secured for the initial costs of ICTs installation?

6. How were staff prepared to use the new technology?

7. Outline how your institution plan to spread the adoption and use of ICTs among agricultural researchers and extension workers.

8. Explain the areas where ICTs are applied in your institution (e.g. research, personnel records, finance, internal and external communication, communication of agricultural information).

9. To what extent are ICTs used in communication of agricultural information?

10. Does your institution have an ICTs Advisory Committee?

11. What are the roles and functions of this Advisory Committee?

12. How many IT specialist staff have you employed? What are their job descriptions?

13. Do you have an institutional ICT policy? If yes, what are its contents?

14. How does your policy relate to the Government ICT policy?

15. Does your institution have a separate ICT budget?

16. How does the ICT budget take into account the following:
- -Hardware and software acquisition (percentage %)
- -Hardware and software maintenance (percentage %)
- -Software license (percentage %)
- -ICT user training (percentage %)
- -Communication fees (ISP connectivity, telephone)

17. State the approximate percentage of your institution budget on ICT (2002, 2001, and 1999)

18. Is your ICT budget decentralised per research centre/department or is it centralised?

19. What are the problems in the application and use of ICTs in your institution? In terms of:

    Technical constraints
    Telecommunication and other relevant infrastructure
    Bandwidth
    Electricity supply
    Human resources development and sustainability
    Enabling environment
    ISP
    Telecommunication and ICTs policy
    Funding
    Costs of maintenance
    Resistance
    Awareness of ICTs tools and services
    Others, specify

20. What recommendations do you propose to improve ICTs application and use in your institution?

Appendix F

INTERVIEW SCHEDULE FOR LIBRARIANS

1.General information
   i) Name of the institution
   ii) Name of the person being interviewed (optional)
   iii) Position (designation)

2. Comment on the nature and types of ICTs in use in the library.

3. When did the library adopt the use of ICTs ?

4. Are your library services fully automated?

5. What library automation package is in use in the library?

6. Is the library linked to the institution network?

7. Can users access OPAC from their offices?

8. Is the library connected to the Internet?

9. Does the library provide email services?

10. How were the library staff and users prepared to use the new technology?

11. To what extent does the users make use of OPAC and the Internet?

12. Is the library connected to regional or international networks (E.g. CGIAR)?

13. Does the library subscribe to electronic journals or/ and host databases (E.g. TEAL)?

14. Which CD-ROM titles are available in the library?

15. Comment on the use of electronic journals by users.

16. Does the library staff assist the users to access electronic information resources?

17. Does the library provide users with training on the use of Internet and other forms of ICTs?

18. Does the library provide electronic document delivery service?

19. How does the library create awareness among the users on new ICTs tools and services?

20. Does the library have a separate ICT budget or is incorporated in the main library budget?

21. How does the budget take into account the following:
   -Hardware and software acquisition (percentage %)
   -Hardware and software maintenance (percentage %)
   -Software license (percentage %)

-ICT user training (percentage)
-Communication fees (ISP connectivity, telephone)

22. State the approximate percentage of your library/ICT budget on ICT (2002, 2001, and 1999)

23. *What are the problems in the application and use of ICTs in your institution? This is in terms* of:

    Technical constraints
    Telecommunication and other relevant infrastructure
    Bandwidth
    Electricity supply
    Human resources development and sustainability
    Enabling environment
    ISP
    Telecommunication and ICTs policy
    Funding
    Costs of maintenance
    Resistance
    Awareness of ICTs tools and services
    Others, specify

24. What recommendations do you propose to improve ICTs application and use in the library and parent institution?

Appendix G.

Self-Participation Observation Guide

Purpose

To examine the nature, types, distribution and accessibility of ICTs among institutions surveyed.

Observer: Self

Date of Observation:

Name of Institution:

A. Nature and Types of ICTs

1. Type of ICT infrastructure e.g. stand alone, LAN
2. Type of carrier technology being used e.g. Fibre optic, wireless etc.
3. Nature and types of ICTs available (List)
4. Application and use of the available ICTs
5. Hardware and software used (list)

B. Distribution of ICTs

1. In offices
2. In departments/sections
3. Accessibility of ICTs by staff

C. Management and coordination of ICTs

1. IT personnel
2. Section coordinating ICTs use
3. Relationship of the section and the library/ information services

D. Nature, types and access of ICTs tools and services available in libraries/information centres

1. Internet and email services
2. CD-ROM databases
3. Electronic journals
4. In-house databases
5. Automation of services
6. Accessibility of the services by users

E. Observed problems in work place

1. Name of the institution and problems observed

Appendix H

RESERCH PERMIT AND REQUEST LETTERS TO INSTITUTIONS SURVEYED

PAGE 2

This is to CERTIFY THAT:

Prof./Dr./Mr./Mrs./Miss JOSEPH KIPLANGAT

of (Address) MOI UNIVERSITY

P.O. BOX 3900 ELDORET

has been permitted to conduct research in

Location,

ALL District,

ALL Province,

on the topic DIFFUSION OF INFORMATION AND COMMUNICATION TECHNOLOGIES (ICTS) AMONG AGRICULTURAL RESEARCHERS AND EXTENSION WORKERS IN KENYA

for a period ending 30th June 19 2003

PAGE 3

Research permit No. MOEST 13/001/24C 206

Date of issue 4th December, 2002

Fee received Shs. 1000

Applicant's Signature

A. G. KAARIA
Permanent Secretary,
Office of the President
EDUCATION

MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY

Telegrams: "EDUCATION", Nairobi
Telephone: Nairobi 334411
When replying please quote
Ref. No. MOEST 13/001/24C 206/6
and date

JOGOO HOUSE "B"
HARAMBEE AVENUE
P.O. Box 30040
NAIROBI

3rd December 20 02

Joseph Kiplangat
Moi University
P.O. BOX 3900
ELDORET

Dear Sir

RE: RESEARCH AUTHORISATION

Following your application for authority to conduct research on 'Diffussion of information and Communication Technologies (ICTS) in Communication of Agricultultural Reseachers and Extensions workers, I am pleased to inform you that you have been authorised to conduct research in all Provinces for a period ending 30th June, 2003.

You are advised to report to all the District Commissioners, all the District Education Officers and all the District Agricultural Officers before embarking on your study.

Upon completion of your research project, you will be expected to avail two copies of your research findings to this Office.

Yours faithfully

for A. G. KAARIA
FOR: PERMANENT SECRETARY/EDUCATION

CC
All the District Commissioners

All the District Education Officers

All the District Agricultural Officers

MOI UNIVERSITY
DEPARTMENT OF LIBRARY & INFORMATION STUDIES

Tel. (0321) 43166
(0321) 43720 Ext.321/316
Fax (0321) 43047/43360

P. O. Box 3900
Eldoret Kenya

Date: 11th December, 2002
Ref: MU/FIS/LIS/FR/2002

The Director,
Kenya Agricultural Research Institute,
P.O. Box 57811,
NAIROBI.

Dear Sir/Madam,

RE: PERMISSION TO CARRY OUT FIELD RESEARCH AT KARI

Mr. Joseph Kiplangat is a member of the academic establishment of Moi University attached to the Department of Library and Information Studies. He is presently carrying out a PhD programme in Information Sciences. As part of this programme, he is required to carry out field research. Your Institution has been selected as one of the places he plans to carry out his field research.

In this connection, it should be greatly appreciated if you would accord him the opportunity to collect the data there.

Thanking you for your cooperation in this regard.

Yours faithfully,

DR. J. OTIKE
HEAD, DEPT. OF LIBRARY AND INFORMATION STUDIES

/apa

MOI UNIVERSITY

DEPARTMENT OF LIBRARY & INFORMATION STUDIES

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Eldoret Kenya

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Date: 11th December. 2002
Ref: MU/FIS/LIS/FR/2002

The Director of Agriculture,
Ministry of Agriculture,
Kilimo House,
P.O. Box 30028,
NAIROBI.

Dear Sir/Madam,

RE: <u>FIELD RESEARCH BY MR. JOSEPH KIPLANGAT</u>

I would like to introduce you to Mr. Joseph Kiplangat, a member of staff of Moi University attached to the Department of Library and Information Studies.

Mr. Kiplangat is presently carrying out a PhD programme in Information Sciences. As part of his PhD programme, he is required to carry out field research. Your department has been chosen as one of the areas where data collection will be carried out. In this connection, it should be greatly appreciated if you would allow him to carry out this exercise there.

Thanking you for your cooperation in this regard.

Yours faithfully,

DR. J. OTIKE
HEAD,
<u>DEPARTMENT OF LIBRARY & INFORMATION STUDIES</u>

/apa