

**Academic research collaborations in  
Kenya: structure, processes and  
information technologies**

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## **ABSTRACT**

This thesis is an investigation of the organisation and conduct of academic research collaborations in Kenya and the factors shaping them. This contributes to an understanding of the status and processes involved in collaborative research, and how this is affected by the associated research environments, important in informing best practice in improving and promoting collaborative research. Information and Communication Technologies (ICTs) have become indispensable tools for supporting collaborative work. This thesis also discusses the role ICTs are playing in collaboration processes, and the factors contributing to their adoption and use within the studied community. Factors and variables identified as affecting the processes of collaborative research from a range of models, theories and frameworks in past studies were analysed for their effects within the Kenyan context. A mixed methods research design was adopted. Data collection involved a quantitative survey involving 248 academic members of staff in four disciplines across four major Kenyan universities. This was supplemented by semi-structured in-depth interviews with selected individuals within the studied population. In addition, this was complemented by an extensive document review that targeted university websites, repositories and policy documents.

The study reveals a relatively high level of collaborative research, in contrast to past studies that indicate low levels of research networking in Africa. However, this varies across disciplinary areas. There is evidence of cross disciplinary and cross institutional research, with a relatively high number of connections observed outside academia. Key factors that emerged as affecting the organisation and conduct collaborative research are grouped into five major categories: resource availability, personal factors, institutional factors, disciplinary factors and technological factors. Resource dependence, especially access to funding emerged as having the strongest influence on decisions to collaborate for this community. This was attributed to low levels of investment in funding research, at both the national and institutional level. At the institutional level, inadequate policies, high levels of bureaucracy, competition among local institutions and weak links with industry were identified, among others, as presenting barriers to collaborative research. Researchers reported lacking time for research, mainly attributed to universities' major focus on teaching. Limited access to digital resources and lack of research information systems affected information access. Problems of internet connectivity, lack of awareness of a variety of technologies, culture of use environments and nature of work affected adoption and use of ICT for support of the various collaboration processes. All these contextual issues informed the resulting model of factors that affect collaborative research in Kenya. The model could be used as a guide to investigating factors affecting knowledge production processes in developing world context exhibiting similar characteristics. A set of recommendations and guidelines is presented, which could act as a reference point for improving research collaborations not only in Kenya, but also the wider developing world.

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## **LIST OF ACRONYMS AND ABBREVIATIONS**

AAU - Association of African Universities  
AKTP - Africa Knowledge Transfer Partnership  
AU - African Union  
CORDIS - Community Research and Development Information Service  
CCK - Communications Commission of Kenya  
CHE - Commission for Higher Education  
CMC - Computer Mediated Communication  
CSCW - Computer Supported Cooperative Work  
CUE - Commission of University Education  
DOI - Diffusion of Innovation  
ESRC – Economic and Social Research Council  
FOS - Field of Science  
Gbps - Gigabits per second  
GCI - Global Competitive Index  
GDP- Gross Domestic Product  
HDI - Human Development Index  
HEFC - Higher Education Funding Council  
HEI- Higher Education Institution  
HEP -High Energy Physics  
HESA - Higher Education Statistics Agency  
HINARI - Health Internetwork Access to Research Initiative  
IBM - International Business Machines Corporation  
ICT- Information and Communication Technology  
IDG - Internet Discussion Groups  
IDRC- International Development Research Centre  
ILRI - International Livestock Research Institute  
IFS - International Foundation for Science  
IMS - Instant Messaging Service  
INASP - International Network for the Availability of Scientific Publications  
IP - Intellectual Property  
ISP - Internet Service Providers  
IST-Africa - Information Society Technologies in Africa  
ITR - Information Technology Research  
ITU – International Telecommunication Union  
JKUAT - Jomo Kenyatta University of Agriculture and Technology

Kbps - Kilobits per second  
KENET - Kenya Education Network  
KNLS - Kenya National library services  
KU - Kenyatta University  
LDCs - Least Developed Country  
Mbps – Megabits per second  
RMIS- Research management information systems  
MOHEST - Ministry of Higher Education, Science and Technology  
MoU - Memorandum of Understanding  
MU - Moi University  
NACOSTI - National Commission for Science, Technology and Innovation  
NCST – National Council for Science and Understanding  
NGO – Non-Governmental Organisation  
NOFBI - National Optic Fiber Backbone Infrastructure  
NREN - National Research and Education Network (NREN)  
NSF - National Science Foundation  
OECD - Organization for Economic Cooperation and Development  
PEOU - Perceived ease of use  
PU - Perceived usefulness  
RAE - Research Assessment Exercise  
RCUK - Research Councils in the UK  
R&D - Research and Development  
SNA - Social Network Analysis  
SPSS – Statistical Package for the Social Sciences  
STI – Science, Technology and Innovation  
TAM - Technology Acceptance Model  
TENET – Tertiary Education and Research Network of South Africa  
UNDP – United Nations Development Programme  
UNESCO – United Nations Educational, Scientific and Cultural Organisation  
UIS - UNESCO Institute for Statistics  
UON – University of Nairobi  
USAID – United States Agency for International Development  
UTAUT - Unified Theory of Acceptance and Use of Technology  
VOIP – Voice Over Internet Protocol  
VRE – Virtual Research Environment  
WEF - World Economic Forum

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## **DEDICATION**

In loving memory of my father, Cyprian Mbogo Muruathama. Daddy, I miss you every day and know that you are looking down on me through very proud eyes.

## **DECLARATION**

I declare that the research contained in this thesis, unless otherwise formally indicated within the text, is the original work of the author. The thesis has not been previously submitted to this or any other university for a degree, and does not incorporate any material already submitted for a degree.

Signed:

Dated:

# **CHAPTER 1: INTRODUCTION**

## **1.1 BACKGROUND AND CONTEXT OF THE STUDY**

Collaboration in research has become an integral component of today's knowledge production process. This is reflected in past studies that record a gradual increase in collaborative research over the years. For example, using co-authorship as a measure of collaboration, statistics from the National Science Board (2010) show that co-authored articles grew from 40% of the world's total science and engineering articles in 1988 to 64% in 2008. This increase has been attributed to a continued evolution in the knowledge production process, referred to by Gibbons et al., (1994) as Mode 2. This mode is characterised by the interaction and working together of many distributed actors to address challenging interdisciplinary problems as opposed to the traditional mode, Mode 1. Mode 1 is entrenched in disciplinary cultures and is highly institutionalised (Gibbons et al., 1994).

On a similar note, Walsh & Maloney (2007) attribute the increase in collaboration to factors like solving global problems that span disciplines and nations, such as climate change, and advances in ICT that make remote collaborations easier. This has seen a growing interest in collaborative research by policy makers and funding bodies, who are increasingly aligning their research policies in its favour, based on an underlying belief in the associated benefits. The benefits include use for diverse range of skills and expertise, and access to resources and special equipment not locally available (Katz & Martin, 1997; Beaver, 2001), personal gains such as increased visibility and recognition, intellectual companionship (Beaver, 2001; Melin, 2000) and higher productivity (Sooryamoorthy & Shrum, 2007; Lee & Bozeman, 2005). This interest is seen in the funding programs by Research Councils in the United Kingdom (RCUK), who Becher & Trowler (2001) note have increasingly favoured collaborative research since the 1990s. An example is the EPSRC's IT-Centric Interdisciplinary Research Collaborations (IRCs) established in 2000 to support interdisciplinary research across institutions and organisations (EPSRC, 2007). Another example is the National Science Foundation (NSF) programs in the US such as the Knowledge and Distributed Intelligence initiative, initiated in 1998 to support cross-disciplinary research across scientific and engineering communities (NSF, 2014). The same trend is observed in some developing countries, whereby in Kenya, for example, the research financing arm of the Ministry of Higher education, Science and Technology, the National Council for

Science and Technology (NCST) requires a research proposal to be multidisciplinary and cross-institutional to be considered for funding (NCST, 2012) .

However, the level of attainment of the benefits is dependent on the context within which research is done. This context includes the social, institutional and technical environments. It differs between regions, countries and even individual institutions, and determines the levels, structures and processes involved in the conduct of collaborative research. Developing effective strategies to improve and support collaborative research requires an understanding of the particular research environment, and the effects it has on the individual and collaborative research.

Increased growth in collaborative work has been matched by an increasing demand in use of information and communication technologies (ICTs) to support the new modes of knowledge production. Their importance in research work is not only recognised by researchers alone but, as noted by Vasileiadou (2009), also by funding bodies and science policy makers. An example is the establishment of the National Centre for e-Social Science in the UK by the Economic and Social Research Council (ESRC), set up to promote use of digital technologies within social science research. Benefits associated with use of such technologies to support research work include reduction in organisational and communication problems (Walsh & Maloney, 2007; Duque et al., 2005) and extension of their networks (Gruzd et al., 2012; Ynalvez & Shrum, 2011). ICT use has also been associated with increased productivity (Lee & Bozeman, 2005). Access to existing body of knowledge and information, and dissemination processes are fundamental to the knowledge production processes. ICTs play a major role in facilitating these processes. However, how ICTs are adopted and used for is heavily dependent on access to the ICT facilities, largely defined by national and institutional ICT environments. In addition, demand for their use is defined by work attributes (Birnholtz, 2007; Fry & Talja, 2007; Fry, 2006), the cultural environments of the researchers, and their *perceived usefulness*, as referred to by Davis (1989), among other factors. Borgman (2007) notes the need to understand the conduct of the research processes in determining tools and services that are most useful to the researcher. Identifying how the processes involved in a collaboration and research environment factors affect adoption and use of ICT, as well as factors influencing individual choices would help in specifying technological needs of this kind of group, thus development of technologies that would be useful to them.



## **1.2 STATEMENT OF THE PROBLEM**

A literature review identified a dearth of studies on collaborative research in developing countries, and specifically Kenya. Although scientific collaboration is a multidisciplinary and widely researched field of study, many studies in this area have focused on research collaborations in the developed world. As noted by Ynalvez & Shrum (2011), reference to the issue in developing countries is mainly based on assumptions that need verification. Such reference includes generalisations made from bibliometric analysis in international databases, which point to low levels of research, networking and productivity from Africa. For example, the Global Research Report Africa, which is part of a series launched by Thomson Reuters to inform policymakers and others about the landscape and dynamics of the global research base, indicates that between 1999–2008, Africa produced 27,000 publications per year indexed on Thomson Reuters Web of Science databases. This is about ‘the same volume of published output as the Netherlands’ (Adams et al., 2010). Bibliometric measures, on which much of the statistics are based, have been accused of under-representing research done in Africa. However, the seemingly low levels of research from developing nations as indicated by the publication productivity statistics raises a need to establish the status of research in these countries.

The Globalization of Science project, headed by Wesley Shrum, has carried out a series of studies generally on organisation of science in selected countries across Africa, among them Kenya. However, their studies are not focused specifically on the process of research collaboration, and their measures of ICT use are examined not within the context of collaborative research, but on general use. Addressing the issues raised by research collaborations requires an understanding of the collaboration process itself, noting that research environments vary. What works for the scientific research community in a certain region may not work in the context of another exhibiting different characteristics, whether political, social, economic or infrastructural. It is only through an assessment of the processes of knowledge production within a particular context that one would be able to understand how interactions between the various components of the research system shape the conduct of the actors in the system, to promote or inhibit growth. A study of literature identified a gap in knowledge that provides an understanding of the nature and conduct of collaborative research in Kenya. This conduct includes the use of ICTs, which have been referenced as critical to today’s knowledge production processes (Gibbons et al., 1994; Borgman, 2007), to support

collaborative research. Though a number of studies on proliferation of the internet in developing regions exist, use within the context of research collaboration has hardly been studied. For this to be understood within this context it was found necessary to understand the usage behaviour and aspects of the individual and work environments that influence the use practices.

A problem also arises in the methods used to study research collaborations and their applicability in developing countries. As noted above, bibliometric measures that mainly derive their data from research output available in international databases are the most commonly used indicators of collaboration and productivity. In developing areas, more priority may be towards research that addresses local needs such as poverty, food security and disease control and may result in much of the output being published locally, rather than in international journals (Ynalvez & Shrum, 2011; Harle, 2010). Such measures have been accused of not being representative enough of research done in developing areas. On the other hand, not all collaborations necessarily result in publications. Information available in university repositories and available curriculum vitae (CV) has also been used as ways to establish levels of scientific output, such as in Bozeman & Corley (2004). However, Ynalvez & Shrum (2011) caution on availability of updated records with this method. A careful consideration of methods that would yield a more accurate representation of the nature and structure of research collaborations within a particular context is needed in such investigations.

Considering the arguments for or against the various methods identified in literature, and on carrying out a preliminary study on availability of records online, this study settled for self-reported measures of collaboration as the main method in establishing the level and nature of collaborative ties. Supplementary information in CVs and university repositories was used to confirm details of those who were indicated as collaborators and were not part of the sample. This gave way for a more detailed exploration through the interviews. The factors investigated were drawn from a range of studies, frameworks and models in literature, and investigated for their effects on collaborative research in Kenya. In the process, factors specific to the Kenyan context were identified.

In this study, collaboration is defined as an interaction between two or more individuals, whether locally or remotely, working closely together in a research project, to achieve a common goal(s). The individuals can be within or across departments,

universities or organisations, or even international. The study therefore focuses on research collaboration at the individual level. An individual is the basic unit that forms a collaboration, and as Bozeman & Corley (2004) put it, ‘many of the factors governing individual scientists collaboration choices remain very much within control of the individual, especially when the researcher works in an academic institution’ (p. 600). Research needs and objectives vary between individuals, departments and universities, and a focus on the individual aids in understanding the specific choices and constraints involved. This need to understand the role of the individual in shaping their research career and productivity forms part of the basis for the motivation to carry out this research.

My background of being a Kenyan, an academic member of staff and upcoming researcher in one of the public universities in Kenya raises my awareness on the role that research plays in national development. I was curious to understand the level and type of research that was being conducted in Kenyan universities. Having some firsthand experience of general problems experienced within university environments heightened my interest in wanting to find out the particular issues researchers faced within their research environments and how these issues affected their conduct or desire to conduct research.

### **1.3 RESEARCH AIMS, OBJECTIVES AND QUESTIONS**

This study was therefore aimed at understanding the process of collaborative research in Kenya with a focus on two major aspects:

- Firstly, the organisation of collaborative research including levels, structure of interactions, collaboration processes and practices and associated factors.
- Secondly, given the important nature of ICT in supporting the collaboration activities, the study was also aimed at exploring the role of ICT in the collaboration process.

The study therefore sought to meet the following objectives:

1. To review relevant literature to identify factors affecting the structure and process of research collaborations, including the adoption of ICTs.
2. To understand the basics and mechanisms of collaborative research in Kenya in terms of form, levels and processes involved in academic networking.

3. To analyse factors affecting the levels, structure and conduct of academic research collaborations in Kenya.
4. To investigate how ICTs are being used to support collaborative research in Kenya.
5. To analyse factors shaping the adoption and use of ICTs for research collaborations in Kenya.
6. To assess the benefits of collaboration and ICT use on research productivity
7. To produce a set of recommendations towards promotion and improvement of research collaborations in Kenya.

Objectives one, two and three mainly address the first aim (on structure and organisation of collaborative research and associated factors). Data on collaboration network was derived from self-reported collaboration ties. This data, combined with data arising from other measures in the survey on the processes and challenges experienced in collaborative research, formed the basis for the ensuing discussion on factors influencing the organisation and conduct of collaborative research

Objectives four and five relate to the second aim (the role of ICT in collaborative research, and associated factors). This involved an assessment of how a number of ICTs were being used to support various collaboration activities, and an analysis of the factors contributing to the indicated levels of adoption and use within this context. The adoption and use factors are discussed within the framework developed by Venkatesh et al., (2003), the Unified Theory of Acceptance and Use of Technology (UTAUT).

Objective six relates to establishing the benefits of collaboration and ICT use in relation to research productivity. Objective seven relates to providing a roadmap for improving collaborative research in Kenya, by providing a set of recommendations and strategies towards promoting collaborative research in Kenya. The recommendations mainly draw from data and information gathered from this study and literature.

The data, subsequent analysis and discussion were an attempt to answer the following research questions:

1. How is the academic research community in Kenya organised?
2. What are the factors contributing to its form of organisation?
3. How have ICTs been adopted and used to support research collaborations?
4. What are the factors contributing to their adoption and use?

5. How is collaboration related to research productivity?
6. How is ICT use related to research productivity?
7. What are the implications of the findings in promoting and improving the process of research collaboration in Kenya?

Figure 1.1 represents a mapping of research aims to the objectives and research questions.

#### **1.4 OVERVIEW OF THE RESEARCH METHOD**

To answer the research questions listed above, the study employed a sequential explanatory mixed methods research design. The mixed methods used involved use of both quantitative and qualitative forms of inquiry, with the former being the primary data collection approach and the later playing a ‘support role’.

The quantitative survey, in form of a questionnaire, involved 248 members of the academic research community in four public universities in Kenya. Though research in Kenya is mainly carried out in universities and research institutes, the study focused on academia. This decision was reached on consideration of limitations of time and resources, the desire to carry out an intensive study on a particular group for more accurate representation of collaborative research, and to a less extent the background of the researcher as having worked in the particular environment. A preliminary study on establishment of the selected disciplines, staffing levels and volume of research done in Kenyan universities found more research concentration in public universities, thus this focus. Four disciplines were sampled for study, agriculture, engineering, public health and computing. The Field of Science and Technology (FOS) classification in the *Frascati Manual* (Frascati Manual, 2007) was adopted for selection of the disciplines under study, to reflect diversities in various disciplinary areas. Selection within the broader fields was based on significance of the research to the country, nature of the discipline and their establishment in the chosen

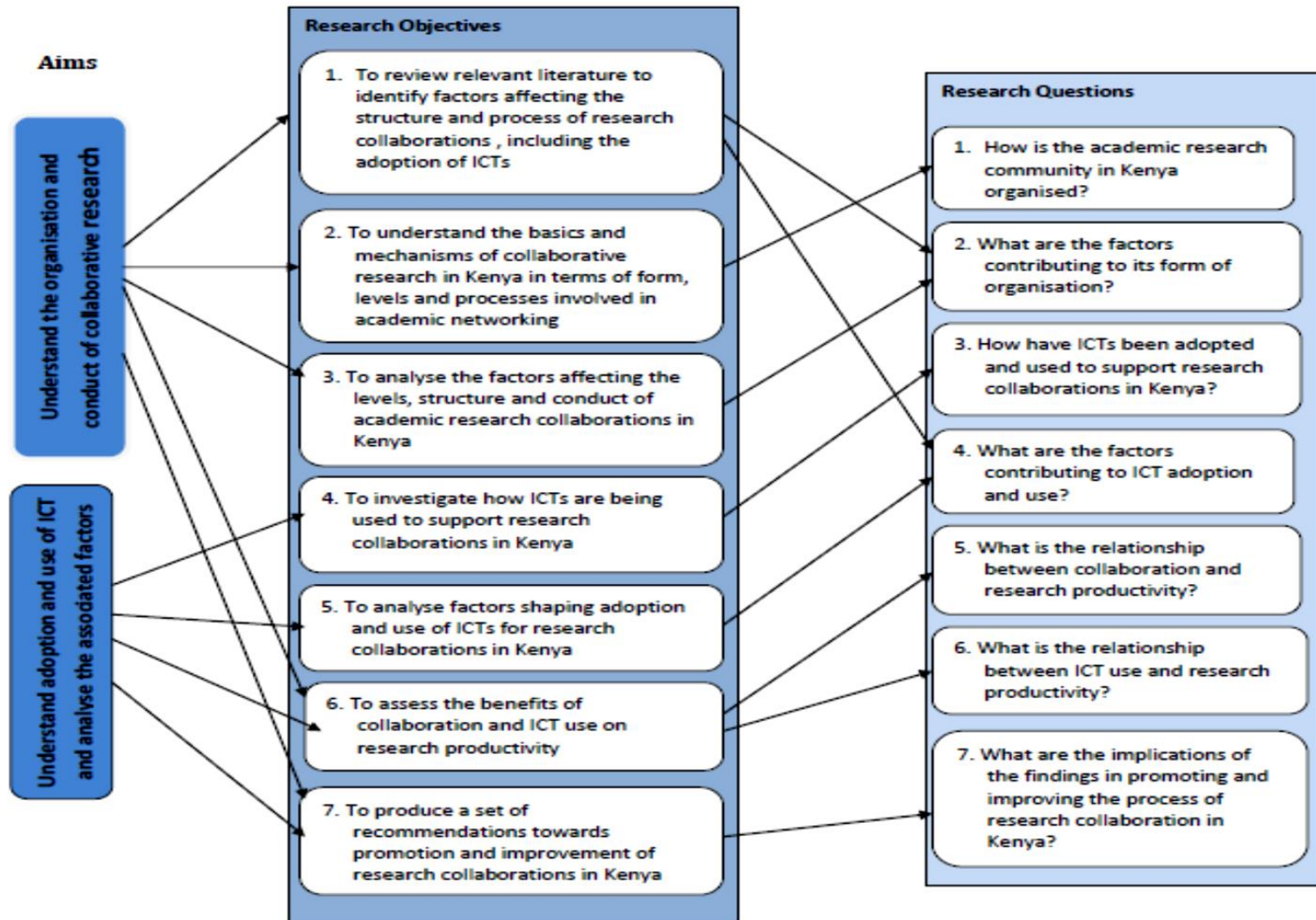


Figure 1-1 A mapping of research aims, objectives and questions

institutions. Further sampling within the selected disciplines and universities was found unnecessary due to the need for an intensive study so as to understand the organisation of this particular community.

The quantitative survey was backed up by qualitative interviews with fifteen individuals selected across the four disciplines and institutions within the study population, and supplemented by information contained in university websites and repositories.

### **1.5 SIGNIFICANCE OF THE STUDY**

This thesis contributes to an understanding of the structure and conduct of collaborative research in Kenya, which has been lacking thus far, contributing to the wider body of knowledge on knowledge production processes in developing countries. The thesis also contributes to an understanding of how ICTs have been used and can be used to support collaborative research within the particular context. The identification and discussion of factors accounting for the existing forms of organisation and practices and subsequent recommendations provides a basis on which solutions can be sought and explored to improve the status and levels of collaborative research. This information could be a useful reference to researchers, in the process of planning for and conducting research collaboration, policy makers in planning for supporting and improving collaborative research, ICT managers and designers of support technologies, in identifying the needs and providing the desired kind of ICT support.

Past studies point to significant differences in knowledge production processes across disciplines and specialist areas (Fry, 2003; Becher & Trowler, 2001; Whitley, 2000). This study contributes to an understanding of the differences in collaboration, productivity and use of technology between disciplinary areas, with implications for promotion of science and technology in developing areas. The influence of disciplinary area on the level of adoption and use of ICT indicates the relevance of disciplinary differences in analysis of adoption and use practices within the context of knowledge production processes, in addition to four constructs represented by UTAUT.

This study also contributes to an understanding of methods best suited for investigating research collaborations in developing countries. The information contained in this thesis could be a useful reference to understanding research collaborations not only for research

systems in Kenya, but to the wider developing country context research environments exhibiting similar characteristics.

## **1.6 ORGANISATION OF THE THESIS**

The thesis is organised into nine chapters. To understand the nature of collaborative research, Chapter Two draws on literature from the wider disciplinary areas of science and technology studies (STS), information science (IS) and computer supported collaborative work (CSCW). This includes literature supporting the rationale for collaborative research, major processes involved, factors that have been identified as having an effect on collaborative research, role of ICT in collaborative research and factors influencing its uptake. A number of models that explain these features are identified and discussed. The review led to identification of the gaps in literature and particular issues that were to be investigated in the study.

Chapter three gives some background knowledge of education and research systems in Kenya, to provide the reader with some knowledge of the setting under which the research and participants are based /operate in. This includes key indicators of the economic setting; a background to higher education system in Kenya, including basics of how research is funded; and status of ICT infrastructure, including the role of Kenya Education Network, KENET.

Chapter Four describes the research design, methods and techniques used. This includes a rationale for selection of methods, participants, disciplines and institutions studied, and the procedures used to collect and analyse data to address the research questions and objectives. The chapter also includes measures that were used in the data collection instruments towards answering each of the research questions, and measures towards ensuring validity and reliability of the data and methods.

Chapter Five presents an analysis of data indicating the state of research collaborations in Kenya, including their level and structure, differences in levels of collaboration across a number of categories and an analysis of issues faced in the conduct of collaborative research. The analysis also includes an assessment of availability of ICT to support collaboration processes, and various usage practices and patterns. These findings are further discussed in Chapters Six and Seven.



The discussion in Chapter Six mainly addresses the first aim of the study, understanding the organisation and conduct of collaborative research. Factors affecting collaborative research are discussed, interrelating the findings to the existing literature, while identifying the context specific issues. The chapter ends with an explanatory model of factors identified as influencing research collaboration.

The discussion in Chapter Seven addresses the second aim of the study, understanding adoption and use of ICT for collaborative research in Kenya, and an analysis of the influencing factors. The adoption and use factors are analysed within the framework of the UTAUT model developed by Venkatesh et al. (2003).

Chapter Eight presents a set of recommendations in addressing the identified barriers to collaborative research. The recommendations are targeted at three main stakeholders in collaborative research, the policy maker, the researcher and designers of ICT systems.. They were mainly drawn from participants' views, and an assessment of best practices identified in literature that seemed applicable to the Kenyan case.

Chapter Nine concludes the thesis, providing a summary of findings in relation to achievement of the aims and objectives as set out in Chapter One. A statement on the contribution to knowledge is made, including empirical, conceptual, and methodological contributions, as well as contribution to policy and practice. Limitations to the study are discussed, and suggestions for areas of further work made.

## CHAPTER 2: LITERATURE REVIEW

### 2.1 INTRODUCTION

This study mainly draws on literature from the wider disciplinary areas of science and technology studies (STS), information science (IS) and computer supported collaborative work (CSCW). STS studies explain the growth of scientific collaboration, the basis for its growth, as well as differences in organisation of scientific fields, studies in information science explain collaboration and communication patterns, scientists' information behaviour, and the influence on success of collaborative research and productivity. Studies under the banner of computer supported cooperative work (CSCW) explain 'support requirements of cooperative work' (Bannon & Schmidt, 1989, p.360<sup>1</sup>) and the role of ICTs in supporting collaborative work. Literature explaining the diffusion of innovations and information technologies is reviewed to identify factors influencing their adoption and use. This includes the widely cited Rogers' *Diffusion of Innovations* theory.

Much of the related literature reviewed is based on empirical work that explains the processes involved in collaborative work and influencing factors. Literature on studies focused on developing theories that explain the dynamics of knowledge production processes, associated with growth of collaborative work, notably the work of Gibbons et al. (1994) are reviewed. Others include theories explaining the differences in social organisation of scientific work (Whitley, 2000) and diffusion of technology (Rogers, 2003; Davis, 1989; and Venkatesh et al., 2003). Limited studies exist on the working dynamics of collaborative research and knowledge production processes in developing countries. Relevant studies seeking to explain organisation of science in developing areas, especially studies carried out under the Globalization of Science project headed by Wesley Shrum provide some useful insights into some of the issues affecting the conduct of science in the region.

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<sup>1</sup> Bannon & Schmidt (1989), noting the different interpretations for work in CSCW attempt to provide a clearer description of CSCW as a research area. They note that 'CSCW should be conceived as an endeavor to understand the nature and characteristics of cooperative work with the objective of designing adequate computer based technologies....The focus is to understand, so as to better support cooperative work' (p.360'. This study adopts this definition with reference to CSCW as a disciplinary field.

Landmark studies of scientific collaboration date back to the 1960s, notably the work of Price and Beaver that traces the growth of scientific collaboration since the late nineteenth century using bibliometric studies, as seen in Price (1963) and Price & Beaver (1966). A sociometric survey by Diana Crane in 1969 marked the beginning of the use of social network data to study the communication patterns of scientists associated with a certain problem area, used to explain the notion of the ‘invisible college’. This led to Crane’s description of the social organisation of an invisible college as comprising of a highly productive group of scientists brought together by a common interest in a problem area irrespective of geographical boundaries. (Crane, 1969; Crane, 1972). Later studies have used similar methods, while others have used a combination of bibliometric and network analysis to demonstrate variations in collaboration networks between fields and the relationship between use of computer-mediated communication and collaboration structure (Walsh & Maloney, 2002; Walsh & Maloney, 2007).

This study is premised on the concept that understanding the nature of the knowledge production process, and specifically collaborative research, and the effects that factors within the research environment have on this process, provides a basis for improving and expanding collaborative research. This chapter presents a literature review based on this concept, which led to establishment of the gaps in knowledge that led to this investigation. The chapter begins with a note on the changing nature of the knowledge production process (section 2.2), which has led to an increasing demand for collaborative research. This is followed by deriving an understanding of basic concepts about research collaboration, including levels and motivation for collaboration in section 2.3. Section 2.4 presents a review of literature on major factors affecting collaborative research, drawing on a number of models and frameworks identified in literature, and noting those that would be most relevant to the developing world context for investigation. One of the main benefits of collaboration has been identified as increased productivity, commonly used as a measure of success. Literature relating collaboration to productivity, including measures commonly used to assess the two is reviewed in sections 2.5 and 2.6. Central to the conduct of collaborative research are communication processes, especially as defined by use of ICT to support these processes. Section 2.7 presents a review of literature on the role of ICT in the collaboration processes while section 2.8 explores theories used to explain adoption and use of ICT. Differences have been noted on the level of scientific research activity between

developed and developing countries. Section 2.9 presents literature on issues pertaining to developing country scientists.

## **2.2 WHY COLLABORATION?**

### **2.2.1 The changing nature of the knowledge production process**

Over the years, major changes have been realised in regards to the knowledge production process. Gibbons et al. (1994) describes the evolution of a newer kind of knowledge production process which he refers to as Mode 2, which collaboration in research is a key component of. Major features of this form of knowledge production are its focus on solving practical problems affecting the society ('context of application'), applying a range of skills beyond disciplinary boundaries ('trans-disciplinarity'), and surpassing institutional boundaries ('heterogeneity') (Gibbons et al., 1994). In addition, Gibbons et al., describe Mode 2 as being more interactive and more conscious of the impact of the outcome on the society, with the criteria for assessing quality not only based on peer review, but also additional measures of impact. In contrast Mode 1 is mainly organised around disciplines and highly institutionalised, with measures of quality mainly based on peer review judgements (Gibbons et al., 1994).

The Mode 2 type of knowledge production described by Gibbons et al. has been the object of a number of criticisms. These include its generalisation of science, that disregards disciplinary differences and national context when making claims regarding the practice of science (Weingart, as cited in Hessels & Lente, 2008). Others have questioned the newness of the Mode 2 type, the argument being that the two modes have existed before the 'birth of modern science' (Hessels & Lente, 2008, p. 753). This argument is supported by Martin & Etzkowitz (2000), who point out that in the United States, for example, more research conducted in the universities in the second half of the 20<sup>th</sup> century was 'funded by mission-oriented agencies.... linked to meeting societal needs in the defense, energy, agriculture, health and space sectors' (p. 17). They propose a view based on shift of balance between the two modes, with more current inclination towards Mode 2 in comparison to the post war period.

Weingart (as cited in Hessels & Lente, 2008) considers Gibbons et al.'s study as lacking in empirical evidence on which to base the claims on societal orientation. He compares

Gibbons et al.'s study, to a study by Bohme et al., which by using a case study of developmental phases of various scientific disciplines, realised the final phase was more shaped by external factors, with the society playing an active role. Though similar to Gibbons' 'context of application' perspective, Weingart notes that Bohme et al.'s views are supported by the empirical findings, in contrast to Gibbon et al.'s views. Hessels & Lente (2008) also note criticism on the notion of basic vs. applied research, with critics of the 'context of application' perspective arguing that it does not clearly bring out the relevance of strategic research. Strategic research is defined by Irvine & Martin (as cited in Hessels & Lente, 2008) as 'basic research carried out with the expectation that it will produce a broad base of knowledge likely to form the background to the solution of recognized current or future practical problems' (Hessels & Lente, 2008; p. 743). This kind of knowledge, though not always providing for immediate uptake, constitutes a significant amount of the knowledge produced today.

Despite the criticisms towards Gibbons et al.'s presentation of the knowledge production process, Hessels & Lente (2008), in their comparison of seven studies addressing changes in knowledge production systems, find a consensus in the related studies on the changing research agenda and the increasing societal orientation.

Collaboration in research is a key component of the Mode 2 type of knowledge production, necessitated by a need to address complex problems facing the society. This often requires a diverse range of skills and sharing of resources, made easier by developments in e-infrastructure. This is evident in the inclination towards support for trans-disciplinary, cross-institutional research as seen in many governments' funding policies and calls for joint research to solve global problems such as climate change.

### **2.2.2 Associated costs and benefits**

Many benefits have been associated with collaborative research. Funding bodies are increasingly aligning their research policies in favour of collaborative research. Collaborating to solve intellectually challenging mission oriented problems across institutional boundaries is therefore being seen by researchers as a mechanism for securing funding (Gibbons et al., 1994; Smith & Katz, 2000; Lee & Bozeman, 2005; Becher & Trowler, 2001). Past studies have also shown that collaboration in research is associated with higher productivity (Beaver & Rosen, 1979; Sooryamoorthy & Shrum, 2007; Lee &

Bozeman, 2005), in addition to numerous personal gains such as increased visibility, recognition and intellectual companionship (Beaver, 2001; Melin, 2000; Crane, 1969). Crane (1969) also notes the benefits of expansion of networks associated with collaborating with highly productive influential individuals. However, this does not imply that collaborative research is all about benefits.

Wray (2000) notes the benefits of learning and training for younger scientists through interactions and working with senior scientists. However, he also considers too much focus on collaborative research a disadvantage to the younger scientists as they need to prove themselves by publishing ‘independent work that testifies to their abilities’ (p.165). Wray also observes that once collaborative networks are in place, they may become ‘powerful lobbying groups .... created to serve political rather than epistemic ends, thus influencing the direction of funding and research at the expense of other areas of research’ (Wray, 2002; p.166). This may especially apply where there is no central body and systems to track research grant awards. Oldham (as cited in Sonnenwald, 2007) notes the unethical conduct associated with some collaborations, such as a scientist deciding to do clinical trials that are not allowed in his country on unsuspecting citizens in another country. Similarly, Beaver (2001) observes that some ‘scientists may collaborate with others for the purposes of intellectual espionage and scooping of results’ (p. 7). Other negative aspects include the costs associated with collaboration such as in travel, time spent in increased communication, coordination, planning and resolving issues (Smith & Katz, 2000). Collaborative research therefore has its positive and negative sides. Though the positives as pointed out in literature outweigh the negatives, it is important to assess the negatives and how they may affect a collaboration, thus factoring ways of dealing with them in planning for research collaborations.

## **2.3 UNDERSTANDING RESEARCH COLLABORATION**

### **2.3.1 Defining collaboration**

The definition of collaboration varies across different settings such as disciplinary areas, social groupings, institutions and even individuals. While some will look at collaboration at a higher level e.g. between nations, institutions or organisations, laboratories and groups of individuals, others define collaboration at the very basic level, that of an individual.

Smith & Katz (2000) propose a definition of collaboration as ‘the working together of researchers to achieve the common goal of producing new scientific knowledge’ (p. 31), based on the dictionary definition of collaboration. However, they elaborate that the term ‘working together’ is relative, as it does not define the type or level of contribution that would qualify an individual as being a collaborator. On the other hand, Laudel (2002) defines research collaboration as a ‘system of research activities by several actors, related in a functional way and coordinated to attain a research goal corresponding with these actors’ research goals or interests’ (p. 5). Sonnenwald (2007) defines scientific collaboration as ‘interaction taking place within a social context among two or more scientists that facilitates the sharing of meaning and completion of tasks with respect to a mutually shared, super ordinate goal’ (p. 645). What is common in all the definitions above is the concept of some form of interaction towards achieving a certain goal, but what is not clear, as noted by Smith & Katz (2000) is the criterion that would be used in assessing who qualifies to be referred to as a collaborator. While some make minimal contribution, or are only involved in the administrative tasks, others are actively involved throughout the project.

Katz & Martin (1997) propose a criterion for defining a collaborator based on the contribution of an individual to the project as:

those who work together on the research project throughout its duration or for a large part of it, those whose names or posts appear in the original research proposal; those responsible for one or more of the main elements of the research and in some cases those responsible for a key step and the original project proposer and/or fund raiser, even if his or her main contribution subsequently is to the management of the research (e.g. as team leader) rather than research *per se*, ... *and exclude* those who make only an occasional or relatively minor contribution to a piece of research and those not seen as, or treated as, proper researchers e.g. technicians and research assistants” (Katz & Martin, 1997; p. 12)

On the other hand, Laudel (2002) defines a criterion of collaborator typology based on the role played by a partner, whether in provision of a service, special equipment, or transmission of know- how. The term collaborator therefore may have different meanings to different people, groups and settings. The conditions regarding the status of each individual need to be clarified at the onset of a project to avoid disagreements and conflicts related to attribution of credit to contributors. For example, conflicts could arise as regards

who is to be included in coauthored publications (and order) and who is to be simply acknowledged.

The criterion used to define a collaboration/collaborator also needs to be considered carefully in collaboration studies, depending on the type and level of collaboration being assessed and the kind of data being sought from such studies. For instance, in relating collaboration to productivity for research scientists across three developing countries, Duque et al. (2005) considered a collaboration as any form of tie with an organisation / institution outside the researcher's own. While this may identify the wider professional network around individuals, it may not be suitable for identifying a research collaboration network for two main reasons: firstly, having any form of contact with someone in another organisation doesn't mean it's for scientific knowledge production endeavour and secondly, past studies show that distance and spatial proximity play a significant role in initiation and execution of projects at the individual level (Kraut et al, 1988; Bozeman & Corley, 2004; Cummings & Kiesler, 2005; Lee & Bozeman, 2005; Olson & Olson, 2000). For instance, a study by Kraut et al. (1988) showed that most people collaborate with those physically closer to them. Exclusion of local ties would therefore affect actual presentation of collaboration levels or networks, or relation to productivity.

### **2.3.2 Levels of collaboration**

Collaboration can be looked at from several levels, '...between research groups within a department, between departments within the same institution, between institutions, between sectors, and between geographical regions and countries' (Smith & Katz, 2000, p. 33). Smith & Katz (2000) use a three tier model to present various levels of collaborations shown in Table 2.1. The main differences between these levels are the rationale for existence, ownership and composition of the group, though the boundary between team and inter-personal collaborations is less clear, especially if it involves groups of individuals across universities (Smith & Katz , 2000). Despite the importance of interpersonal collaboration, considering that it is people who collaborate at whichever level, Katz & Martin (1997) note that more attention is given to collaboration at the higher levels. Smith & Katz (2000) consider fostering collaboration at the interpersonal level as important as the other levels, as "meaningful collaborations are almost always driven from the bottom-up and from within the research process itself" (p.92), a view also shared by Bozeman &



Corley (2004). Collaboration ties pegged on material needs as many of those under corporate partnership may end when the collaboration comes to an end, but a collaboration based on a personal working relationship and interests is likely to endure beyond the lifetime of an individual project.

<b>Model of collaboration</b>	<b>Basic Features</b>
Corporate partnership	‘corporately initiated and ‘owned’’ formalised structures, mainly constituted due to necessity for funding and access to external resources, ownership and control external to the group (p.71)
Team collaborations	Semi-formalised existence, ‘Ownership’ and control retained by the teams, drawn together by the need for sharing skills and experience, problem and task based
Inter-Personal collaboration	No formal structure, bottom-up and people driven, ‘based on personal relationships, trust and ability to work together’ (p.72)

**Table 2.1 Models of Collaboration**

(Adapted from Smith & Katz (2000), pp 71-72)

### **2.3.3 Motivation for collaboration**

Melin (2000), in his study aimed at establishing the reasons for, form and effects of collaboration, focussing on the individual/micro level, established that most people will look at a collaboration in terms of the gains, whether ‘material, knowledge based or social kind’ (p.38). Sargent & Waters (2004) break down motivating factors into two major categories, ‘instrumental’ and ‘intrinsic’ (p. 312). In their classification, instrumental motivation refers to knowledge and resource based rationales while intrinsic motivation refers to factors related to individual choices and preferences such as friendship. The extent to which ‘instrumental’ or ‘intrinsic’ reasons influence collaboration decisions could vary based on the existing conditions within the research environment. To establish the role of the individual in collaboration choices and strategies, Bozeman & Corley (2004) carried out a study involving 451 scientists and engineers at academic research centres in the USA. While acknowledging the significance of external environmental constraints and institutional factors in collaboration decisions, they found that personal interests were a major determinant of scientists’ collaboration choices and strategies. Unlike the situation in developed countries, environmental constraints may outweigh personal interests in scientists’ collaboration decisions in developing countries. With the majority of research

systems in developing countries constrained by limited resources (Harle, 2009; Harle, 2010, Gaillard & Tullberg, 2001), the liberty of choosing what collaboration to get into may be limited. This is illustrated by Luo (2008), in her study aimed at understanding how researchers in developing countries benefited from participating in collaboratories involving those in developed countries. She found that dependency, whether for work or resources, was a major determinant for participation in collaboratories, and determined the kind of relationship the scientists had. She illustrates this kind of dependency with the involvement of US and Chinese scientists in a collaboratory that sought to study the immunity of Chinese individuals to HIV-1 virus, which was thought to spread fastest in China. The US scientists depended on Chinese scientists to collect data, while the Chinese scientists, who agreed they were less experienced in the research field, reported having learnt new technologies and skills to apply in their research work from their US counterparts.

In their desire to promote collaborative research, funding bodies may impose conditions such as requirement for collaborators to be from different institutions. This may also affect flexibility of personal choice. A summary of motivations identified in literature is presented in Table 2.2. The list is not exhaustive, as the motivating factors can be as many as personal preferences and choices of various individuals.

#### **2.3.4 Existing models / frameworks**

This section reviews various models and frameworks that have been used or proposed to understand research collaborations, and were considered in developing a synthesis framework for the study.

A scientific collaboration goes through various stages from its inception to the end. A number of models and frameworks have been developed to explain the process of scientific collaboration. Some of the models focus on identification of stages, and tasks associated with each phase of collaboration (Sonnenwald, 2007; Kraut et al., 1987; Sargent & Waters, 2004). Others focus on factors that influence accomplishment of the tasks or performance (Amabile et al., 2001; Maglaughlin & Sonnenwald, 2005), while others focus on particular aspects of the collaboration process itself, such as decision making processes (Vasileiadou, 2009). Sonnenwald (2007), for instance analyses literature on

<b>Motivation</b>	<b>Reference / source</b>	<b>Example</b>
Changing patterns or levels of funding	Smith & Katz (2000), Katz & Martin (1997), Walsh & Maloney (2007).	EPSRC funding programs
Access to resources and Special equipment	Beaver (2001), Melin (2000), Katz & Martin (1997), Duque et al. (2005), Birnholtz (2007), Luo (2008), Sargent & Waters (2004); Finholt & Olson (1997).	GenBank (online genetic or protein databases)
Increased popularity, visibility and recognition	Beaver (2001), Beaver (2004), Crane (1969), Melin (2000), Hara et al (2003), Katz & Martin (1997), Wray (2002)	More citations, grants
Diversified expertise and special skills	Beaver (2001) Melin (2000), Hara et al. (2003), Cummings & Kiesler (2003), Katz & Martin (1997), Sonnenwald (2007), Wray (2002), Sargent & Waters (2004).	Skills possessed by people in various specialist areas
Higher productivity	Beaver, 2001; Lee & Bozeman, 2005; Sooryamoorthy & Shrum, 2007.	More publications
Training apprentice researchers	Beaver (2001), Melin (2000), Bozeman & Corley (2004).	PhD students and post-doctoral fellows
Transferring tacit knowledge and technique	Beaver & Rosen (1979), Beaver (2001), Duque et al. (2005), Luo (2008)	Through Working with experienced researchers
Intellectual companionship	Beaver (2001), Smith & Katz (2000), Walsh & Bayma (1996)	Keeps one more focused on research
Structural factors eg cheaper and faster modes of communication	Katz & Martin (1997), Duque et al. (2005), Walsh & Maloney (2007), Melin (2000)	Email, video conferencing, IMS
Personal gains	Katz & Martin (1997), Melin (2000), Beaver (2001), Birnholtz (2007), Sargent & Waters (2004).	Building individual reputation, establish a viable career path, intellectual interest, fun and pleasure
Time and labor efficiency	Beaver (2001)	Reduce errors and mistakes
External rewards	Maglaughlin & Sonnenwald (2005), Ynalvez & Shrum (2011)	Extra income, travel and expanding networks

**Table 2.2 Motivation for collaborative research**

various aspects of scientific collaboration to come up with a framework that identifies the phases through a collaboration (see Table 2.3) and factors influencing the processes within each phase. She identifies four stages in research collaboration: foundation, formulation, sustainment and conclusion. In the *foundation stage*, she describes conditions that lead to initiation of a collaboration or the motivation for collaboration, which she groups into five: *scientific factors* such as to gain access to resources, knowledge and expertise, *political factors* such as for the purpose of promoting unity in a region, *socio-economic factors*

given the importance attached to the link between research and economic development and *social network and personal factors* such as ideas springing up as a result of ties within one's personal networks. At the *formulation stage*, Sonnenwald discusses factors affecting project planning as diverse disciplinary, institutional and organisational cultures. Like Kraut et al., (1987), she notes the negative effects of distance on formation and performance of collaboration processes, and the importance of leadership structures that do not constrain collaborative activities. In her framework, the *sustainment stage* mainly deals with emerging challenges including changes in administration and relevant policies (also noted in Katz & Martin, 1997), access to resources, communication and coordination and personal differences. At the *conclusion stage*, she identifies problems associated with dissemination of results such as disagreement on publication forum, authorship inclusion and order of author names. Sonnenwald's analysis brings out both internal factors, related to actual performance of tasks and external factors that may influence the initiation of a collaboration and the processes that follow.

On the other hand, Kraut et al. (1987) drawing on empirical data involving 50 semi-structured interviews across three disciplines, identify three major phases through a collaboration process (see Table 2.3). The phases are similar to the phases identified by Sonnenwald, if the foundation and formulation stages are mapped onto their initiation stage. In addition, they discuss each of the phases at two levels, the task level and the relationship level. At the initiation level, their discussion touches on the role of external environment factors (access to resources, physical proximity and institutional factors) in establishing relationships. However, unlike Sonnenwald (2007), their discussion through the other phases mainly focuses on the tasks/internal processes such as coordination and sharing information, falling short of explaining external processes that would influence the internal processes.

Like Sonnenwald (2007) and Kraut et al. (1987), Sargent & Waters (2004) identify the phases in the lifetime of a collaborative research project, and highlight the factors affecting the processes at each phase. They note that contextual factors play an important role in shaping collaboration processes, as 'collaborations do not occur in isolation from the broader professoriate community' thus integral to success of collaborations (p. 311). Drawing on data from a two stage empirical study involving a total of eleven 'distinguished

careers researchers' (p.309), they develop a process framework that identifies four main collaboration phases as presented in Table 2.3. The first stage in their study involved three academics, to come up with the process framework. The second stage involved enriching the framework with data on successful research collaborations from eight academics from different national settings and at different stages in their careers. The framework identifies both contextual ('resources, institutional support and climate') and interpersonal processes ('trust, communication and attraction') affecting collaborative research (p.311). They identify the institutional climate shaping nature of collaborations as including institutional processes and strategies, differences across universities (e.g. research oriented vs. teaching oriented) that determine the level of support and issues of prestige. Inclusion of people from different national settings captures collaboration experiences across different contexts or environments in which collaborations occur which could influence the processes. However, the sample size raises a question on its sufficiency in capturing a range of experiences that could be generalised to a wider population.

While Sonnenwald's discussion is based on a synthesis of literature on studies of scientific collaboration, Kraut et al.(1987) and Sargent & Waters (2004) draw on empirical data from their studies in developing and discussing the frameworks. A summary of the stages identified and proposed for use in understanding research collaboration processes by the authors discussed above is presented in Table 2.3.

Other authors have proposed frameworks based on understanding the influence factors. Amabile et al. (2001) for instance, in their exploration of academic-practitioner collaborations, classify determinants of successful collaborations into three categories. The first, collaborative team characteristics focus is on personal factors related to the individual such as skills and knowledge, attitude and motivation. The second, collaboration environment characteristics focus is on support required for collaboration to succeed, mainly in form of institutional or organisational support. The third, collaboration processes and outcomes focus is on issues of managing the process, including conflict resolution, task allocation and coordination and dissemination of results. Amabile et al.'s framework encompasses both team characteristics and process specific factors towards explaining the effects of the individuals or group behavior in success of collaborations across sectors. However, their study, like those described above, fall short of identifying the effects of the

nature of the work or disciplinary orientation, commonly referenced in literature as affecting collaboration processes, as shall be seen in section 2.4 (Disciplinary factors).

<b>Author</b>	<b>Stages in Scientific collaboration</b>	<b>Description</b>
Sonnenwald (2007)	Foundation	Conditions required for a collaboration to be initiated and motivation for collaboration.
	Formulation	Project planning - defining goals, assignment of tasks and responsibilities, contractual agreements e.g. rules governing execution and delivery of tasks, IP rights etc
	Sustainment	Carrying out tasks and dealing with emerging issues towards accomplishment of goals once work has began
	Conclusion	Release and dissemination of results
Kraut et al., (1987)	Initiation	Establishing relationships and commitment to work, project planning
	Execution	Carrying out the tasks – division of labour, coordination of activities, sharing information, management
	Public presentation	Documenting and dissemination of research
Sargent & Waters (2004)	Initiation	Motivation for collaboration – instrumental and intrinsic
	Clarification	Establishment of nature and type of project (local/remote, inter disciplinary ..) scope, tasks and goals
	Implementation	Focuses on collaborator roles –mentor/mentee, apprentice, colleague and sponsor
	Completion	Evaluation of success – career advancement, personal gains, expanded networks, new knowledge.

**Table 2.3 Frameworks of common phases through collaboration processes**

On the other hand, Maglaughlin & Sonnenwald (2005) identified four major categories of influencing factors presented in Table 2.4.

<b>Personal</b>	<b>Resource</b>	<b>Motivation</b>	<b>Common Ground</b>
Expertise	Support from funding agencies	Learning & teaching	Physical proximity
Social networks	Support from scientists' institutions	New discoveries	Research organizations
Trust	Literature	Fun	Disciplinary bias
Personal compatibility	Scientific publishing	External rewards	Discipline-specific languages
Common professional traits	Students		Bridges
	Time		

**Table 2.4 Factors impacting interdisciplinary scientific research**

(Adapted from Maglaughlin & Sonnenwald, 2005 p. 507)

The categorisation was a result of an exploration of factors influencing interdisciplinary research collaborations in academia using both interviews with 22 academic scientists and longitudinal study involving a research center distributed over five universities. Similarities are noted in categories of factors between Amabile et al. and Maglaughlin and Sonnenwald's frameworks. Both have categories regarding characteristics at the individual scientist/personal levels (represented as personal and motivation factors by Maglaughlin and Sonnenwald, and collaborative team characteristics by Amabile et al.) Both also have categories identifying factors external to collaboration affecting the processes. Differences emerge in the kind of collaborations considered. Amabile et al. studying academic-practitioner collaboration, and Maglaughlin and Sonnenwald studying academic collaborations. Though many similarities are noted on issues affecting the two types of collaborations, differences in working styles e.g. allocation of tasks, decision making processes and output production processes, present special challenges for those in academic-practitioner collaborations. For instance, practitioners in the Amabile et al. study felt their skills were rather underused, and differences emerged regarding the point at which results should be released to the public. Such differences may still arise in academic collaborations, but may be more common with people from different organisational backgrounds.

Another framework by Vasileiadou (2009) focuses on the collaboration processes, centering the discussion on five major work practices that she regards as requiring substantial consideration for success of a collaboration. These are decision making processes, conflict management, socialisation processes, task allocation and coordination and output production. She identifies the activities and processes involved in each of the work practices, her major interest being their support using ICT.

The frameworks discussed above show that scientific collaborations go through various stages, and do not occur in isolation of the environments within which they are situated. Various factors, both internal to a collaboration (working processes of scientists) and external environment factors are at play and influence the processes involved. A number of variables and measures derived from these frameworks were useful in developing a synthesis framework used to investigate the Kenyan case.

In the next section, the collaboration process is looked at in the light of the two major phases evolving out of the phases/processes identified in the models discussed above.

### **2.3.5 The collaboration process**

Nardi (2005) consider inter personal communication as comprising of two major processes, ‘establishing feelings of connection’, that lay the grounds for communicative activity, and the actual information exchange (p. 92). Similarly, a collaboration can be seen as going through two major phases, the pre-collaboration phase involving conditions that facilitate collaboration ideas to develop, building ties and basis for collaboration decisions established. Once the collaboration is set up the in-collaboration phase involving planning for and actual performance of tasks towards accomplishing the set objectives sets in.

#### **The pre-collaboration phase**

The pre collaboration phase, can be mapped onto the *foundation stage* in Sonnenwald (2007) and the *initiation stage* in Kraut et al. (1987) and Sargent & Waters (2004), and sets the stage for the collaboration. At this phase, a research problem is identified and the required set of skills and resources needed to solve the problem established. Connections are sought or made, dictated by the various factors that motivate people to work together, as discussed in 2.3.3. Kraut et al. (1987) notes the need to create opportunities for people to build ties and strengthen relationships, referred to by, Nardi (2005) as ‘building fields of connection’ (P. 91). Physical proximity and informal communication play a significant role in facilitating and creating opportunities in which meaningful interactions that probably yield collaborative ties happen, as well as providing for an environment where research ideas can sprout and grow (Kraut et al., 1987; Cummings & Kiesler, 2005).

Institutional and national research environments to some extent determine facilitation of access to information and resources, important at the initiation of projects as well as ongoing support into the collaboration (Melin, 2000; Harle, 2009). Existence of and participation in professional and personal networks make it easier for people to share and seek information and help (Luo, 2008), and provide an environment within which collaborative ties develop (Ynalvez & Shrum, 2011). Further discussion on the external factors that have an effect on setting the grounds on which collaborative relationships develop and grow is presented in section 2.4.



### **In-collaboration phase**

Once the collaboration has been established, the actual collaboration work begins. The in-collaboration phase can be mapped to the rest of the phases identified in the frameworks presented in Table 2.3. It involves project planning whereby terms and conditions are drawn and plan or map for the collaboration laid out, accomplishment of the tasks, dealing with emerging challenges and dissemination of results. A clear set goals (Sargent & Waters, 2004), personal compatibility, trust, maintaining a healthy interpersonal relationship, and a commitment towards working together through conflicts and disruptions are identified as important towards the success of a collaboration (Kraut et al., 1987; Amabile et al., 2001). Kraut et al. (1987) stress the importance of sharing information and timely delivery of results so as not to impede others activities. They identify problems associated with task execution as including division of labour, conflict management, coordination problems, personal problems and differing perspectives and levels of commitment, also echoed by Sooryamoorthy (2013).

The main processes involved in the in-collaboration phase are discussed within the framework of the major collaboration processes proposed by Vasileiadou (2009). These include allocation and coordination of tasks, decision making processes, conflict resolution processes, socialisation processes and output production processes.

#### ***Task allocation and coordination***

Proper task allocation is important for the success of collaborative research. The kind of tasks differs, based on the nature of the work and can range from being complementary to being integrative (Hara et al., 2003). According to Hara et al., complementary tasks may result in division of labour, where each person or group works on and is responsible for their own pieces of input. Integrative tasks on the other hand, involve individuals within a project working closely together in all aspects of the research project, such as ‘developing research problems, refining ideas, and analysing results through to reporting the results (Hara et al., 2003, pp. 958-9). Integrative tasks involve a high level of interdependence between the partners, and usually require much more coordination mechanisms as compared to complementary kind of tasks.

The kind of tasks as dictated by the nature of the work defines an individual's role in the collaboration, and needs to be made clear to each individual. Consideration and awareness of skills and capabilities of individuals in task assignment is necessary to avoid conflicts over responsibilities and contributions. Such was the case in Amabile et al. (2001), who, in their study of collaborations between academic and industrial practitioners found that industrial practitioners, felt their capabilities were not being adequately utilised, based on the tasks they were allocated. They felt that the academics were sidelining them in major tasks, resulting in conflicts between the two groups.

### ***Decision making processes***

The structure of decision making processes influences a number of other collaboration processes, such as task allocation and conflict resolution. Factors identified in literature as affecting decision making processes include the existence of, and style of leadership (Chompalov et al., 2002; Melin, 2000). Many levels of authority, both at the managerial level and project level, and status differences may complicate the decision making process (Shrum et al., 2001). Vasileiadou (2009) also found that level of formalisation of decision making processes, i.e. the existence of formal rules and regulations also affects the process.

Chompalov et al. (2002) group organisational formats of collaborative research into four levels of authority: bureaucratic, leaderless, non-specialised and participatory. Bureaucratic collaborations are characterised by 'clear lines of authority (administrative and scientific), and a well-defined hierarchy of authority' (p.756), and are highly formalised. Leaderless collaborations have the same type of characteristics as bureaucratic, but with no scientific leader, while non-specialised have less formalisation and lines of authority as compared to bureaucratic. On the other hand, participatory collaborations are the opposite of bureaucratic, where all freely participate in decision making (Chompalov et al., 2002). Shrum et al. (2001) observes that the form of decision making process adopted affects other processes including conflict resolution, made more complicated by increased levels of authority. Participatory decision making may present a number of advantages as all individuals are responsible for decisions made, promoting a sense of ownership of the project. However, Vasileiadou (2009) notes the importance of an authoritative voice, especially in times of conflict.

### ***Conflict resolution***

Conflicts are bound to arise in a group of people owing to the diverse disciplinary backgrounds and cultures, differing perspectives and working styles (Hara et al., 2003). Shrum et al. (2001) observe that conflicts can be within or between groups or with project management, the latter two presenting more serious cases. They further note competition for resources and control, and assignment of credit as common sources of conflict between groups. An imbalance between the amount of work done and the credit claimed usually leads to a feeling of discontent and can be a source of conflicts (Kraut et al., 1987). Similarly, Vasileiadou (2009) points to Atkinson et al. as having found a source of conflicts and tension the competitiveness associated with some disciplines for recognition in being the first to make a claim or discovery. The differences did not surface in her study, which she attributes to having investigated social sciences, where the level of such competition was lower compared to ‘hard’ sciences. However, her study identified sources of conflicts to include competition for resources and control, assignment of credit and hierarchical decision making processes, as in Shrum et al. (2001). Putting in place conflict resolution mechanisms is important to ensure that extended disagreements do not impede the collaboration activities.

### ***Output production***

Issues associated with the output production process include equitable division of credit – important for maintaining long term relationships (Kraut et al., 1987). Beaver (2001) notes that differences may arise with respect to assignment of credit associated with order of authorship in different disciplines, thus the importance of an agreed on criteria on which merit will be based. In their study, Kraut et al. (1987) note that ownership of the original idea is a major determinant of credit attribution, no matter how much another collaborator contributed to execution of project. The professional backgrounds and cultures can also be a source of conflict, regarding the mode and stage of output dissemination. For example, Amabile et al. (2001) found that practitioners in their study wanted results disseminated as soon as they were available, more a result of the competitive nature of their profession. On the other hand, academics, whose credit and recognition is to a large extent based on the quality of work and output, were keener on disseminating complete results, resulting in what Amabile et al. refer to as both task and process conflict. They note the importance of

making clear the tasks and processes involved in the project planning phase, as well as an understanding of others' cultures.

#### **2.4 FACTORS AFFECTING RESEARCH COLLABORATIONS**

A number of factors have been identified in the literature (including the studies described above) as influencing the formation, process and structure of research collaborations. The factors can be grouped into two major categories, internal and external factors. Internal factors mainly relate to the researcher characteristics and role of the individual in conduct of collaboration tasks. These factors are within control of the collaborator and include personal traits such as information seeking and communication behaviour, level of commitment, and process management factors. External factors relate to research environment conditions, that the researcher may not have direct control over, but may shape his conduct, behaviour and the collaboration processes. These include access to resources and the national and institutional research support structures.

It is important to note that the effect of these factors may vary over the course of the collaboration. For example, external factors may play a larger role at the pre-collaboration stages, while personal and process management factors may be more important in the in-collaboration stages. However, the effects of some of the factors may not be associated with a particular phase. For example, personal attributes such as level of motivation of an individual that drives an individual towards seeking collaborations has an effect on one's conduct throughout the collaboration process. Due to the overlapping nature of the effects of some of the factors across the various phases, the sections below review the factors affecting collaborative research, not within the framework of phases identified above, but from the view point of the definition of internal and external factors described above. Table 2.5 therefore presents a summary of the factors established in the literature as affecting scientific collaborations, divided into these two major categories, followed by a discussion of how they affect collaborative research, as reviewed in the literature.

##### **Internal factors**

As much as most people collaborate when there is something to gain, personal chemistry is important for successful collaborations (Melin, 2000; Hara et al., 2003). Hara et al. (2003) stress on the importance of personal compatibility, which they see as being influenced by

<b>Internal factors</b>	<b>Reference</b>
<b><i>Personal factors</i></b>	
Motivation for collaboration – resource dependency (funding, special equipment), work dependency (skills and expertise, labour efficiency), personal gains (visibility and recognition, increase productivity, intellectual companionship)	Beaver (2001), Melin (2000), Hara et al. (2003), Katz & Martin (1997), Sonnenwald (2007), Birnholtz (2007), Luo (2008), Walsh & Maloney (2007), Amabile et al. (2001), Maglaughlin & Sonnenwald (2005), Kraut et al. (1987), Sargent & Waters (2004), Sooryamoorthy (2013)
Personal characteristics - skills and capability, commitment and readiness to collaborate, trust, ethical issues and transparency, personal expectations, beliefs, and individual goals	Hara et al. (2003), Beaver (2001), Cummings & Kiesler (2005), Maglaughlin & Sonnenwald (2005), Amabile et al. (2001), Sargent & Waters (2004), Olson & Olson (2000), Kraut et al.(1987),
Prior collaboration experiences	Cummings & Kiesler (2008), Sonnenwald (2007), Sooryamoorthy (2013); Hara et al (2003); Stokols (2005)
<b>Personal networks</b>	Maglaughlin & Sonnenwald (2005), Ynalvez & Shrum (2011),
<b><i>Common ground</i></b>	Olson & Olson (2000), Nardi (2005), Luo (2008), Maglaughlin & Sonnenwald (2005)
<b><i>Process Management factors</i></b>	
Communication and coordination mechanisms, including use of ICT	Cummings & Kiesler (2005), Ynalvez & Shrum (2011), Walsh & Maloney (2007), Vasileiadou (2009)
Nature of the work, task interdependency	Kraut et al. (1987), Melin (2000), Birnholtz (2007), Whitley (2000), Fry & Talja (2007)
Leadership structures – e.g. bureaucratic vs. participatory that affect decision making processes	Sonnenwald (2007), Chompalov et al. (2002), Bush (1957) in Sooryamoorthy (2013)
Conflict resolution mechanisms	Ynalvez & Shrum (2011), Kraut et al. (1987), Vasileiadou (2009), Amabile et al. (2001)
Different patterns of work activities and scheduling issues	Hara et al (2003), Walsh & Maloney (2007), Amabile et al. (2001),
Agreements on quality, IP rights, information security	Birnholtz (2007), Sonnenwald (2007)
Problems of cultural differences and information security, scientific competition, and commercialisation	Walsh & Maloney (2007), Sonnenwald (2007), Amabile et al. (2001)
<b>External factors</b>	
<b><i>Resource availability</i></b> – funding, special equipment, ICT resources	Ynalvez & Shrum (2011), Melin (2000), Katz & Martin (1997), Birnholtz (2007), Luo (2008), Beaver (2001), Duque et al. (2005)
<b><i>Institutional cultures and support structures</i></b> - provision of resources, institutional norms and procedures, processes for information flow, reward mechanisms	Bozeman & Corley (2004), Birnbaum (1979), Sonnenwald (2007), Sooryamoorthy (2013), Cummings & Kiesler (2005)
<b><i>National research environment, policies and political situations</i></b>	Sonnenwald (2007)
<b><i>Distance and Spatial proximity</i></b>	Lee & Bozeman (2005), Kraut et al (1988), Katz & Martin (1997), Walsh & Maloney (2007), Luo (2006), Stokols et al.(2005)

**Table 2.5 A summary of factors affecting research collaborations**

individual work styles, approach to science and personality. Personal differences are bound to arise as regards perception and attitudes on various issues, such as information security issues (Walsh & Maloney, 2002), and issues of trust (Olson & Olson, 2000). Sonnenwald (2007) notes that ‘some individuals may behave inappropriately by not honouring some aspect of the plan, failing to complete tasks, withholding needed information from their partners, or not sharing credit appropriately’ (p. 665). All these issues may lead to conflicts and tension within the collaboration, affecting the interpersonal relationships.

In a review mainly drawing on their investigations of collocated and non-collocated synchronous group collaborations spanning over ten years, Olson & Olson (2000) note the importance of common ground for effective collaborative work. They describe common ground as ‘the knowledge that the participants have in common, and they are aware that they have it in common’ (p. 157). With multidisciplinary research, people come from different disciplinary backgrounds and possibly different understanding of issues, thus the importance of gaining broad shared knowledge of the problem at hand (Olson & Olson, 2000). Olson & Olson (2000) note the importance of collocation in establishing common ground. In the absence of physical collocation, they note the importance of employing technologies that promote common ground. However, as noted by Finholt & Olson (1997), more effort may be required in building common ground in online environments. Communicating explicitly in a computer mediated environment to compliment for tacit cues that may be lost, as compared to face to face communication is essential (Finholt & Olson, 1997). Drawing on work by Clark and Brennam, Olson & Olson (2000) give characteristics of media that promotes common ground as one that promotes co presence, visibility and audibility, simultaneity and sequentiality, and reviewability and revisability:

Co presence typically implies access to the same artifacts to support the conversation, allowing diectic reference and shared context. Visibility and audibility provide rich clues to the situation and the state of the person one is conversing with. Simultaneity and sequentiality relieve the person of having to remember the context of the previous utterance when receiving the current one. Reviewability and revisability assist people in both formulating carefully what they mean and having several chances to decode the message received (Olson & Olson, 2000, p. 159)

The characteristics described above would seem not only important for building common ground, but for supporting remote work in general. Differences in the various disciplinary

backgrounds and practices for individuals in inter-disciplinary collaborations may result in conflicts and misunderstandings, affecting interpersonal relationships. This includes disagreement on publication forum, format of papers especially for interdisciplinary research competition, authorship inclusion and order (Sonnenwald, 2007). For example, in some disciplines, the first author is the main contributor as is the case in information science. In biomedical sciences, the last author is usually the principal investigator, though Tschardt et al. (2007) note that this is not a formalised convention. This could be a source of misunderstanding and would need to be addressed and a consensus reached before writing of a paper (Sonnenwald, 2007).

Differences could also emerge in working styles of individuals from different cultural backgrounds. For instance, Olson & Olson (2000) note that Americans, being very task focussed, usually allow no room for pleasantries in the conduct of a meeting, while Europeans will usually start a meeting with pleasantries. They note that this can cause misunderstandings, in that the Europeans may see such behaviour as rude and unfriendly, while Americans may view Europeans as time wasters. They refer to a common rule of behaviour as 'when in Rome, do as the Romans do', in reference to understanding and adapting to a culture of the other when in their physical environment (p.172). However, it may not be clear in an online environment whose behaviour to adopt, which leads the Olsons to pose the question, 'in a video conference, where is 'Rome'?' (Olson & Olson, 2000, p. 172)

The nature of the work (e.g. level of interdependency) as well as type of collaboration (e.g. distributed vs. local) has been found to impact on various aspects of the collaboration, including communication and coordination mechanisms. Hara et al. (2003) propose a typology of collaboration based on the nature of the work, which they describe as ranging from being complementary to integrative. Unlike complementary group work, they describe integrative work as requiring more interaction and working closely to achieve project goals. Such work therefore is seen as involving a higher level of interdependency and according to Walsh & Maloney (2007) and Olson & Olson (2000), requiring more communication and coordination mechanisms.

Past studies show that more problems of communication and coordination are associated with distributed groups. For instance, Cummings & Kiesler (2005), in their study of

collaborative research across disciplinary and organisational boundaries, focusing on projects sponsored by a program known as Knowledge and Distributed Intelligence (KDI), found that more problems were associated with multi-institutional and multi-disciplinary projects. These projects tended to be less successful than those within one institution, which they attributed to the coordination mechanisms involved. They realised that distributed teams used fewer coordination mechanisms. The most effective coordination mechanism applied was direct supervision, which is more possible with collocation, thus more success of projects within one university (Cummings & Kiesler, 2005). Cummings and Kiesler note one of the problems of their study as its focus on projects sponsored by one funding agency in their early stages of funding multidisciplinary / multi-institutional research. This, they note, could have brought a bias on the kind of projects investigated. For example, the criteria used for their selection, and the fact that they were in their early stages of existence thus various problems were bound to happen before they came up with strategies for dealing with them, (Cummings & Kiesler, 2005). However, the benefits of collocation and physical proximity in groups that work together has been demonstrated in other studies, such as Kraut et al. (1988).

Cummings and Kiesler's findings on the effects of distance on coordination are supported by Walsh & Maloney (2007), who identified collaboration size, distance, and task independence as sources of communication problems in a collaboration. In their study, bigger dispersed groups, whose work involved more interdependence, posed more problems for coordination. On the other hand, field or discipline diversities were not associated with increased problems. The latter finding, also shared by Cummings & Kiesler (2005), and Chompalov et al. (2002) could be an implication that in the face of constant communication and interaction, resolving disciplinary differences and other collaboration problems could be easier. Like Kraut et al. (1987) and Cummings & Kiesler (2005), Dimitrina & Koku (2009) propose 'organizing project work in a way that minimizes the need for coordination and maximizes the independence of the researchers' (p.7) as a way of coping with coordination and communication challenges. But this would depend on the nature of the work, if it allows for such division of labour.

Several other internal factors may affect the collaboration processes. Sonnenwald (2007) identifies such problems as access to resources once the project has started, especially if not



planned for at the formulation stage, delays in acquiring equipment, restrictions in international travel, lack of agreements governing the collaboration such as IP rights, information security issues, dissemination of results and dealing with unethical conduct. Expanding personal and professional networks related to one's work creates a base for building and forging meaningful relations which are important for collaborative work. In such networks, Luo (2008) notes the importance of building a sense of group identity that encourages more sharing and opens possibilities for working together.

It's important to note that challenges will usually crop up even for the most prepared of collaborations. Putting in place measures to minimise their occurrence is important, but so are the mechanisms that have to be put in place to deal with upcoming challenges.

### **External factors**

#### ***Spatial proximity***

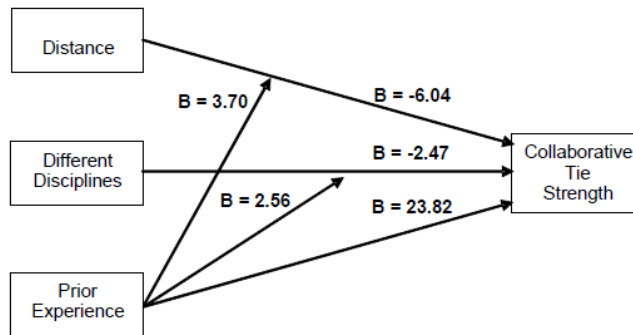
Distance and spatial proximity matter (Lee & Bozeman, 2005; Bozeman & Corley, 2004; Kraut et al 1988; Katz & Martin, 1997; Cummings & Kiesler, 2005; Olson & Olson, 2000). In addition to easing the coordination process discussed above, Olson & Olson (2000) note that collocation played a big role in establishing common ground, and building trust. Similarly, Kraut et al. (1987) and Shrum et al. (2001) note that trust is easier to build among collocated individuals, mainly due to more chances of informal communication and encounters.

The effect of distance on collaboration was illustrated by Lee & Bozeman (2005), in their study of academic scientists associated with the NSF in the US. They found that 51.1% of research time was spent with colleagues in the immediate workgroup, while only one third of time was spent with those outside their university. On testing for the same effect on people in the same institution but different campuses, he still found that distance was negatively related with collaboration. Similarly, Bozeman & Corley (2004), in their study of the American academic scientists focusing on their collaboration choices and strategies found that most collaborated with those within their immediate environs. This led them to thus conclude that 'most researchers are not particularly cosmopolitan in their selection of collaborators' (p. 613). This observation is supported by Kraut et al. (1988), who, in his study involving a large industrial research and development lab with approximately 500

PhD and MS level researchers found that the highest number of pairs collaborating was on the same corridor and the lowest in different floors. However, the traditional institutional arrangements that usually place people in the same department or with similar interests on the same floor or close to each other could have contributed to these findings.

Similarly, Stokols et al. (2005) provided evidence that collocation yields smoother running collaborations. Employing a longitudinal study to investigate the process of trans-disciplinary research in a number of National Institute of Health centres, he used a variety of methods including face to face interviews, structured surveys, behavioural observations, focus groups and use of archived documents. In the initial three years, he compared trans-disciplinary research at three centres, one centre made up of people located in same building who had a history of working together, while those from the other two centres were spread across multiple university departments and schools and shared less history of collaboration. He reported more conflicts and lots of time spent on resolving differences among those from other two centres, an indication that distance resulted in more problems for the collaboration.

The informal interactions associated with collocation are likely to yield more tightly knit relationships, thus the possibility of their endurance beyond a particular project. Cummings & Kiesler (2008) investigated the strength of collaborative ties using a model based on three factors, distance, disciplinary field and prior experience. By analysing social network data of the Information Technology Research (ITR) program of the U.S National Science Foundation, they found that while distance and disciplinary differences were negatively associated with collaborative tie strength, prior experience was positively associated with collaborative tie strength, and reduced the negative impact of distance and different disciplines. Their model in Figure 2.1 summarises the findings. (B in this case is a measure of the tie strength. A positive value indicates a positive influence, a negative value a negative influence)



**Figure 2-1 Effects of distance, disciplinary background and prior experience on collaborative tie strength**

(Adapted from Cummings & Kiesler 2008, p.6)

Though physical proximity plays a significant role in establishment of collaborative relationships, Katz & Martin (1997) note that ‘scientists may be more concerned with seeking the most appropriate expert partners, even if they have to travel some distance to find them’ (p.7). People need not only work with those they have worked with in the past. New relationships bring in new ideas into a project, and the need for diversified expertise and resources leads to exploration of the possibilities of forming new relationships. The major concern should be making those relationships work.

### ***Disciplinary factors***

Disciplinary factors that may affect collaboration processes include the level of resource dependence, largely defined by the nature of the work in a discipline and the different disciplinary cultures and practices (Birnholtz, 2007; Whitley, 2000; Melin, 2000; Lee & Bozeman, 2005). Studies have shown that levels of collaboration and multiple-authorship vary with the disciplinary area or specialty.

Whitley (2000) looks at the differences in the nature of intellectual fields as mainly resulting from their ‘task uncertainty’ and ‘mutual dependence’, with regard to both the field and scientists. According to Whitley, some fields are characterised by collective intellectual goals and clearly defined knowledge production and dissemination mechanisms, and target audience. In such fields, scientists are aware of and have more control over the kind of problems to be solved within the field and how they are solved. To make significant contributions, dependence on knowledge produced by others, and

sometimes resources is high (Whitley, 2000). This description is similar to the notion of paradigms advanced by Kuhn (1962). Kuhn argues that a paradigm arises out of shared definition of work that is considered important in a field of science, thus determining the nature of the problems to be solved and methods used to address them. In a paradigm therefore, task uncertainty is low. On the other hand, some fields have research that is less coordinated, diverse audience and ‘a number of competing research schools, and it is often not clear what the major issues in the field are or how competence is to be assessed between such schools’ (Whitley, 2000, p. 86). To illustrate such differences, Whitley gives the following example:

University chemists, for instance, are able to control the nature and boundaries of research skills in chemistry to a much greater extent than can many academics in the social sciences and humanities where both lay groups and the intellectuals from other fields are able to influence evaluation and competence standards (Whitley, 2000, p. 84)

Such differences are seen by Birnholtz (2007) as accounting for differences in collaboration rates, whereby it’s higher in fields that display high levels of ‘mutual dependence’, whether for knowledge/skills or resources, and ‘low task uncertainty’. For instance, Birnholtz (2007) observes that the high resource concentration and need for sharing facilities in High Energy Physics account for the associated huge collaborations. Similarly, explaining the effect of task uncertainty on collaboration rate between disciplines, Melin (2000) notes:

It is probably more difficult to collaborate in the humanities than in other sciences since there is less consensus of what the actual research task is, what the relevant questions are and how to investigate them. Much of this is clear and agreed upon in medical and natural science, at least to a significantly higher degree. (Melin, 2000, P. 38)

Other studies that have associated researchers in predominantly theoretical disciplines with less collaboration and publication rates as compared to those in experimentally-intensive or applied fields such as engineering are Katz & Martin (1997), Lee & Bozeman (2005) and Becher & Trowler (2001). Lee & Bozeman (2005), for instance, in their study of American academic scientists realised apparent differences in numbers of publications between disciplines. They found that chemistry had the highest number of publications and computer science the lowest, and engineers were more collaborative than biology and life sciences. It would be interesting to know the possible cause of the variations between the disciplines they studied. However, this is not addressed in their analysis and discussion.

Though the nature of the work has been looked at mainly from the disciplinary field perspective, some studies have shown a lack of clear boundaries between the broader disciplinary fields advocating for the specialism area as a ‘better’ way of looking at scientific organisation and communication. For instance, Crane (1969), in her investigation of the social organisation of scientists in a problem area, found the existence of a core group of active individuals within the wider membership of the area, which constituted of a number of connections with outsiders to the particular research area. These individuals were in constant communication and shaped the growth of knowledge in the area. This reflects the interdisciplinary approach to solving problems, by which Crane concludes that ‘scientists in problem areas are usually committed more to the solution of the problem than to the group itself’ (Crane, 1969, p. 349).

A similar observation is made by Becher & Trowler (2001) in their discussion of knowledge domains, with reference to the taxonomy developed by Becher in 1994 following a study investigating social, intellectual and organisational elements of twelve academic disciplines. In this taxonomy, knowledge is classified into four broad categories, hard pure, soft pure, hard applied and soft applied, under which the various disciplinary areas fall. However, Becher & Trowler (2001) note that there are no clear boundaries between these knowledge domains, as a specialism within a specific discipline may have stronger connections with a specialist area in a different discipline. Similarly, Birnholtz (2007), in his study of academic researchers in the US, argue that collaboration behaviour is better explained by nature of the work rather than ‘a collectivist orientation of a field’ (p. 2235), a view shared by Fry (2006). High Energy Physics (HEP) has been found to be highly collaborative as a specialist area, which is not to mean that physics in general is highly collaborative, an observation also made by Chompalov et al. (2002). It is the kind of problems being investigated in HEP, skills dependence, and scarcity of resources that make it highly collaborative. Whether looked at from disciplinary or specialist level, it is however clear that different areas of science have distinct characteristics that define the way knowledge is created.

### ***Institutional factors***

The university plays a major role in the knowledge production process. Martin & Etzkowitz (2000) note the evolving role of the university, from its core functions of teaching and

training to creation of knowledge, and a subsequent increasing demand for knowledge that meets societal needs and that contributes to the economy. This has resulted in significant changes in the structures of university functions and external relationships, with more links with non-academic institutions and private organisations (Martin & Etzkowitz, 2000), in support of Mode 2 claim of 'heterogeneity'. This involvement is supported by a bibliometrical study by Godin & Gingras (2000), who noted a rise in non-university contributions in academic publications. However, unlike Gibbons et al. (1994) who predicts a diminishing role of universities in knowledge production, Godin and Gingras note that universities remain the major producers of knowledge. This, they illustrate with statistics showing an increase in the percentage of papers with university addresses in Canada as having increased from 75% to 82% between 1980–1995 (Godin & Gingras, 2000).

The department is the basic unit of organisation in a university. With the increasing inter and trans-disciplinary research and more specialisation in science some scholars feel that the rigid structures and organisation of research around disciplines needs realignment to allow the flexible flow of ideas and access to resources. Martin & Etzkowitz, (2000) for instance, question the effectiveness of the departmental organisation based on disciplinary area in meeting the 'newer' demands of the knowledge production processes. Similarly, Smith & Katz (2000) argue that the 'once taken-for-granted notions of disciplinary empires and boundaries, still used predominantly in the organisation of academic employment and teaching, make far less sense in several research contexts' (Smith & Katz, 2000, p.66 ). An organisation based on specialist areas would prove useful especially in university settings where assignment of resources is based on departmental (disciplinary) basis. Restrictions in access to resources across departments limit individuals in a certain specialist area based in different departments freedom of access to the resources. However, the danger in such an organisation (based on the specialist unit) is that with growth of inter/multi/trans-disciplinary research, newer areas of specialisation keep springing up, and the creation of departments to reflect upcoming specialist areas may not be feasible. In addition, research interests of groups and individuals change over time, and they may belong to different specialist areas over time. This would mean they change their departmental affiliation with every change in interest, which may be difficult from a management point of view. Perhaps the solution to this problem would be to allow and facilitate free interaction and integration of ideas between the various departmental units.

Access to resources has been identified as a major motivator for collaboration, which to some extent depends on capabilities of individual universities. Prestige of an institution has been found to determine the kind of environment a scientist operates in e.g. in terms of research facilities, working with prominent scientists and contacts developed, therefore affecting overall productivity (Crane, 1965; Long, 1978). In the UK, the research strength of a university as exemplified by the RAE<sup>2</sup> rankings is used as a basis for allocation of competitive funding and influence external links to a university (Smith & Katz, 2000). Though this may be seen as a motivator for universities that lag behind in the ranking to focus more on research to improve their ranking, it may mean the bigger universities continue to attract the best of opportunities, support and connections, creating a situation of ‘top remains top’.

Research policies should address the issues that encourage collaboration at the individual level. Institutional policies in support of research vary from institution to institution, but a general need has been noted for ‘good institutional policy environments and cultures of management which create the conditions and set the rules and procedures which enable research to take place’ (Harle, 2009, p. 11). Such is the need for institutions to put mechanisms in place that help people discover each other, with Melin (2000), noting that research policies should ‘create arenas/systems for social interaction and networking, and support existing ones’ (p.40).

Past studies note the need to involve researchers in decision making processes about research collaborations as they are the main stakeholders and greatly determine the success of the collaborations. This importance is demonstrated by Melin (2000), in his study of the reasons for and the form of collaboration at the individual level, whereby he observed that a major indication in his study was towards researchers making major decisions without interference from policy makers. For example, some participants in his study felt that diversity should not be forced onto them as was the case with European Commission’s Framework Programmes, where one had to show a network of scholars from more than one

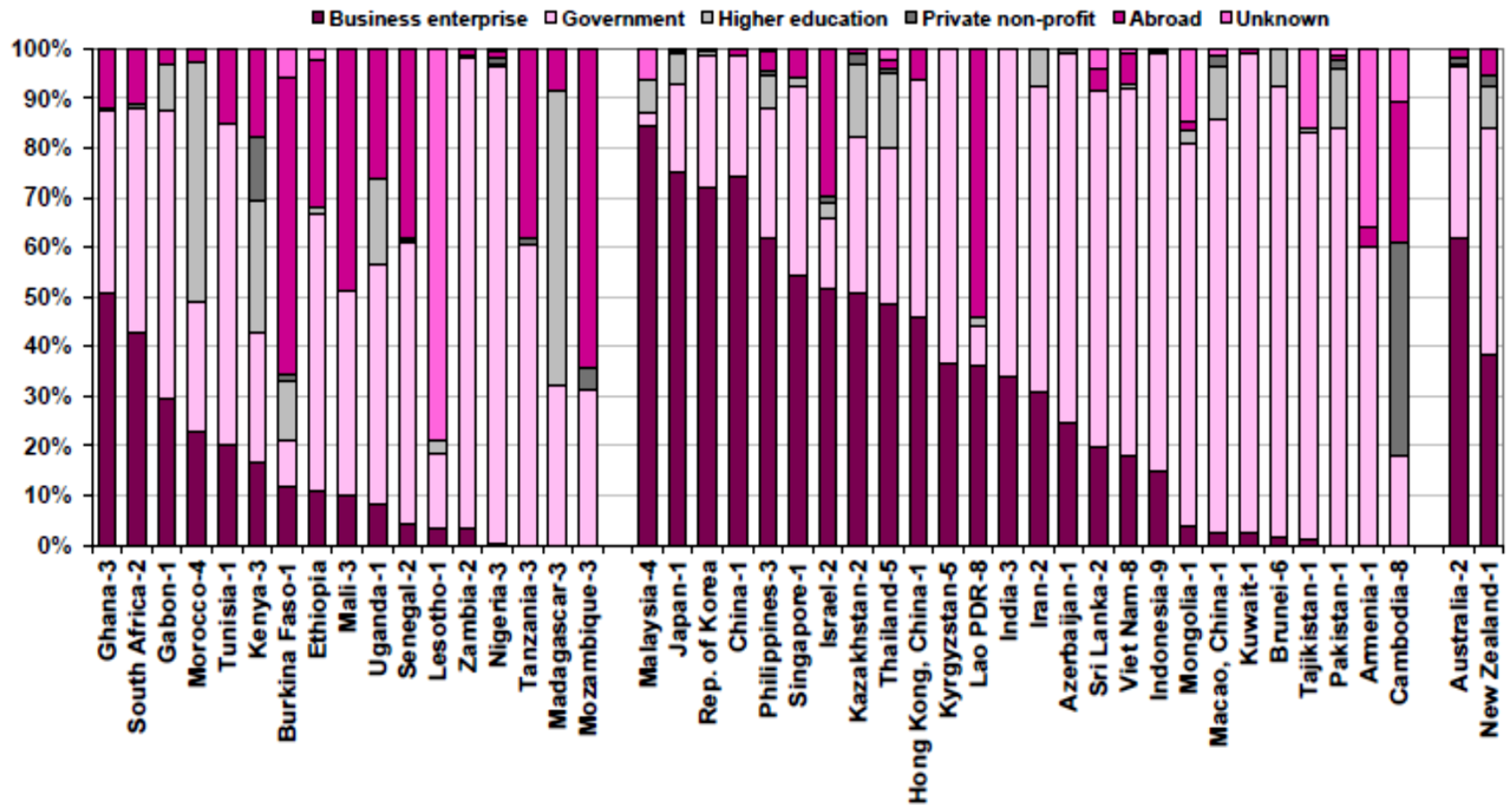
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<sup>2</sup> RAE is an exercise carried out jointly by the Higher Education Funding Council for England (HEFCE), the Scottish Funding Council (SFC), the Higher Education Funding Council for Wales (HEFCW) and the Department for Employment and Learning, Northern Ireland (DEL,) approximately every five years. The purpose is to ‘produce quality profiles for each submission of research activity made by institutions’, useful in funding decisions (RAE, 2014)

country in order to win a funding grant (Melin, 2000). The policy makers, on the other hand, look at this as a way of encouraging international collaborations, and indication that the policy maker and researcher may be looking at issues from different points of view. The trend is the same in Kenya, whereby the National Council for Science and Technology (NCST), the arm of the ministry that deals with higher education issues, only fund research that is multidisciplinary and cross institutional. As pointed out before, collocation has the benefit of brewing brilliant research ideas that policies targeting only cross institutional research may lock out. Similarly, Chompalov et al. (2002) note that the link between leadership structures and independence of knowledge producers is very important. Bureaucratic leadership structures may affect or constrain the task organisation and management of some collaborations, impacting on their success, and this may discourage researchers from seeking support or funding for their collaborations where extreme cases of bureaucratic procedures are the norm.

Institutions operate within a wider national setting. Therefore it's important that a country prioritises the research agenda and create policies that support research. This, for example, is seen in the amount of GDP a country commits to research, and the disbursement processes. Figures released by the UNESCO Institute for Statistics (UIS) in October 2012 indicate that North America leads in investment in R & D, spending an average of 2.7% of GDP on R&D activities, followed by Oceania (2.2%), Europe (1.8%), Asia (1.6%), Latin America and the Caribbean (0.7%) and Africa (0.4%). Investment by individual country varies, with Japan and South Korea leading globally with over 3% of their GDP invested in R&D. The same statistics indicate that of the total GDP spent on R&D in North America and much of Europe, the business enterprise contributes the larger percentage and much of the other funding comes from the government. Africa lags behind in the R&D funding, with little investment by the private sector as seen in Figure 2.2. Kenya, for instance, spends only 0.48% of its GDP on R&D (NEPAD, 2010), with little investment from the business enterprise (see Figure 2.2). At the 12th AAU conference in 2009, the need for African universities to forge closer links with industry to increase their resource funding base was noted as one of the ways of creating a strong research base referred to as important for sustainable development (Ssebuwufu et al., 2012). In addition to benefits associated with a wider resource base, such partnerships will encourage uptake of the





Notes: +1 = 2011, -1 = 2009, -2 = 2008, -3 = 2007, -4 = 2006, -5 = 2005, -6 = 2004, -8 = 2002, -9 = 2001.

Source: UNESCO Institute for Statistics, October 2012.

Figure 2-2 Percentage of investment in research by various sectors over a number of countries

products of research, thus more impact, improving the relevance of the university in the knowledge production process.

## **2.5 RESEARCH COLLABORATION AND PRODUCTIVITY**

Increased productivity has been cited as one of the benefits of scientific collaboration. While some past studies show a positive association, others find no clear relationship between the two (Lee & Bozeman, 2005; Duque et al., 2005; Ynalvez & Shrum, 2011). Lee & Bozeman (2005), in their study of university researchers associated with the National Science Foundation in the US, investigated this relationship using two measures of publication productivity, normal count and fractional count. While a normal count resulted in a positive relationship between collaboration and productivity, the relation was not clear using a fractional count, in which co-authored papers were divided by the number of co-authors. Noting the strong implications of the normal count on the collaboration / productivity relationship, they too note implications of fractional count for policy makers, that individual research can also be quite productive, thus should also be considered when making decisions on funding, (Lee & Bozeman, 2005). However, a limitation in using the fractional count is that it assumes that all individuals contributed equally to the project. This may not be the case thus a fractional count may not be the best method to measure individual productivity in a collaboration.

Similarly, a study carried out by Duque et al. (2005) show this correlation as being less clear in developing countries. Their study on research productivity involving research scientists in universities and research institutes across the state of Kerala in India, Kenya and Ghana between the years 2000 – 2002, found ‘a limited association with the productivity of academic scientists and, if anything, a negative association with the productivity of scientists in government research centres’ (p.775). Kenyan scientists were most collaborative and least productive, though there were differences in publication productivity levels between academic scientists and those in research institutes. Kerala was most productive in terms of number of publications reported by respondents, yet was least collaborative. Duque et al. associate the low productivity to problems of ‘costs associated with collaboration’ due to requirement of extensive exchange and interaction not well supported by ICT infrastructure (p. 758). However, the reasons could be many and varied. Scientists maybe involved in collaborations with government institutes, international

organisations and NGOs, who have less interest in publications as an outcome of the collaborations. Dimitrina & Koku (2009) attribute this to interest and motive. They argue that while those in academia care much about peer reviewed publications which are considered important for advancement in their research careers, non-academic scientists are more interested in other outputs such as manuals, reports and innovations.

However, Duque et al.'s measures of collaboration and productivity could also have had an effect on the established relationships. They defined collaboration as any form of contact with someone in another organisation, excluding those in the same organisation. Their assumption was that many projects depend on resources external to the local context, thus considered inter organisational collaboration more important than intra for the developing world (Duque et al., 2005). This definition may be important in identifying professional networks, but not necessarily collaboration networks. Their exclusion of ties internal to an organisation or department may fall short of identifying the actual level of collaboration, and could affect the results of an assessment of the relationship between collaboration and productivity. Furthermore, their measure of self-reported publication productivity did not exclude publications co-authored with colleagues, causing an imbalance between their two measures.

One of the most commonly cited benefits of collaboration is increased productivity. The study by Duque et al. indicates that this may not always be the case, as other factors affect this relationship. Some of the factors identified in literature as determining productivity rate of scientists include disciplinary field or specialist area (Lee & Bozeman, 2005; Melin, 2000); availability and amount of funding (Lee & Bozeman, 2005; Bozeman & Corley, 2004); research work connections and size of professional networks (Ynalvez & shrum, 2011; Hara et al., 2003, Bozeman & Corley, 2004; Luo & Olson, 2008); having a PhD and location of graduate training (Ynalvez & shrum, 2011, Luo & Olson, 2008) and age, and number of years into PhD (Lee & Bozeman, 2005).

The institutional environment in which a scientist trains or works may have an impact on his productivity and scientific career. Crane (1965), on measuring productivity levels of scientists from graduate schools of varying prestige levels, found that those who trained in major universities had higher productivity levels, regardless of the work environments. She attributes this to facilities, opportunities and stimulation for research that comes with

working in a research intensive environment with prominent scientists and the contacts developed. On the other hand, those who trained at minor universities were less productive, unless working at a major university. This, she attributes to the influence of having been trained by less productive scientists, thus less likeliness of having learnt from them or being provided with ‘an adequate model of the optimal way to proceed’ (Crane 1965, p. 707). In addition, Crane found that the increased visibility that was gained from being associated with a major university contributed positively to productivity.

Similarly, Long (1978), using a longitudinal study carried out an assessment of whether the prestige of an institution or its location determined a scientist’s productivity, or if the productivity of scientists determined prestige an organisation. He found a weak effect of scientific productivity on location, but a strong effect of organisational context on productivity. On extension of Long’s study to include non-academic settings, Long & McGinnis (1981) still found a strong effect of the institutional context on productivity. Affiliation with non-academic institutions resulted in lower publication rates. The two studies therefore indicate that institutional environments have a major effect on productivity of scientists. This could be in term of resources accessible to them, and organisational structures of the particular institutions, such as existence of strong research groups, availability of and level of involvement of mentors in research as well as reward mechanisms.

The motive for collaboration partially determines the processes involved and outcomes. While a service motive such as simple access to equipment may end when the two parties fulfil their part of the bargain, a collaboration based on intellectual gains may realise much more than just delivering on the project mandate. This is seen in Lee & Bozeman (2005), who found that having complementary skills ‘had a strong impact on productivity’, while the service and nationalist motive were not significantly related to productivity (p. 691).

It is therefore clear that scientific productivity is affected by various aspects of the research ecosystem. Understanding how the various aspects affect scientific research, a core issue addressed by this study, is the first step towards improving the productivity of academic scientists, not only in form of publications, but also in the quality and value of other outputs from research.

## 2.6 MEASURING COLLABORATION AND PRODUCTIVITY

Ynalvez & Shrum (2011) note that three methods have dominated studies on the dynamics of research output: the 'number of published articles derived from bibliometric databases, self-reported productivity measures derived from surveys, and written papers and publication counts obtained from self-constructed vita' (p. 205). Of the three, publication counts in international databases have been the most widely used as a measure scientific collaboration and productivity, including the initial studies in the area such as Price (1963) and Price & Beaver (1966). Duque et al (2005) and Shrum (1997) attribute the wide usage of bibliometrics to the ease of accessing the data and analysis. Van Raan (2005) sees their wide use emanating from the assumption that 'scientists who have to say something important do publish their findings vigorously in the open international journal ('serial') literature' (P. 2). However, he notes that this may not always be the case, as journal articles may not be the only output of scientific research. This view is shared by Lee & Bozeman (2005), who argue that other outputs also count. In support of this argument, Smith & Katz (2000) warn that using co authorship as a measure of collaborative activity must be treated with caution, as:

There are many cases of collaboration that are not consummated in a co-authored paper and which are consequently undetectable with this approach. Conversely, there are other cases of, at best, only very peripheral or indirect forms of interaction between scientists which nonetheless yield co-authored publications (p. 37).

Co-authorship therefore, on its own would not be an accurate measure of collaboration (Katz & Martin, 1997; Shrum, 1997; Duque et al., 2005; Lee & Bozeman, 2005). Though making wide use of bibliometric study of co-authorship to measure collaborative activity over the years, Beaver & Rosen (1979) note as a shortcoming of this method the reliance on core journals that mainly reflect the work of a few visible elite. The studies may not give a true representation of the nature or extent of collaborative work. This especially applies to studies of developing areas which prioritise local needs such as poverty relief, food security and disease control. Such research may result in much of the output being published locally rather than in international journals (Ynalvez & Shrum, 2011; Harle, 2010; Duque et al, 2005; Mouton, 2008). Shrum (1997), for example, in his comparison of visibility of scientists using two measures, bibliometric analysis in international databases and self-reported measures, found that self-reported measures yielded 2.7 times more productivity

than bibliometric measures. This low visibility of African scientists international databases led Shrum (1997) to conclude that bibliometrics studies based on international databases could not accurately represent scientific activity in least developed countries. Thus, without completely discounting the use of bibliometrics to study research output in developing countries, combining it with other methods would give a more complete picture.

Ynalvez & Shrum (2011) propose self-reported productivity gathered through surveys, to be more representative of research and productivity in developing areas. Like Shrum & Beggs (1997), they note that bibliometric approaches 'exclude output from developing countries due to differences in thematic emphasis, making it difficult for developing world scientists to publish due to differences in literary style, or utilise less sophisticated methods and techniques owing to resource scarcity' (Ynalvez & Shrum, 2011, p. 205). However, like Duque et al. (2005), their measure of collaboration ignores internal linkages i.e. those within an organisation.

Other studies that used self-reported measures of collaboration include Lee & Bozeman (2005) in their study of academic scientists in the US. They observe that focusing on the collaboration rather than publications gives a way for inclusion of important collaborations whose outputs are not publications, as it 'relies on researcher's idea of a significant collaboration rather than an externally imposed concept' (p. 683). Self-reported productivity was also successfully used by Bozeman & Corley (2004), in his study focusing on American academic scientists' collaboration choices and strategies. They identified participants by studying the CV database of university researchers associated with NSF, which they followed up with questionnaires having questions on productivity. The vitae method of assessing productivity has also been proposed. However, Ynalvez & Shrum (2011) note that this would only be useful if the vitae are kept to date, which they observe was not the case with the majority in their Philippine surveys described earlier.

It is therefore clear that no single method would be completely adequate in studies measuring collaboration. Despite the criticism towards use of bibliometrics, Katz & Martin (1997) observe that co authorship cannot be completely dismissed as a measure of collaborative activity, as it has its merits such as its verifiability and ability to incorporate a big sample. As a solution to deciding on applicability of bibliometric analysis, Van Raan (2005) proposes a first study of publication practices to establish the major mode of

communication in a field. Depending on the research environment context and the kind of data sought, one would need to weigh the pros and cons of the different measures used in collaboration and productivity studies in making a decision on the most appropriate.

## **2.7 ICT AND RESEARCH COLLABORATIONS**

### **2.7.1 Benefits of using ICT to support collaborative work**

The use of ICTs to support research work has become increasingly common over the years. Gibbons et al. (1994) partly attribute this to the changing nature of the knowledge production process (as discussed in section 2.2). They note the critical role communication technologies play in supporting distributed teams, made possible by improvements in computer networks and associated development of tools and applications to support e communication and access to and distribution of information.

Major changes have been realised in development of computing technologies and networks over time that may affect how technologies were perceived and used in the 1990s and at present. However, reference is made to literature that spans changes in time to support some of the arguments on their consistency in supporting scientific work. A note is made about use of the acronym CMC and ICT. The term ICT is a more general term in reference to a wider set of communication and information access media, including cell phones, and is the main term used in this study. However the term CMC (which stands for computer mediated communication) defined in Thulow et al.(2004) as ‘communication that takes place between human beings via the instrumentality of computers’ (p.83), is used in a number of past studies, thus its use in this section is for purposes of matching use of the term in studies referencing it.

Past research points to a number of positive impacts of ICT on research work. These include:

- Facilitation of access to a wider range of information resources (Sooryamoorthy & Shrum, 2007)
- Reduction in organisational and communication problems (Walsh & Maloney, 2007; Cummings & Kiesler, 2005)
- Extension of networks (Gruzd et al., 2012; Walsh & Bayma, 1996 b; Ynalvez & Shrum, 2011)

- Cutting down geographical barriers (Walsh & Bayma, 1996b; Walsh & Maloney 2002)
- Keeping updated on research and promoting one's work (Gruzd et al, 2012).
- Increased productivity (Lee & Bozeman, 2005; Cohen, 1996; Ynalvez & Shrum, 2011; Sooryamoorthy, & Shrum, 2007; Barjak, 2006).
- Increased collaboration (Walsh et al., 2000; Barjak, 2006).

Walsh & Bayma (1996b) in their study of how scientists perceived the effects of CMC on their work, in four disciplines, mathematics, physics, chemistry and experimental biology found evidence that CMC led to new collaboration patterns. This was evident in the increased size of research groups and remote collaborations, especially notable in mathematics. Using statistics from the American Journal of Mathematics between 1970, 1980 and 1990, they show that the average number of co-authors in a paper rose from 1.1 in 1970 to 1.6 in 1990, with most of the collaborations being with remote colleagues (Walsh & Bayma, 1996b).

However, contrary to the finding on CMC increasing the size of the group, Walsh et al. (2000), in their analysis of the role of email in scientific work in four fields, experimental biology, mathematics, physics and sociology, found no significant relationship between email use, a common form of CMC, and the size of the group. They note that this could imply email is a very common general media of communication whether within a research group or not. Their measure of use (number of messages sent per day) could possibly have had a different effect if it were tested within the context of use for research activities. Such a measure was used by Ynalvez & Shrum (2011). They measured diversity of email use in relation to participation in discussion groups, remote professional communication with people met on the internet, discussion of funding issues and in research dissemination processes. A positive association was found between diversity of email use on research related matters and professional network size, an indication of the role ICT plays in the process. On the other hand, frequency of use and number of years into use was not significant in determining network size. This could be construed to mean that as speculated by Walsh & Bayma (1996b), email is a common type of communication media, whether in support of research or not, thus no effect of intensity or extensity on professional network size. From a methodological point of view, and extending the debate to measuring the



effects of ICT on collaboration activities, this indicates the need to measure use against collaboration type activities to understand better the effect on collaborations as opposed to general use.

The positive effects of CMC on scientific work were also highlighted in Walsh & Maloney (2007) in their study of structural elements likely to increase collaboration problems among American scientists. The collaboration problems were categorised into two: problems of coordination, and problems of culture and information security. Their study realised that email use resulted in fewer problems of coordination, while having no significant effects on problems of culture and security.

Use of ICT has also been associated with reducing status differences that would arise in face to face discussions between junior and senior scientists. This encourages participation from peripheral researchers and more open discussions on common ground (Sproull & Kiesler (as cited in Cohen, 1996); Finholt, 2002). Walsh & Bayma (1996b) found that ICTs provided more opportunities to the younger researchers and those who were not in major universities to participate in discussions with those from prominent universities. A major effect was increased network size and widening participation as discussed above. However, they note that this may not have led to 'a levelling of status' (p. 359). Other studies that find similar effects of ICT on reducing status differences are Matzat (2004), who in a survey of the role of internet discussion groups (IDGs) in informal academic communication found IDGs did not have 'equalizing effects on the general structure of academic communication' (p.221). On the contrary, Ducheneaut (2002), in his study of the effect of email on status differences in a university setting found that email only reinforced the existing 'power games'. He noted that messages from the administration and those in power, were 'impregnated with authority and rigour, while those from students and colleagues were more informal and friendly' (p.178), an indication that the power distances existed even with use of ICT. This means that ICT may not change existing communication or organisational structures within an institution or research collaborations. The way it is used may at times reinforce the levels of authority, reinforcing the status differences that may affect equal participation in knowledge networks.

Studies have found a positive correlation between CMC use and productivity. Cohen (1996), in his investigation of the effects of CMC on productivity of American scientists in

four disciplines and varying university settings found increased use of CMC was related to increased publication productivity and recognition. Unlike studies focussing on one form of CMC, email, e.g. Walsh & Maloney (2002), his study tested the effects across a variety of CMC. This included email, discussion groups, and use of application layer protocols such as Gopher, FTP and Telnet as well as use of electronic journals. Introduction of the World Wide Web has made access to and sharing files even easier thus overriding some of the technologies used then, but his study shows the positive attitude with which scientists adopted technologies for their work even then. However, the participants in his study viewed CMC as being more important for communication with those outside their local setting, construed to mean that face to face interaction was the preferred form of communication locally, as seen in Walsh & Bayma (1996b), Finholt & Olson (1997), Vasileiadou (2009) and Cummings & Kiesler (2005). Consistent with other studies, they found email to be the most commonly used form of CMC. However, they found use differed across disciplinary fields, with humanities (philosophy) having lower levels of use as compared to social (sociology) and physical sciences (chemistry). Cohen also found a positive effect of CMC on collaboration, with highest number of co-authorships among CMC users. Though noting that it was not clear if increased productivity was a result of CMC use, prestige of an institution or extent of collaboration, a question on benefits of CMC to scholarly activities indicated positive effects (Cohen, 1996).

The local context into which technology is introduced varies, and will determine its use and effects on productivity. The relationship between ICT use, collaboration and productivity may be difficult to decipher. This is because at times it is not clear if effects on productivity are more associated with ICT use, or collaboration status that necessitates the use of ICT, as noted by Cohen (1996) above. It would be expected that ICT use promotes both collaboration and productivity, but this is not always the case. This complexity is seen in Duque et al. (2005), who in their earlier described study found that though Indian scientists had greatest access to the internet, they were least collaborative and most productive. On the other hand, Kenyan scientists faced more problems with use of the internet, were most collaborative yet least productive, thus creating what they refer to as a 'collaboration paradox'. On regressing problems in research against access to email and collaboration frequency, the results of their study showed that access to email was significantly associated with reduced problems of coordination and security of information. On the other

hand, collaboration was associated with increased problems. Their speculation is that by involving themselves in more collaborations, African scientists face more problems, as a result of the local context affecting their productivity. On the other hand, Indian scientists face fewer problems by collaborating less, allowing them to ‘enjoy the pure productivity benefits accruing to those who employ new ICTs’ (p. 777). Noting the need to look closely at the local context in assessing effects of internet use on collaboration and productivity, Duque et al. (2007) thus observe that ‘while the internet may still prove to be an ‘elixir’ for developing world productivity, it may only be so for those who take advantage of its problem-solving attributes while keeping their collaborative behaviour stable’ (p.777). However, though Duque et al. identify the national and regional context as defining internet use, collaboration and productivity, their study does not provide the details of the particular aspects of the context and how they produce the effects. Another limitation of their study is their sole focus on email. It would be interesting to see the effects of other forms of ICTs on collaboration processes.

### **2.7.2 Role played by ICT in collaboration processes**

With similarities to the classification by Kraut et al. (1987), Finholt (2002) groups technologies supporting collaborative processes into three, depending on the role they play: those used for communication such as email, instant messaging services, video conferencing tools and web forums; those used to search for information such as www and digital libraries; and those used to accomplish specific tasks such as data viewers. While some offer more support for communication and coordination processes, others are more useful for gaining access to information, important for the knowledge production process (Sooryamoorthy & Shrum, 2007).

Kraut et al. (1987) note that a single technology can serve different functions through the various stages of the collaboration, but at times some technologies will offer better support for some tasks than others. In the pre-collaboration stage, technologies that help people find each other, build trust and strengthen relationships, which are considered important ingredients for working together would be useful. However, Kraut et al. (1987) note that much attention has been on tools that support tasks, and little on those that support building personal relationships. Sooryamoorthy & Shrum (2007) note that unlimited access to existing bodies of knowledge and information is important for the knowledge production

process, as it enables scientists to identify potential areas of research and gather information that feeds into development of their research proposals. Providing for access to a wide range of information in digital libraries is therefore important in this early phase of developing a research proposal. Once a viable research area has been identified comes the need for establishing resources needed to complete the research, in form of people and material resources. Physical meetings facilitated by collocation, organised meetings such as in conferences and workshops and people in one's social and professional network are valuable sources of connections (Kraut et al. (1987). In addition, online platforms such as that provided by ResearchGate allow people to search for and make connections.

Once the collaboration has been established, a decision is made on choice of tools that support collaboration processes such as decision making and strengthening social bonding. Walsh & Bayma (1996b), for example, observe that while Netnews bulletin boards are useful in reaching a wide audience in which anyone can participate in a discussion (e.g. to deliver research news and get feedback), a field (group) specific distribution list only targets members of the group who are subscribed to receive information. The use of bulletin boards systems common in the 1980s and 1990s has faded with the growth and widespread use of WWW to give way to internet forums, useful for disseminating research results to a wide audience. However a group specific distribution list may be more useful for sharing within an already established collaboration. In addition to the purpose of sharing information within a group, Vasileiadou (2009) found that such lists created a sense of shared team identity and were important in giving emotional support, such as 'rewarding and praising each other's work' (p.127). Such a tool therefore promotes the socialisation process.

The existing organisational structure would determine the effects of use of certain tools. For example, a general mailing list that tends to involve all in the group in decision making may work in support of participatory kind of leadership structures, but effects may be different for bureaucratic structures. Vasileiadou (2009) found that decision making processes in her study usually resulted in conflicts due to the hierarchical structures, supported by managerial lists, impacting negatively on the pace of resolving conflicts. Applying technology to an already problematic organisational structure did not resolve the problems. This can be seen to support Walsh & Bayma's (1996b) view that use of ICT does

not transform the organisation of science or research collaborations, but rather facilitates them.

Social media has been found to have the advantage of keeping researchers updated on current research in their field, creating contacts and strengthening relationships as well as for output dissemination (Gruzd et al., 2012). As noted by Gruzd et al., social networking sites contain search facilities that can be used to look up for particular individuals of interest as well as their connections, thus can be a valuable source of identifying and seeking connections. Informal communication in a social networking site has been found to promote social bonding. For instance, Nardi (2005) observes that the instant messaging service (IMS) facility creates a feeling of presence, close to physical collocation whereby 'you notice when they log in and out, when they are off for lunch ... you get a visual image of the person' (P.93) which promotes a feeling of connection. Using the IMS facility embedded in online networking sites and email systems, one can start a conversation, drop a question and its responded to instantly, the kind of interaction and response important in collaborative work teams. Luo (2008) also notes that IMS helps build space for chance encounters, in the process of responding to questions and comments on material posted online, which could end up in close working relationships.

Adoption of social media among scholars varies. Perceived benefits and social influence from the immediate environment, identified by Venkatesh et al. (2003) as affecting adoption and use of technology have been found to determine use among researchers. Gruzd et al. (2012), in his study aimed at establishing if, why and how scholars in information science and technology research community were using social media, including for research purposes found that quite a number found some forms of social media useful for their work. However, how they were used varied, with junior scholars citing more benefits in establishing and strengthening connections. This, Gruzd et al. attribute to the possibility that senior scholars already had established networks before social media gained popularity, while junior scholars who were still establishing networks and in this information era found more use for them. This supports Walsh & Bayma (1996b) finding on ICT offering extra benefits for junior and peripheral researchers. In addition, Gruzd et al. (2012) realised that non-academic social networking tools that were common among general public, such as Facebook and LinkedIn were most common among

scholars too. On the other hand, academic social networking tools such as academia.edu and virtual worlds were less commonly used in research work. They attribute the use to the level of general popularity, making it easier for them to be adopted for research work. However, Gruzd et al. note that use of non-academic social networking tools could lead to difficulties in managing content, information flow and boundary loss. In an application such as Facebook, it may be difficult to control content, privacy issues, and distinguish between personal and professional boundaries (Gruzd et al., 2012). They note that using academic social networking sites such as academia.edu and researchgate.net could help resolve issues regarding personal and professional boundary loss as the two sites are mainly used for professional networking and interactions.

Blog posts can be a viable medium for searching for and identifying potential collaborators. Bukvova et al. (2010) carried out an empirical qualitative study aimed at understanding the use of blogs by German researchers by identifying the kind of content as well as level of engagement in information posted by 17 academic researchers in 15 research related blogs. They observed that researchers usually disclose their research interests, current research activities as well as contact information in blogs, which is important information in searching for collaborators. However, they found differences in the ‘verbosity’ of the content, in terms of the amount of information that was provided per particular topic and how far the authors related with the content, e.g. through personal opinions and the level of interaction with the audience. Blog posts from junior researchers, and especially from natural sciences were mainly expertise-oriented with low levels of interaction. On the other hand, those from senior researchers were both expertise and activity oriented, with high levels of detail and interaction (Bukvova et al., 2010). This could mean that researchers who were more experienced in their fields were more confident in sharing their thoughts online. It could also mean that the recognition accorded to them as senior researchers made their research to be regarded highly thus more people wanting to respond to their blog posts and interact with them. This can be seen as supporting studies that found technology did not reduce status differences as discussed in section 2.6.1. Given that most blog posts carry identification information, status differences associated with face to face communication may be carried on to online communication. However, Bukvova et al (2010) note the insufficiency of their sample in generalising about the blogging habits of general population

of academic researchers. They note that the study would need to be extended to include more research blogs and bloggers as well as include international researchers.

Drawing on data from an analysis of media used within two case studies of FP5 research collaborations, Vasileiadou (2009) distinguishes between tools in their appropriateness to support communication and work processes of a collaboration, summarised in Table 2.6.

Her classification shows tools that would be appropriate for supporting communication within or external to a collaboration, and those suited for supporting personal and/or team processes. It is important to analyse the desired effect or purpose a tool is expected to achieve in decisions of what tools to adopt.

<b>MEDIA</b>	<b>INTERNAL/EXTERNAL</b>	<b>PERSONAL/TEAM-LEVEL</b>	<b>WORKING PROCESSES</b>
<b>General list</b>	internal	team	all
<b>Management list</b>	internal	team	Decisions, tensions
<b>Website</b>	both	team	Task allocation, output production
<b>Blackboard</b>	internal	team	Task allocation, output production
<b>Meetings</b>	internal	both	all
<b>Personal emails</b>	both	personal	all
<b>Phone</b>	both	personal	Decisions, tensions
<b>Chat</b>	internal	personal	Decisions, Task allocation

**Table 2.6 Classification of functions of media**

(adapted from Vasileiadou 2009, p. 105)

## **2.8 ICT ADOPTION MODELS**

The above sections have discussed the benefits of ICTs for research collaborations and identified some of the roles they play in this process. However, how they are used is strongly linked to the socio-technical context of the use environment (Matzat, 2004; Kling et al., 2003; Walsh & Bayma, 1996 b). This environment may vary ‘across institutions, projects and individuals’ (Cummings & Kiesler, 2008, p.8).

Kling et al. (2003) emphasise on the need to look at communication systems as socio-technical interaction networks, allowing for analysis of user behaviour and settings within

which the technologies are used. They note that such kind of analysis is important in designing and organising e forums that support scholarly communication, in which though influenced by technology, are largely defined by scientists' social structures and practices. This view is shared by Keraminiyage et al. (2009), who observe that 'to ensure proper take up of the Virtual Research Environment (VRE) concept within research communities, it is essential to assess the potential of VREs to address the issues and challenges faced by modern research collaborations' (p. 60). Olson et al (2008) add to this discussion by warning that the key to adoption of any technology is 'to understand the real needs of the end users, not to push *cool* technologies on people. The more user centred the development process, the more likely the technology will be used' (Olson et al, 2008, p.87).

Many collaboration platforms have been built, which are not widely used for the purposes they were built. For example, Riemer et al. (2008), in their analysis of usage of the GARNET Network of Excellence, which was built to support collaborative activities of its members across Europe, thus observed that the platform was mainly used for administrative tasks rather than for actual scientific discussions. This was especially so prior to an upcoming event. Their study points to the fact that technologies and platforms may be built to support research collaborations, but may not be utilised for the intended purpose. It would be important to look into why such technologies are not used, identify and possibly resolve the issues surrounding their use or non-use, thus encouraging their uptake in the future.

A range of models have been proposed and used for understanding the determinants of intention to use or actual usage of technology and innovations. This section discusses some of the commonly used IT acceptance models: the widely cited Rogers (1995) Diffusion of Innovation (DOI) Theory, Davis (1989) Technology Acceptance Model (TAM), and the Unified Theory of Acceptance and Use of Technology (UTAUT) model.

#### *Rogers' Diffusion of Innovation (DOI) Theory*

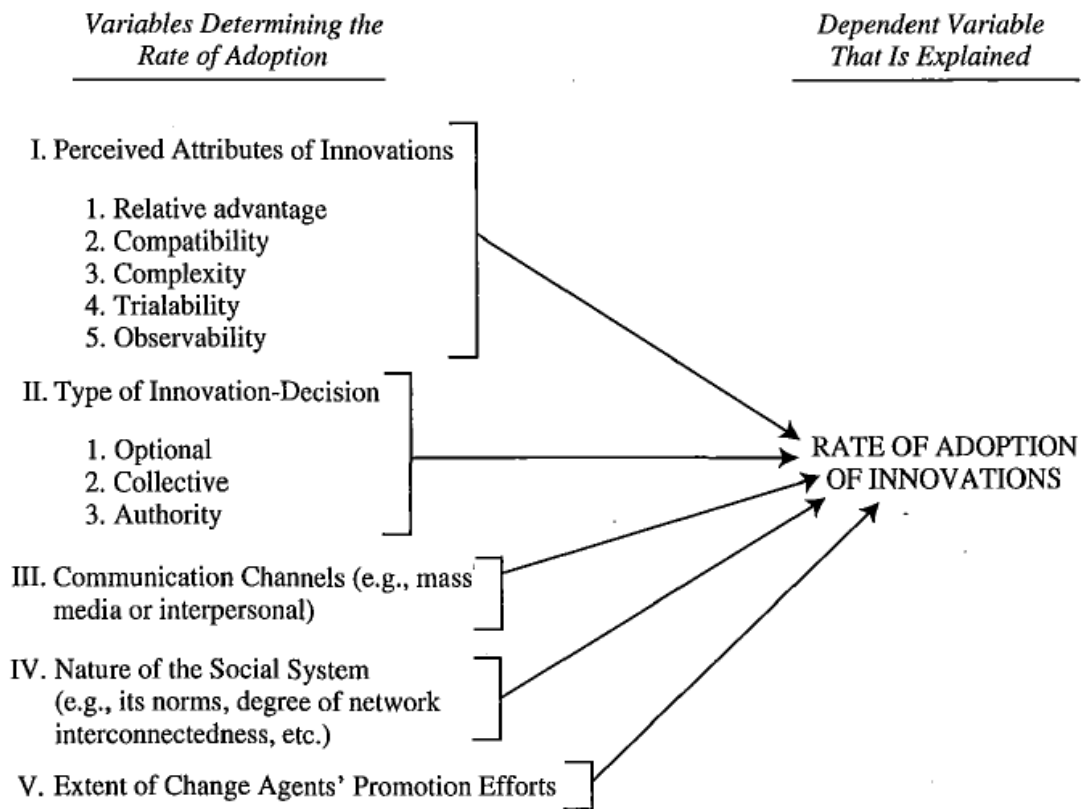
Rogers' DOI work spanning over four decades (1962 – 2003) was born out of a curiosity generated by farmers in his home community in IOWA, over what took them a long time to adopt new ideas that seemed profitable for them (Rogers, 2003). His work thus started with diffusion of agricultural innovations research for his doctoral studies in 1957, through



which he realised ‘diffusion was a general process not bound by the type of innovation studied, who the adopters were or by place and culture’ (Rogers 2003, p.xvi). This allowed the general model of diffusion of innovation he developed to be generalisable to many innovation studies and across academic fields. Since his first book on Diffusion of Innovations in 1962, the general model has been revised and modified through five editions to reflect changes in ‘diffusion traditions’, newer kind of innovations, role of diffusion networks and methods used to test diffusion (Rogers, 2003).

Rogers (2003) defines innovation as ‘an idea, practice, or object that is perceived as new by an individual or other unit of adoption’ (p. 12), noting that most of the new ideas are technological innovations, thus using the words as synonyms. Diffusion is defined as ‘the process in which an innovation is communicated through certain channels over time among the members of a social system’ (Rogers, 2003, p.5). Focussing on the individual, Rogers looks at an innovation-decision process as a five stage process in which ‘an individual (or other decision-making unit) passes from first knowledge of an innovation, to forming an attitude toward the innovation, to a decision to adopt or reject, to implementation of the new idea, and to confirmation of this decision’ (Rogers 2003, p. 216). This corresponds to the stages advanced by Kim & Crowston (2011) as *pre adoption*, in which one examines a technology and considers if to adopt, the *adoption stage* in which the decision to adopt is made and one acquires and uses the technology, and the *post adoption* stage in which the technology may continue being used or abandoned.

Rogers identifies five main elements as affecting the innovation adoption rate, as presented in Figure 2.3.



**Figure 2-3 Determinants of the rate of adoption of innovations**

(Quoted from Rogers 2003, p.222)

Under perceived attributes of innovation, Rogers identifies five variables that determine an innovation's rate of adoption and use (pp 229 – 258):

- *Relative advantage* defined as ‘the degree to which an innovation is perceived as being better than the idea it supersedes’. The level of expected gains is positively related to rate of adoption (p. 229).
- *Compatibility* defined as ‘the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters’. Higher level of compatibility with existing social systems and needs is positively related to rate of adoption and use (p. 240).
- *Complexity* defined as ‘the degree to which an innovation is perceived as relatively difficult to understand and use’. Reduced complexity or ease of use is associated with higher rates of adoption (p.257).

- *Trialability* defined as ‘the degree to which an innovation may be experimented with on a limited basis’. Pre testing for workability gives meaning and assurance of its purpose, and is thus positively associated with rate of adoption (p.258).
- *Observability* defined as ‘the degree to which the results of an innovation are visible to others’. A technology associated with positive tangible results will be associated with higher rates of adoption. (p. 258)

Rogers (2003) gives the mobile phone as an example of an innovation that was rapidly adopted in the US (and worldwide). This was due to its meeting the above criteria in terms of ease of communication resulting in savings in time and costs (relative advantage); compatibility with existing telephone services; ease of use, triability as in one can borrow a friend’s handset and use; and observability in that the advantages of convenience brought about by use were visible.

In addition to the perceived attributes, Rogers (2003 pp. 221 - 223) sees other variables that would determine the rate of adoption and use as:

- *Type of innovation decision* - He argues that adoption rate will be higher if the adoption decision is made at a personal level as opposed to an organisational level, due to the hierarchical decision making processes and procedures at organisational level that may slow down the process.
- *Communication channels* - Rogers sees awareness knowledge created through mass media as leading to faster adoption in comparison to interpersonal channels. However, Rogers (1995) notes that ‘communication channels and attributes of innovation often interact to slow down or speed up the rate of adoption’ (P. 207 ), giving an example of Petrini et al. having found interpersonal channels being more important in adopting complex technologies among Swedish farmers.
- *Nature of the social system*- existing communication and social networks and their interconnectedness, coupled with the perceived value, norms and practices, will determine how fast an innovation is adopted within the system.
- *Extent of change agents’ promotion efforts*- the promotional efforts that go into the innovation affect its adoption. Rogers observes that this may be more effective if

done at certain stages in the diffusion process. He also notes that the effect could be greater if leaders were to adopt first, thus setting an example for others to follow.

Rogers' DOI theory has found use in many studies because it covers a wide range of factors that could explain the rate of adoption and use of technologies in a variety of contexts. Its strength is in addressing a wide range of variables (Venkatesh et al., 2003), in relation to the individual user, the technology itself and the social system within which the technology is introduced. However, Rogers' model falls short of identifying variables related to the supporting physical infrastructure that supports use of information technology, that have been found to affect intention and usage of technology behaviour. This could be because his model is not based specifically on diffusion of information technologies, most affected by computing infrastructure, but on a more general definition of innovation.

#### *Davis' (1989) Technology Acceptance Model (TAM)*

Davis' (1989) TAM model explains determinants of user acceptance focussing on computing technologies, unlike Rogers who adopted a more general definition of innovation. Davis explains that a study of past empirical studies led him to identify two variables that were indicated as 'fundamental and distinct constructs that are influential in decisions to use IT': *perceived usefulness (PU)* and *perceived ease of use (PEOU)* (Davis 1989, p. 323)

*Perceived usefulness (PU)* is defined as 'the degree to which a person believes that using a particular system would enhance his or her job performance' (Davis 1989, p.320). Items measured within *PU* include effects on job performance, effectiveness, time management, productivity and importance to job. The measures are similar to those employed to measure *relative advantage* in Rogers' DOI theory.

*Perceived ease of use (PEOU)* is defined as 'the degree to which a person believes that using a particular system would be free of effort' (Davis 1989, p.320), and can be likened to complexity in Rogers' DOI model. PEOU is measured with items related to complexity in learning, using and interacting with the system. Davis' study found performance expectancy to have a stronger linkage to adoption and use of computing technologies than ease of use, thus his argument that:

Users are driven to adopt an application primarily because of the functions it performs for them, and secondarily for how easy or hard it is to get the system to perform those functions. For instance, users are often willing to cope with some difficulty of use in a system that provides critically needed functionality (Davis 1989, p.333)

Davis' TAM model focuses on measures related to individual benefits in terms of the gains, and the technology itself. It falls short of identifying a range of social and cultural factors that may affect adoption such as nature of the social system in Rogers' DOI. Like Rogers' DOI model, Davis does not address issues related to support infrastructural factors. The TAM model is revised in TAM2 by Venkatesh & Davis (2000), to include the social influences, but still lacks in addressing issues related to supporting infrastructure.

*The Unified Theory of Acceptance and Use of Technology (UTAUT), Venkatesh et al., (2003)*

Venkatesh et al. (2003) give the basis to developing UTAUT as having noted the challenges faced by technology acceptance researchers in choosing a model to use, sometimes having to pick constructs across the various models. This resulted in the decision by Venkatesh et al. to come up with a unified model, the UTAUT. The UTAUT is therefore a result of the review and comparison of constructs represented by eight common technology acceptance and usage models. These are listed in Venkatesh et al (2003, p.425) as: *the theory of reasoned action; the technology acceptance model; the motivational model; the theory of planned behaviour; a model combining the technology acceptance model and the theory of planned behaviour; the model of PC utilization; the innovation diffusion theory; and the social cognitive theory*. In coming up with the unified model, the authors did a comparison of the constructs represented within the eight models, using data from four organisations, to identify those that were most significant in determining user intentions to use information technologies, and the similarities across the models, leading to UTAUT. The resulting model was then not only tested with data from the four organisations involved in the first phase of the study, but also cross validated with data from two additional organisations to provide what they described as a 'strong empirical support for UTAUT as described in the excerpt below:

UTAUT was able to account for 70 percent of the variance (adjusted R<sup>2</sup>) in usage intention—a substantial improvement over any of the original eight models and their extensions. Further, UTAUT was successful in integrating key elements from

among the initial set of 32 main effects and four moderators as determinants of intention and behaviour collectively posited by eight alternate models into a model that incorporated four main effects and four moderators (Venkatesh et al., 2003, p.467)

UTAUT proposes four main factors influencing adoption and use of information technology: performance expectancy, effort expectancy, social influence (the three linked with intention to use) and facilitating conditions (more linked to actual usage behavior).

Performance expectancy is defined as ‘the degree to which an individual believes that using the system will help him or her to attain gains in job performance’ (Venkatesh et al., 2003, p. 447). This can be looked at as *perceived usefulness* of the technology in Davis’ TAM model, or *relative advantage* in Rogers’ DOI model, referring to expected gains or value in usage of a technology. Like Davis (1989), Venkatesh et al. (2003) noted that performance expectancy was the strongest predictor of intention to use technology. They further noted that the gender and age were significant moderators of the relationship between performance expectancy and intention to use technology. More usage was associated with men and younger workers, a finding also established by Venkatesh & Morris (as cited in Venkatesh et al., 2003).

Effort expectancy is defined as ‘the degree of ease associated with the use of the system’ (Venkatesh et al., 2003, p.450). This includes complexities in learning and interacting with the system, and the time and effort required to perform a task, and is similar to Davis’ *perceived ease of use* in the TAM model and *complexity* in Rogers’ DOI model. Venkatesh et al. (2003) note that technologies that are perceived as complex and difficult to use will have a slow rate of adoption. They quote Davis et al. as noting that effort related constructs were likely to be more significant at the earlier stages of introducing the technology, and ‘later become overshadowed by instrumentality concerns’ (Venkatesh et al., p. 450). At the initial stages, the process of learning new skills and the uncertainty of what to expect, noted as key to adoption decisions in Rogers (2003), may increase the complexity with which a technology is viewed. However, this may ease with time as people get used to it.

Social influence is defined as ‘the degree to which an individual perceives that important others believe he or she should use the new system.’ (Venkatesh et al., 2003, p. 451). This construct is represented by items referring to influence from important individuals in the

surrounding environment and support systems. They found a greater effect of social influence constructs on intention to use when use is mandatory, more significant in the early stages of introduction to and usage of a technology. Under voluntary settings, adoption is lower especially for technologies they do not regard as particularly useful for their work, and there's no pressure to adopt them. However, on the contrary, Lewis et al. (2003) found no effect of social influence on adoption decisions, mainly attributed to the autonomous nature of faculty members, who exhibited preference for independence in adoption decisions. Similarly, Rogers (2003) argues that adoption rate is higher if adoption decisions are at personal level. However, while acknowledging the complexity of social influence, Venkatesh et al. note that a number of other factors will affect an individual's belief structure, other than having to comply with mandatory requirements. Such is the tendency to comply with others' expectations for a certain reward or opinion, or out of desire to fit within the social circle.

The facilitating conditions construct is defined as 'the degree to which an individual believes that organisational and technical infrastructure exists to support use of the system' (Venkatesh et al., 2003, p.453). The construct is represented by items referring to availability of knowledge and resources necessary to use the system, compatibility with other systems used and work style, and technical support. Though compatibility in Rogers' DOI model partly describes the items addressed in *facilitating conditions* construct, his description of compatibility is in reference to the individual's work style and the technology itself. Among the other models studied by Venkatesh et al, *Perceived Behavioural Control* best identifies items related to facilitating conditions, with regard to resource availability, knowledge requirements and compatibility with other systems. Facilitating conditions is also captured by *Model of PC utilization*, with the items used representing measures of technical support.

Socio technical factors have been identified as playing a major role in determining adoption and use of ICT in various settings. In environments with constrained ICT resources, past studies show that support infrastructure play a significant role in decisions of which technology to use and sustained usage (Duque et al., 2005; Ynalvez & Shrum, 2011; Harle, 2009). The UTAUT model encompasses a wide range of constructs that are useful in testing technology acceptance in a variety of contexts. UTAUT uses gender, age,

experience and voluntariness of use as the moderating factors. However, other moderating factors would need to be considered depending on the context within which technology acceptance is being tested. For example, studies in use of ICT for knowledge production processes have found use to vary between various disciplines as seen in the section that follows (Disciplinary factors related to use of ICTs) below. Using disciplinary area as a moderator would perhaps have revealed differences in various aspects that define disciplinary fields to be a significant factor in determining intention to use and actual usage of computing technologies.

Other studies have found differences in adoption and use between regions. For instance, Putnam & Kolko (2010) use Davis' TAM model to assess differences in internet usage across two different regions, the US and Central Asia. They demonstrate that perceived usefulness is viewed differently across the two contexts. While a number of similarities were seen in demographic features of participants across categories such as age, education and income levels between the two regions, many differences were realised between the internet behaviours in terms of frequency and type of use. They note that non instrumental use was common among Central Asia users, such as playing music and videos, which they relate to perceived usefulness. Similarly, Gomez (2014), in his multinational study of public access computing venues across 25 developing countries found that the ICTs at these centers were mainly used for personal needs. This was mainly in form of creation and maintaining social relations and entertainment, and less used for health, government services and agricultural services. The results of these studies indicate that regional differences exist in terms of social and computing infrastructure between developed and developing countries, which influence what technologies are used, and how they are used. The ICT environment in the US is relatively advanced and integrated within other systems such as the educational, health in which 'useful use' can be derived. However, the technologies were quite new within the Asian context and not well integrated into the national systems, resulting in what the authors see as simplistic use of the technologies that define the use differences between the two regions. They emphasise the importance of looking closely at the socio-technical context when analysing diffusion and use of technologies. This is important because major differences exist that shape how technology is viewed and used in different regions.



In addition to the factors identified in the models above, literature shows that disciplinary factors account for the rate of adoption and use of ICT for knowledge production processes. The following section reviews studies that relate disciplinary differences or nature of the work to the rate of adoption and use of ICT for research purposes, not addressed by UTAUT.

### *Disciplinary factors related to use of ICTs*

There are significant differences in use of ICT across the various fields of science (Olson & Olson, 2000; Walsh & Bayma, 1996; Fry & Talja, 2007). Like Birnholtz (2007), Olson & Olson (2000) see the differences as resulting from characteristics of the work itself, noting that tightly coupled work that is more interdependent, ambiguous and non-routine calls for more frequent communication. Such work requires more support for communication and coordination mechanisms to succeed. Such work thus may reflect higher rate of adoption and use of ICT (Olson & Olson, 2000; Walsh & Maloney, 2007; Kiesler & Cummings 2002). On the other hand, loosely coupled work with ‘fewer dependencies or is more routine’, and there is general agreement on goals and procedures, requires less frequent communication, and may reflect lower use of ICT (Olson & Olson, 2000, p. 162). Similarly, Hara et al. (2003) describe the continuum of activities in a collaboration as ranging from serial to integrative. They note that different technologies maybe appropriate for each type. Serial collaborations involve division of labour and tasks are not parallel, thus communication through email and electronic file transfers may be adequate. However, the parallel nature of tasks in integrative collaborations may require more interactive technologies to support synchronous activities (Pikas, 2006; Kraut et al., 1990).

The nature of the work varies across disciplinary and specialist areas. Some disciplines are associated with having individuals dispersed over wide areas, while in others, collaboration tends to be local. For example, like Walsh & Bayma (1996b), Walsh et al. (2000) noted that of the four disciplines studied, mathematics, physics, chemistry and experimental biology, mathematics had the highest usage levels of CMC. They attribute this to the dispersed, independent nature of mathematicians, who would rely heavily on technology for communication. On the other hand, experimental biology had lowest levels of CMC usage, attributed to the lab based local nature of their work, with more of face to face interactions thus less integration of CMC for communication purposes. This is an indication that remote

collaborations rely more on ICT for communication processes than local work. Such use is also associated with HEP, which, due to the collective and distributed nature of its work, and sharing of expensive equipment, has been associated with a greater tendency to use CMC (Birnholtz, 2007; Fry, 2006; Fry & Talja, 2007).

Other studies that have noted differences in ICT use between disciplines include Matzat (2004), who identified differences in use of Internet Discussion Groups (IDGs) between the range of disciplines investigated. This study found use of IDGs was higher in management science, sociology and mathematics and lower in physics and chemistry. This is attributed to the work organisation of the physicists, who are seen as having built an informal communication system through which they stay updated and informed. Technologies that support internal communication within the group would therefore be more useful to them. On the other hand, social scientists and those in humanities work in a more independent manner, addressing varying issues thus tend to rely more on IDGs to keep informed. The findings corroborate Walsh et al (2000)'s findings on the use of ICT within mathematics and chemistry, and Luo (2008)'s view that IDGs were most appropriate for sharing explicit knowledge.

Similarly, Fry & Talja (2007) found that mailing lists were more commonly used and recognised among social sciences and humanities as compared to natural and health sciences. Their study sought to understand the relationship between work organisation across a number of academic fields defined by task uncertainty and mutual dependence as in Whitley (2000), and their use of digital tools and resources. They found that high-energy physicists made more use of private intranets to support intensive communication as a result of the high mutual dependence on others to get the work done. Such fields have well defined research areas / problems, priorities and procedures thus found little use in open scholarly mailing lists that did not address their particular objectives (Fry & Talja, 2007). On the other hand, like Matzat (2004), Fry & Talja provide an explanation for more use of open mailing lists in social sciences:

It was important for the social/cultural geographers to have access to researchers in sociology and anthropology to ensure that they were not overlooking key theories from those disciplines. Participation in cross-disciplinary lists or lists within neighbouring fields, typically following a particular topic or methodological debate, was important for keeping up to date with the state-of-the art. Junior scholars within literature and cultural studies similarly found scholarly mailing lists

useful for locating themselves within the conversations and schools of thought currently existing in their own or neighbouring fields (Fry & Talja 2007, p. 123)

Fry & Talja (2007) also found differences in use of homepages. Research group homepages were more used to support discussions and sharing within fields with low ‘task uncertainty’ and high ‘mutual dependence’ due to the collective nature of the research. On the other hand, personal pages were of more use to fields of less interdependence and high task uncertainty. Differences were also observed in form of dissemination of output across the fields. Within fields where work was done collectively, e pre-printing was a common practice while their counterparts believed in traditional dissemination channels for reputation building. According to Fry and Talja, social structures and work organisation of disciplinary fields determine the use of digital resources to support scholarly communication. Technology use therefore varies with the nature of work supported, and this may vary across disciplinary fields and specialist areas.

## **2.9 SCIENTISTS IN DEVELOPING COUNTRIES**

The importance of developments in science and technology to foster economic development in Africa has been echoed by many. Pifer & Demissie (2009) note that:

Strengthening the capacity of scientific research in African universities will help countries tap into the resources of the global research and education community to solve immediate and long range development problems, and prepare the human capital that is a prerequisite for attracting international investment (p. 2).

However, many challenges hinder the development of science and technology in Africa. A study by Jonathan Harle, commissioned by the British Academy to investigate issues faced by African universities seeking to collaborate with the UK and other international partners in social sciences and humanities identified a number of challenges. The preliminary investigation, a desk-based survey in 2007 involved 152 university staff members (90 academic and 62 university management and support staff), from 72 institutions across 14 countries in Africa (Harle 2007). The results of the survey formed the basis for a subsequent conference in Nairobi in 2008 to deliberate on the findings, summed up in Harle (2009). The large sampling frame used, which resulted in just a few responses from a country, would make some of the findings not generalisable to the research community in a particular country. However, the study highlights a number of issues facing general African

research systems, which are frequently referenced in this study. The discussion below highlights some of the major issues noted in literature.

### *Access to Funding*

Availability of funding is crucial to the initiation, survival and success of collaborative research projects, and has an effect on the form, structure and success of collaborations. Funding is a major constraint for research in Africa (Gaillard & Tullberg, 2001; Harle, 2009). The January 2007 African Union summit saw the heads of state in AU countries agreeing to allocate at least 1% of their GDP to research and development by 2010 (Mutume, 2007). However, statistics show that most African nations spend on average 0.4% of their GDP on research and development compared to a global average of 1.7% (UNESCO, 2012). Most African universities depend on funding from their governments, which are overburdened by a myriad other problems such as food security and health for their citizens, thus leaving very little for the higher education sector (Harle, 2007; Harle, 2009; Jowi & Obamba, 2013). The funds generated by most of the institutions are hardly enough to sustain their systems, let alone committing them to research, thus research is highly underfunded, and mainly dependant on donor agencies and international organisations (Shrum & Beggs, 1997; Gaillard & Tullberg, 2001; Mouton, 2008; Harle, 2009; Jowi & Obamba, 2013). Shrum & Beggs note a problem with over dependence on donor support for research systems in the developing world:

much of the financial support for science and technology originates from outside the country where research is done, and donors, and international organizations continue to maintain a diversity of goals and interests in developmental issues, It would be truer to say that S&T policy does not have its institutional locus 'within' the country, at least not in the same way that developed countries do (Shrum & Beggs, 1997, p. 1)

Donors need to be realistic in their expectations, as many of them do not understand the context under which the research is done (Harle, 2007; Shrum, 2005; Duque et al, 2005). Shrum (2005) discusses a common problem in doing research in developing areas as 'reagency' (p.10). Research initiatives and problems may be defined outside the developing world, but the researcher may end up solving a different problem due to contextual situations on the ground. To illustrate this, he narrates how his proposal for studying diffusion of the internet in selected countries in Africa became problematic with the

realisation that some of the institutions he had proposed to study had no internet connectivity. Thus interest was diverted to providing the internet first. Though a sociologist by training, the circumstances turned him into what he refers to as a ‘social engineer’, and he had to personally get involved in the technical details of delivering internet connectivity to these communities, a process he refers to as ‘reagency’. He advises donors to develop personal contact with developing areas so as to understand challenges faced in these research environments, a view shared by Harle (2007).

The diverse sources of funding and interests present problems with coordination of research done. This may exacerbate the spirit of competition instead of cooperation among African institutions and researchers, with each trying to win the scarce funding support. However, it should also be noted that research systems within Africa vary, with some institutions having better facilities and support mechanisms than others (Shrum,1997; Mouton, 2008; Harle, 2009). The Global Research Report Africa (2010) shows that countries that lead in GDP in Africa such as South Africa and Egypt also lead in research output in most fields of science and technology, which is also a reflection of stronger research systems. However, the same report indicates an under investment in research by countries that could have done better given their GDP, such as Nigeria.

In addition, Harle (2009) observes that as much as funding is a problem, so is the organisation and management of the funding. In his investigation of challenges facing African universities undertaking collaborative research with the UK and other international partners, Harle (2007) noted that while research managers reported an increase in donor funding and internal research budgets, academics did not. This raises a question on distribution of research funds and the systems that are in place to communicate the availability of such funds and funding opportunities, as well as the management of funds. He opines that the reason could be that ‘support, where it is given, is very concentrated and so only a limited few within a supported institution will have observed any benefit’ (Harle 2007, p. 8). The beneficiaries could be a minority ‘elite’ that Price & Beaver (1966) and Beaver & Rosen (1979) note have greater authority within their areas and profession and are usually favoured in funding decisions. Harle (2007) notes a need to address the mechanisms and systems through which research funds are disbursed. Donors need the confidence that money disbursed for research is used in the right way and produces tangible

results. Thus some donors may as well be comfortable dealing with the particular individuals who they believe will deliver. However, Harle (2009) warns that ‘institutions are the bases from which research is built’ (p.10), and should not be side-lined by donors who target particular individuals or department, thus should work with, rather than against or around university structures.

*Professional networks, scientific collaboration and productivity*

Past studies point to little networking for scientists in developing countries (Galliard & Tullberg, 2001; Harle, 2007; Adams et al., 2010). For example, Harle (2009) argues that there is little networking between African scholars, and ‘communication is greater between African researchers and colleagues in Europe, North America or Asia than it is within the continent, on a sub-regional level, or even within a single country’ (p.14). His claim is based on his 2007 study, in which the respondents were required to estimate the extent of their linkages with other HEIs had increased or decreased in recent years. Clearly, this measure and the size of population would not give statistics representative of a certain country or region, and the measure ‘extent’ is subject to varying interpretations between individuals. However, it points to a need for more detailed exploration to validate or invalidate the claim.

Similarly Galliard & Tullberg (2001), did a survey of 702 scientists across Africa who were recipients of the International Foundation for Science (IFS) and International Cooperation programme (INCO-DEV) of the European Union grants between 1974 and 1999. They found little networking between scientists from developing countries, while observing more networking with those from developed countries. However, methodological problems in Galliard & Tullberg’s study are noted, as concerns the sampled population and the measures used. The sample included a selective group of IFS and INCO-DEV grantees over the 25 year old period, who had already been introduced to the international research arena by holding such grants. This group thus could not be said to be representative of developing country scientists. Their conclusions on levels of networking are based on a frequency of communication<sup>3</sup>, which does not quantify the number of connections, type of

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<sup>3</sup> Respondents in their survey were asked to rate how often they communicated with scientists in a number of categories (own department, institutions in their country, other African countries, Europe, Canada, Asia or Latin America, funding agencies, NGOs, private clients, consultancy groups, extension staff and others),

communication, or context of communication. Similar criticisms were advanced by Luo (2008) and Shrum & Campion (2000) on Gaillard's 1991 study.

Contrary to Gaillard & Tullberg (2001) and Harle (2007), Shrum & Campion (2000) in their study seeking to determine the size and type of professional networks for scientists in LDCs found an inverse relation between international and domestic networks, leading them to conclude thus:

Scientists in the developing world have professional networks that are more local than international in character- just as most scientists in the developed world-and that does not warrant an ascription of 'isolation' (Shrum & Campion, 2000, p.28).

The type and composition of professional networks are however determined by a number of other factors. Gaillard et al. (1997) for instance, links the existence of the relatively many professional research networks and international agriculture research based organisations in Kenya to the colonial time. This time saw the establishment of a number of experimental stations for agricultural research, with much funding directed towards agricultural institutes in the mid-1950s (Worthington, as cited in Gaillard et al., 1997). Gaillard et al. (1997) notes that these institutes were the most favoured avenues for donor investment, a trend that may be observable up to date. Such existing structures and the support they attract are likely to provide a basis on which professional networks expand and grow.

Differences may also be observed in the size and form of professional networks between sectors. Like Shrum & Campion (2000), Ynalvez & Shrum (2011), in their study that sought to establish the link between professional networks, scientific collaboration and productivity among Filipino agricultural scientists, found that working in national research institutes was associated with bigger network size as compared to academic institutions. Ynalvez and Shrum speculate that this could be as a result of limitations in resources and time that facilitate travel and extension of networks for academic scientists. They also found graduate training in a developed country as having significant effects on the network size and composition. They take this as an indication that 'tacit technical and interaction skills learned from abroad have implications for building professional ties in those

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measured on a 5 point likert scale ranging from Never, rarely, annually, monthly to more often. (Gaillard & Tullberg, 2001, p.57)

locations' (Ynalvez & Shrum, 2011, p. 210). This finding, however, contradicts Shrum & Campion (2000) who found no significant differences in international professional ties based on country where a researcher trained.

Past studies associate developing countries with low levels of productivity. Many of the studies of scientific collaboration and productivity have been faulted as being based on bibliographic searches in international databases that do not give an accurate reflection of productivity and networking in Africa (see section 2.5). Though the measures have been faulted and may not be accurate, studies that have involved other measures such as self-reported measures of productivity still find low levels of productivity in developing countries as compared to developed countries. For example, while Lee & Bozeman (2005) found that an American scientist published an average of 18.9 articles over a five year period, Duque et al (2005), in their study focusing on developing country scientists, found that they published an average of 4.5 articles over a similar period. Variations have also been noted between countries within developing regions. For instance, Duque et al (2005) found that an Indian scientist published an average of 7 articles while a Kenyan scientist published an average of 2.5 articles over a five year period. Ynalvez & Shrum (2011) point out the causes of low publishing in developing countries, views also largely shared by Harle (2009) as:

inadequate governmental support for research; out-dated equipment and scarce material resources; frequent power outages; differences in thematic emphasis, methodology, and the publication culture of foreign journals that result in local submissions being 'weeded-out'; and the counter-productive effect of heavy teaching loads, combined with the large amount of time needed to publish in scientific journals (Ynalvez & Shrum, 2011, p. 213).

Ynalvez & Shrum (2011) find no impact of collaborative relationships on productivity, contrary to the general assumption that collaboration results in greater productivity. This, they attribute to problems with hierarchical structures that characterise most collaborations, distance, management and coordination problems, spirit of competition rather than cooperation and problems resulting from limited resources. As for the question of why Filipino scientists still collaborate despite the problems and yet low productivity, they speculate that collaborations for them offer material rewards and recognition from colleagues, which are more appealing than publications. Their views are supported by Duque et al (2005), who note:



African scientists make limited use of the internet to reduce research problems.... are encouraged to take up ‘collaborations for development’ regardless of their direct connection with personal scientific interests, search for consulting projects and teach additional courses for needed familial income, and as they brave the deadlines, hazards and reporting requirements of increased collaboration, they undermine gains in productivity by incurring additional research problems (Duque et al 2005, p.777)

Though the two studies use measures of collaboration that raise issues on their definition of collaboration (discussed in section 2.5), they highlight the role of external environment factors in shaping scientists collaboration and productivity behaviour. These factors need to be identified and addressed, if the benefits of scientific collaboration are to be realised by researchers in a certain country or region.

### *Research policies*

Weak and outdated policies at national and institutional levels that do not contribute to strengthening the research base, and the low priority given to investing in research have been cited as hindrances to research and development in Africa. Pifer & Demissie (2009) note that ‘to succeed in knowledge based economy, a country should be able to adopt policies to strengthen its science and technology capabilities’ (p.3), an observation supported by Mutume (2007). Harle (2007) and Mouton (2008) note a lack of adequate policies supporting research in African universities. Statistics from the UNESCO Institute of Statistics, UNESCO (2012), as seen in Figure 2. 2 indicate little investment in research by industry in majority of countries in Africa, and indication of the weak university-industry links. This indicates a need for national and university systems to devise strategies and policies that will attract industry to investing in their research, and may call for reorganisation of university systems to accommodate industrial needs.

Building competence has been identified as a need for African research systems. Hassan & Schaffer (2011) report most African countries as having an average of 164 researchers per 1 million population, compared to a global average of 1100 researchers per 1 million population. With nearly 15% of the world’s population, Africa has just 2.2% of the world’s researchers, producing just 1.5% of the peer reviewed scientific publications (Hassan & Schaffer, 2011). Brain drain has been noted as a major problem in Africa. Mouton (2008), for instance points to statistics in a United Nations report on international migration in 2006 showing that ‘between 33 and 55 per cent of the highly educated people of Angola,

Burundi, Kenya, Mauritius, Mozambique, Sierra Leone and Uganda live in the countries of the OECD' (p. 9). Similarly, Adams et al. (2010) note that many of the students from Africa who take their degrees in developed countries do not return, majority citing poor research environments back home. It is important that policies address issues such as the ones identified above, for the development of human capacity that will be in a position to address local challenges for sustainable development of a country/region. Harle (2009) also notes a need for policies to be well linked. He, for instance, identifies a poor link between postgraduate training, staff development and research policies. This, he illustrates with the following example: 'A university may have staff development policy which assists people to identify and secure opportunities to study abroad, but it may not make provision for them to be effectively supported and re-integrated into their departments on their return' (Harle, 2009, p.11)

#### *ICT infrastructure*

Internet connectivity is crucial for integration of African scientists into the global research community. African scientists incorporating communication technologies into their research will realise major benefits associated with their adoption and use. Many developing countries are characterised by poor ICT infrastructure, and low prioritisation of the same (Harle, 2009). However, major developments in internet access have been realised within the last five years, as noted in the United Nations Millennium Development Goals (MDGs) reports UN (2013) and UN (2014). Internet penetration in Africa doubled from 10% in 2010 to almost 20% in 2014, though constituting the lowest penetration of internet services globally (UN, 2014).

Likewise, the ICT infrastructural situation in Kenya has improved to a large extent, especially after the arrival of the undersea cable at the Kenya coast in 2009. Major developments in the national ICT infrastructure have been realised, with major towns in the country now connected by fiber optic cabling. Changes have been realised in internet experience at the institutional level too. Before 2009, universities used to connect to the internet through satellites, which was very costly. For example, Kashorda & Waema (2014) report that in 2008, Kenya Education Network (KENET), the national research and education network in Kenya was purchasing internet satellite bandwidth from Intelsat at a subsidised cost of \$ 2300 per Mb/s per month. The high cost was being passed to the

Higher Education Institutions (HEIs), thus most institutions could not afford much bandwidth. Improved access to international bandwidth and improved national infrastructure has led to a reduction in internet bandwidth prices. KENET member institutions currently purchase bandwidth at \$160 Mb/s, resulting in increased bandwidth consumption (Kashorda & Waema, 2014).

However, even with these major improvements, major differences exist in ICT infrastructure between developed and developing world (Ayanso et al., 2014; ITU, 2013), that determine how ICTs are used for research purposes. HEIs in the developed world enjoy high capacity internet connections capable of supporting various forms of communication. In the UK, for instance, all research and education institutions are connected to each other and to the rest of the world through a super-fast Joint Academic Network, Janet, with speeds of up to 2Tbit/s and interconnect capacity of around 40Gb/s (Janet, 2014a). Kashorda & Muia (2013) report an interconnect capacity to KENET backbone of 1Gb/s and above for 35 institutions in Kenya as of August 2013, though the bandwidth available to an institution depends on what an institution can afford to purchase. On the contrary, in the UK, the cost of the internet access is shared among institutions, based on the wealth of an institution, as assessed by the Higher Education Funding Council. Thus no university is limited to the amount of bandwidth it can access based on ‘affordability’ (Janet, 2014b).

Having a dedicated National Research and Education Network (NREN) designed to operate specifically for higher education and research has been proposed as a way of improving internet access and usage within the sector (Kotencha, 2010). Kotencha (2010) observes that ‘broadband for general internet service may not be sufficient to address particular needs of research’ (p.58), thus the need for dedicated NRENs, such as Janet in the UK. The NREN could connect to regional RENs and to international RENs such as GEANT<sup>4</sup> in Europe. Such an NREN would be expected to improve distributed knowledge sharing and communication among research teams, as well as enabling for construction of ‘virtual platforms for experimental design and research collaborations’ (Kotencha, 2010, p. 57). Kotencha notes that NRENs in Africa are still maturing, the main emerging function being to act as ‘bandwidth purchasing consortia’ (p.58). Establishment of regional RENs and

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<sup>4</sup> GEANT is ‘the pan-European research and education network that interconnects Europe’s National Research and Education Networks ([www.geant.net/about/pages/home.aspx](http://www.geant.net/about/pages/home.aspx))

improvement of internet services takes the political will of the countries in the region to cooperate to overcome complexities brought about by individual national regulatory environments and competing national goals. Kotencha gives an example of such differences as:

differences of opinion between the Kenyan and South African governments as to whether EASSy<sup>5</sup> should be controlled by the private sector or be an open access system have meant the two countries have taken separate paths in their quest to access bandwidth for broadband communications (Kotencha, 2010, p. 62)

Improvement of infrastructure at the institutional level and national level is important, but so is improvement at regional and international levels, which offer more benefits for researchers in connecting to the global research community. However, it's important to note that the ICT environment may improve, but the effect on the work of scientists will depend on how the individuals make use of the technologies (Ynalvez & Shrum, 2011). Despite the many problems reported by participants in their study in email use, Ynalvez & Shrum (2011) as well as Duque et al. (2005) realise a positive association between diversified use of email and professional networks, collaboration and productivity. This is an indication of the power of ICTs in transforming research collaborations as realised by other studies such as Walsh & Maloney (2007).

## **2.10 CHAPTER CONCLUSION**

This chapter reviewed literature that provides an understanding of the basics of research collaboration, including a justification for why it is important, motivations for collaboration, processes involved and factors influencing the collaboration processes. Literature highlighting the role of ICT in the collaboration process and factors influencing their uptake was also reviewed. Literature on scientists in developing countries shows differences in research environments between developed and developing world, and points to the need for taking into account regional differences in studying knowledge production processes between different regions. Major differences arise as regards availability of resources and support infrastructure that affect various dimensions of collaborative

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<sup>5</sup> 'EASSy is a 10,000km submarine fibre-optic cable system deployed along the east and south coast of Africa to service the voice, data, video and internet needs of the region. It links South Africa with Sudan via landing points in Mozambique, Madagascar, the Comoros, Tanzania, Kenya, Somalia and Djibouti' (<http://www.eassy.org/>)

research. Models and studies in developed countries focus more on the dynamics of the collaboration process itself or operational needs of research collaborations. However, studies referencing research systems in developing countries (Harle, 2007; Gaillard & Tullberg, 2001; Mouton, 2008) indicate that factors external to a collaboration play a major role in development of science in these regions. Much of the literature specific to research collaborations has been carried out in developed countries. This chapter therefore makes much reference to this literature, important in identifying best practices in organisation and conduct of collaborative research that may apply to the Kenyan case.

A review of a number of models and frameworks used to explain or investigate collaboration processes and ICT adoption have led to identification of a number of variables and measures used to investigate research collaborations relevant to this research. Though the models have been developed or are a result of studies in developed world, a number of the variables were found useful for investigating research collaborations in Kenya. This is because though the particular research environment varies from region to region, country to country or even institution to institution, the knowledge production process is similar in many ways thus various common traits may be observed in researchers from different research environments. However, no single model covers the broad range of issues pertinent to knowledge production in the developing world. Most of the models put more weight on internal processes, and do not address comprehensively external environment factors that particularly affect scientists in developing areas. For example, a number of the ICT adoption models have no measures for access to ICT resources as a determining factor, more so because this may not be an issue in developed countries while it's a major issue in developing countries.

Literature reviewed in this chapter portrays deficiencies in understanding of the levels and organisation of research collaborations in Kenya, at the individual level. In this study, research collaboration is defined as an interaction between two or more individuals, no matter their location, working together on a research project to achieve a common goal. This definition differs from that provided by past studies in the region, especially the work of the Globalization of Science project, headed by Wesley Shrum. They look at differences in the organisation of science between a number of regions, first between Ghana, Kenya and Kerala in Southwest India, and later included South Africa and the Philippines. In their

study, they demonstrate the differences brought about by regional context in conduct of research, focussing on productivity and access to the internet. However, their studies assume a more general level of professional networks, whereby for instance, any form of contact with an organisation is taken to be an indicator of being part of the professional scientific network, also referred to as collaboration. Moreover, their studies focus on the indicators of collaboration rather than the collaboration process itself.

In addressing the deficiencies, this study looks at the collaboration process in more detail, through an intensive study that examines the type and nature of collaborative research, focussing on researchers affiliated with Kenyan universities. To understand research collaborations in Kenya, this study takes into consideration the broader range of variables represented in the various models discussed in this chapter, as well as other literature reviewed to help analyse the Kenyan case. The study gives special attention to factors expected to have more impact on collaborative research in developing regions. This study therefore addresses the following gaps in knowledge:

- An understanding of the levels of collaboration and academic networking in Kenya that has remained vague thus far.
- An understanding of the factors that determine the levels, form and conduct of academic research collaborations in Kenya.
- An understanding of how ICTs are being used to support collaborative work in Kenya, and factors determining their adoption and use. Use of ICT has not been analysed within the specific context of supporting collaborative work.
- As a way of establishing some of the benefits of collaboration and ICT use, establish the effects of collaboration and ICT use on productivity of Kenyan scientists.

This forms the discussion in chapters five, six and seven. Many developing world countries exhibit similar contextual situations (Mouton, 2008; Harle, 2007). Though the major focus is Kenya, perhaps some of the findings could be generalised to the wider developing world context. The next chapter gives background knowledge to Kenya, to create a better understanding of the environment in which the study is situated and better explain the factors being investigated.

## **CHAPTER 3: KENYA - BACKGROUND INFORMATION**

### **3.1 INTRODUCTION**

The knowledge production process has been said to vary between regions and countries. This is partly attributed to differences in the research environment, determined by the political, social, economic and infrastructural backgrounds within which the researchers are based. This chapter gives a brief introduction of the context within which academic scientists in Kenya operate, which could aid in understanding factors contributing to the nature of collaborative research and the behaviour of academic scientists in Kenya. The chapter begins with some basic information on Kenya (3.2), including some economic indicators (3.3). This is followed by an introduction to the higher education system (3.4). Funding emerged a major issue facing research collaborations in developing countries in the literature, thus some background information on funding for research in Kenya is provided in section 3.5. Communication processes are a core component of collaborative research and much dependent on the existing ICT infrastructure. Section (3.6) gives a background to the state of ICT infrastructure both nationally and within institutions.

### **3.2 GENERAL KNOWLEDGE**

Kenya is a developing country, lying along the equator on the east coast of Africa. It occupies an area of approximately 581,313 sq. km (UN statistics, 2014). The last population census of 2009 established a total population of 38.6 Million people. With a population growth rate of 2.7% p.a, and a population density of 71.6 per square kilometer (UN statistics, 2014), the population is estimated to be 44.4 million in 2013 (World Bank statistics, 2013). Much of the country's landscape is sparsely populated due to its arid/semi-arid nature. Majority of the population live in rural areas, relying on agriculture mainly at the subsistence level. There are over seventy distinct ethnic groups in Kenya, broadly divided into three broad linguistic groups Bantu (67%), Nilotic (30%) and Cushite (3%) (US Department of state, 2012). The official language of communication is English, and Swahili the national language, while there are over forty other languages from the various ethnic groups. These diversities though a source of diverse cultures have been a source of ethnic tensions and rivalry for power between the larger groups, bound to undermine national unity and development.

### 3.3 ECONOMIC BACKGROUND

The US Department of State, Bureau of African Affairs, on May 7, 2012 reports Kenya's economic growth as having faced turbulent times since Kenya attained independence from the British colonial masters in 1963. It is reported as being moderately high in 1960s and 1970s, growing at an annual average of 6.6%, very low in 1980s and 1990s, and only starting to recover in 2000s, from 2.8% in 2003 to 7% in 2007. However, a breakout of post-election violence in December, 2007 general election and the global economic crisis brought down the growth massively to less than 2% in 2008, though there has been gradual increment up to 4.3% in 2011(US Department of State, 2012) and 5% in 2013 (World Bank, 2014).

To help understand the economic status of Kenya, the table below presents some economic development indicators, relative to selected countries in Africa and two developed countries.

Country	Total Population (in Millions)*	GDP (current US \$ in Billions)*	GNI per capita ppp (current international \$)*	GDP Annual Growth Rate (%)*	Human Development Index (HDI)**	HDI Ranking 2012 / 185 **
Kenya	44.4	44.1	2250	4.7	0.519	145
Uganda	37.6	21.5	1370	5.8	0.456	161
Tanzania	49.3	33.2	1750	7.0	0.476	152
South Africa	60.0	350.6	12,240	1.9	0.629	121
Nigeria	173.6	522.6	5600	7.3	0.471	153
UK	64.1	2,522.3	35,760	1.7	0.875	26
US	316.1	16,800	53,960	1.9	0.937	3

**Table 3.1 A comparison of Kenya and a number of other countries - some economic indicators**

(\* are statistics derived from World Bank (2013) statistics, \*\* are statistics derived from UNDP's human development report (2013)

The statistics in Table 3.1 indicate that Kenya remains a low income country. However, it does better than its immediate neighbours in East Africa in socio-economic development as indicated by the HDI (computed as an average of a country's adult literacy rate, life expectancy and GDP per capita), but lags behind South Africa. The statistics also indicate it is incomparable to the developed nations like the UK and the US. Differences exist in economic development across regions within the country. Bailey et al. (2009) describe



Kenya as a dual economy, with a ‘small relatively sophisticated urban economy based largely in Nairobi and a large, underdeveloped rural economy’ (p.9)

To further illustrate its economic status, Figure 3.1 presents statistics on ranking of Kenya in Global Competitive Index (GCI) in the World Economic Forum’s Global Competitive Report (WEF, 2013).

	Rank (out of 144)	Score (1–7)
<b>GCI 2012–2013</b> .....	<b>106</b>	<b>3.7</b>
GCI 2011–2012 (out of 142).....	102	3.8
GCI 2010–2011 (out of 139).....	106	3.6
<b>Basic requirements (60.0%)</b> .....	<b>123</b>	<b>3.6</b>
Institutions .....	106	3.4
Infrastructure .....	103	3.1
Macroeconomic environment .....	133	3.4
Health and primary education.....	115	4.6
<b>Efficiency enhancers (35.0%)</b> .....	<b>76</b>	<b>4.0</b>
Higher education and training.....	100	3.6
Goods market efficiency .....	93	4.1
Labor market efficiency .....	39	4.6
Financial market development .....	24	4.7
Technological readiness.....	101	3.3
Market size.....	75	3.5
<b>Innovation and sophistication factors (5.0%)</b> .....	<b>56</b>	<b>3.7</b>
Business sophistication .....	67	4.0
Innovation.....	50	3.4

**Figure 3-1 Kenya's Ranking in the Global Competitive Index**

(adapted from WEF’s Global Competitive Report (2013, p. 154).

The statistics give an idea of Kenya’s positioning relative to 144 other economies, based on twelve main pillars of competitiveness<sup>6</sup>, broadly classified as: basic requirements; efficiency enhancers; and innovation and sophistication factors. Table 3.2 further compares Kenya’s competitiveness to its immediate neighbours in East Africa and to South Africa, generally ranked highly in the continent, to give an idea of its competitiveness relative to other African countries. As seen in this report, though Kenya ranks low in basic requirements, it is ranked quite high in innovation, coming only second to South Africa in

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<sup>6</sup> Competitiveness is defined by World Economic Forum as ‘how countries create the best economic, social and environmental conditions for economic development, measuring what makes up this development in things like policies, institutions and productivity.’ The GCI is the measure of competitiveness of a given country (www.weforum.org).

the region. As can be seen in Table 3.2, under higher education and training, it ranks higher in terms of quality of education (37) and internet access in schools (85) than both its two East African counterparts and South Africa. However, Kenya ranks lower than South Africa in terms of availability of research and training services, extent of staff training, technology readiness and aspects of innovation, though higher than its two East African counterparts.

Country	GCI Rank <sup>7</sup> / 144 countries 2012/13	Higher Education and Training <sup>8</sup>					Technology readiness <sup>9</sup>	Innovation <sup>10</sup>
		Average Ranking	Quality of Education	Internet access in schools	Availability of research and training services	Extent of staff training		
Kenya	106	100 (3.6)	37 (4.3)	85 (3.8)	64 (4.3)	70 (3.9)	101 (3.3)	50 (3.4)
South Africa	52	84 (4.0)	140 (2.2)	111 (3.1)	51 (4.4)	26 (4.6)	62 (4.0)	42 (3.5)
Tanzania	120	132 (2.7)	80 (3.5)	120 (2.8)	103 (3.6)	77 (3.8)	122(2.8)	75 (3.1)
Uganda	123	127 (2.9)	69 (3.7)	118 (2.9)	91 (3.8)	100 (3.6)	117 (2.9)	117 (2.9)

**Table 3.2 Kenya's ranking relative to selected countries in Africa**

(Data derived from WEF's Global Competitive Report (2013: pp 154 – 195). In brackets is a score measured on a scale of 1-7).

Kenya's development is highly constrained by corruption, and is ranked 154 out of 182 countries on Transparency International's Corruption Perception Index, 2011. Challenges are many, such as high levels of unemployment, frequent droughts, crime and poverty, close to half of the population living on less than \$1.25 per day (UNDP, 2013). All these have adverse effects on the country's economic growth, affecting the development of other sectors including investment in higher education and research. Despite all these problems, Kenya remains a leading economy in the East African region, with Nairobi

<sup>7</sup> The GCI is measured on a score ranging from 1-7, and derived from three sub-indexes and 12 pillars of competitiveness, as seen in figure 3.1.

<sup>8</sup> Higher education and training is measured by % secondary and tertiary education enrolment, quality of the education system, quality of science and maths education, quality of management schools, internet access in schools, availability of research and training services, and extent of staff training

<sup>9</sup> Technology readiness includes measures of availability of latest technologies, firm-level technology absorption, technology transfer, individuals using the internet, broadband internet subscriptions, international internet bandwidth and mobile broadband subscriptions.

<sup>10</sup> Innovation readiness is measured by capacity for innovation, quality of scientific research institutions, company spending on R&D, university/industry collaboration in R&D, government procurement of advanced tech products, availability of scientists and engineers, PCT patents, applications / million pop.

being the ‘primary communication and financial hub of East Africa enjoying the region's best transportation linkages, communications infrastructure, and trained personnel’ (US Department of State, 2012).

### **3.4 THE KENYAN HIGHER EDUCATION SYSTEM**

The higher education sector has seen a rapid expansion in recent years. At independence in 1963, there was only one university level institution in Kenya, the Nairobi University College, which between 1963 and 1970 had an enrolment of about 1,000 students. It then gradually increased its enrolment to 8,900 in 1984 (CUE, 2014). The pressure on the government to increase enrolment at the university was such that it became necessary to establish more universities, leading to the establishment of Moi University (MU) in 1984; Kenyatta University (KU) in 1985; Egerton University in 1987; Jomo Kenyatta University of Agriculture and Technology (JKUAT) in 1994; Maseno University in 2001 and Masinde Muliro University of Science and Technology (MMUST) in 2007. There are currently 22 fully accredited public universities in Kenya as of June 2013, an increase from seven public universities before December 2012 to 22, fifteen having been accredited between December 2012 and June 2013. A majority of the newer universities had been constituent colleges of the older universities (details in Commission of University Education website<sup>11</sup>, CUE (2014)).

The increasing demand for higher level of education has seen the establishment of a number of private universities since 1991. Of the 31 private universities, 17 are chartered / fully accredited by CUE; twelve operate with Letters of Interim Authority and two had been offering degrees long before the establishment of the Commission for Higher Education in 1985, and are yet to be accredited. In addition to the public and private universities are constituent colleges, nine associated with the older public universities and five with private universities (CUE, 2014).

The majority of Kenyan universities are located within major towns served by major road networks. Of the seven public universities established before December 2012, the University of Nairobi’s major campus is located right at the center of Nairobi city. Kenyatta

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<sup>11</sup> Commission for University Education (CUE) was initially Commission for Higher Education (CHE), transformed following an Act of Parliament, Universities Act No. 42 of 2012.

University's main campus is located 23 kilometers from the city of Nairobi on the Nairobi-Thika super-highway, and JKUAT major campus 36 kilometers north east of Nairobi, along Nairobi-Thika super highway. These three therefore have their major campuses located within close proximity of the capital city of Kenya, Nairobi, and enjoying the associated infrastructural facilities. With most international organisations and a number of research institutes located within Nairobi and its environs, it would be expected that the location of these universities would favour interactions between researchers based within this area. The other four major Kenyan universities also have their main campuses located within the vicinity of major towns in Kenya. Moi University main campus is located in Eldoret, 310 kilometers northwest of Nairobi. Egerton University in Njoro, Nakuru, around 180 kilometers northwest of Nairobi, Maseno University in Kisumu, 400 kilometers west of Nairobi and Masinde Muliro University in Kakamega, western Kenya, around 395 kilometers northwest of Nairobi. Each of the seven major universities has a number of campuses. The schools/institutes and departments usually reflect an organisation based on the broader disciplinary areas.

The University of Nairobi (UoN), being the oldest university in Kenya with its roots dating back to the colonial era, boasts of well-established diversified academic departments, programmes and specialisations in sciences, applied sciences, technology, humanities, social sciences and the arts. To date, the range of programmes offered number approximately 584, broadly ran under the following colleges/campuses: College of Agriculture and Veterinary Sciences; College of Architecture and Engineering; College of Biological and Physical Sciences; College of Education and External Studies; College of Health Sciences; and College of Humanities and Social Sciences (University of Nairobi, 2014). The UoN has the largest number of academic staff totaling to 2052, including 154 professors, and 253 associate professors (University of Nairobi, 2014). As a leading university in Kenya, its level of establishment, location and relatively large number of trained academic staff in the various fields could have an effect on the level of development of research support systems within the university. This also places it in a better position as target for collaborations by various private and international organisations.

Moi University was originally set up as an institution of science and technology but has deliberately integrated art and social sciences for a holistic approach and dimension to

knowledge (Moi University, 2014). The university has the following schools: School of Business and Economics; School of Education; School of Information Sciences; School of Engineering; School of Medicine; School of Dentistry; School of Public Health; School of Law; School of Arts and Social Sciences; School of Aerospace Science; School of Human Resource Development; School of Biological Sciences and School of Nursing (Moi University, 2014)

Kenyatta University was primarily a teacher training institution, a reputation it enjoys to date. On becoming a fully-fledged university in 1985, Kenyatta University immediately started establishing new faculties and constituent colleges. Over time the college has diversified its course offerings to include the following schools: School of Agriculture and Enterprise Development; School of Humanities and Social Sciences; School of Business; School of Economics; School of Education; School of Engineering; School of Environmental Studies; School of Graduate studies; School of Health Sciences; School of Humanities and Social Sciences; School of Law-newly established; School of Pure and Applied Sciences; School of Visual and Performing Arts and School of Hospitality & Tourism Management (Kenyatta University, 2014)

Since 1984, when its graduates were only in agricultural sciences, JKUAT has diversified its programmes and has various schools, faculties and institutes including College of Engineering; Faculty of Agriculture; Faculty of Science; Institute for Biotechnology Research; Institute of Computer Science & IT; Institute of Energy & Environment Technology; Institute of Tropical Medicine and Infectious Diseases; School of Architecture & Building Sciences and School of Human Resource Development. The university has a strong research interest in the areas of agriculture, biotechnology and engineering (JKUAT, 2014)

Each of the major universities has campuses strategically established, mainly in major towns to extend the universities presence and make their degrees accessible to those within other towns. For example, of the seven major universities, six (apart from the University of Nairobi) have established their campuses in the city of Nairobi. However, these campuses are established mainly for teaching and professional training purposes, as opposed to research purposes.

Public universities have introduced part time or parallel degree programmes across most departments which target both the public and private sector employees and school leavers, so as to be able to extend university education to a larger group of those who qualify, as well as boost their source of income. Most of the programmes in strategically placed town campuses are offered on parallel degree programme (module two) basis.

Though many of these universities offer a wide range of programmes across the various disciplines, public universities are generally better equipped to support the traditional disciplines such as the pure and applied sciences, including agriculture and engineering, as well as arts and humanities. Upcoming private universities support the newer market driven disciplines, such as business administration and information technology (Bailey et al, 2009). It is therefore not surprising to find majority of established trained researchers within the *traditional* disciplines based at major public university campuses.

### **3.5 RESEARCH FUNDING IN KENYA**

Higher education and research matters in Kenya fall under the Ministry of Education, Science and Technology (MOEST, 2014), who describe their mandate as *Science Technology Innovation (STI) Policy, Research development, research authorization and coordination of Technical Education* (MOEST, 2014). Under it are three technical directorates, *Directorate of Research management and Development (DRMD), Directorate of Technical Education (DTE), Directorate of Higher Education (DHE) and one Semi-Autonomous Governmental Agency (SAGA), the National Council for Science and Technology (NCST)*. NCST was later renamed the National Commission for Science, Technology and Innovation (NACOSTI) in 2013 (MOEST, 2014).

Towards funding its programmes, a university prepares and submits a budget to the government every year. The government, through MOEST makes an allocation to meet the budget. The amount allocated by the government to a particular university is usually way under budget. For instance, records at one of the major public universities reveal that out of a total budget of Ksh 9.329 billion (~£70 million) for 2009, the government allocated only Ksh 3.586 billion (38.4% of the total budget, which is approximately £27 million) as capitation grant, leaving a deficit of Ksh 5.882 billion (~£43 million). The university is expected to meet the deficit through funds generated internally. Thus the university will be busy trying to raise funds to meet the deficit and keep its programmes running, and in many

cases, little is left for research. For example, records at one major Kenyan university show that the university only spent Ksh 8.5 million (~£66,700) to fund research, though an amount of Ksh100 million (~£759,000) had been factored in the 2009/2010 budget. This shows a serious case of underfunding of research at both the institutional and national levels. The amount allocated to the universities varies, and so does the amount that each university allocates to research, depending on the university's policies and ability to generate funds to support its programmes.

In addition to the funds disbursed directly to the universities from the ministry, the government's Science, Technology and Innovation (STI) grant, administered through the NACOSTI, was established to support scientific research and innovation. Among its core functions, NACOSTI is mandated to identify and determine areas of priority in STI; coordinate, monitor and evaluate activities related to scientific research; advise the government on national science policies; and promote the adoption and application of scientific and technological knowledge (Full list of functions in NACOSTI (2014)).

<b>Grant Type</b>	<b>Description</b>
Research	Supports cross institutional interdisciplinary research across the universities
Innovations	Supports innovation by individuals or teams who do not have to be part of the universities
Women scientists	Tailored specifically to supporting women in science
Post Graduate research	Supports post docs, PhD and MSc students in their research
Research facility	Supports acquisition of expensive equipment that can be shared across the universities
Conference and Symposia	Supports organisation of conferences at the institutional levels
Publication incentive	Newly introduced, to encourage publication in recognised journals

**Table 3.3 Categories sharing the STI grant under NACOSTI**

On identifying the priority areas of research, NACOSTI allocates grants to fund projects in these areas, competitively. A call for proposals is made on the selected thematic areas. The proposals submitted go through external review, are ranked in order of priority and recommendations given to NACOSTI. NACOSTI then releases funds for the recommended projects through the university to which the principal investigator is affiliated, to a maximum of KSH 15 million (~ £12,000) for each project. The amount disbursed by

NACOSTI is allocated to projects under various categories as shown in the table below, as per the NCST annual report (2012). On realising of the need to support and fund research, the government has gradually increased this kitty of STI grant, from KSH 260 million (~ £2.08 Million) in 2008/2009, to KSH 400million (~ £3.2 Million) in 2011/2012. This may be a trial on the government's part to promote research, but is a clear indication that research in Kenya is highly underfunded. Therefore academic scientists are left no other choice but to actively search for research funding from the donor community (or funding support from outside the country) and private organisations to keep afloat in their research careers.

### **3.6 ICT INFRASTRUCTURE IN KENYA**

#### **3.6.1 General overview**

Like many other nations across the globe, Kenya recognises the importance of developing her ICT infrastructure to meet information, communication and service delivery needs important for national development (Jowi & Obamba, 2013). The government has come up with an ICT master plan aimed at creating an enabling ICT environment that enhances economic growth. This includes stimulating creation of service sector businesses that thrive through making use of ICT (Government of Kenya, 2012). Efforts towards achieving the objectives outlined in this master plan are already visible such as support for establishment of digital villages, grants towards development of local digital content and the Kenya open data initiative (IST Africa, 2014). Kenya is the first developing country to have an open government data portal and second in the continent after Morocco, providing easy access to a variety of data from various government sectors (IST Africa, 2014).

A robust ICT infrastructure is necessary to support the running of ICT enabled services. The arrival of the first undersea cable, TEAMS at the Kenyan coast in mid-2009 had wide reaching implications for the information infrastructure in Kenya. TEAMS and three other submarine cables, SEACOM, EASSY and LION provide international connectivity. The arrival of the cables has seen progressive increase in international bandwidth available, e.g. from 305,174 Mb/s in June 2011, to 574,704 Mb/s in June 2012 to 862,850 Mb/s in June 2013, (CCK 2012; CCK 2013). This meant that the Internet Service Providers (ISPs) were in a position to acquire greater bandwidth at less cost, and pass it on to the consumer, thus a general reduction in internet access costs. However, only a fraction of the available



bandwidth is actually consumed, with progressive increase in the last three years. For example, only 32,370 (10.6%) Mb/s of available bandwidth was consumed in the financial year ending June 2011, 264,584 (46%) Mb/s in financial year ending June 2012 and 356,874 (41.4%) in financial year ending June 2013(CCK 2012; CCK 2013).

Consumption of internet bandwidth is partly dependent on the infrastructural network within the country. The last five years have seen major improvements in building of the physical infrastructure, through implementation of the National Optic Fiber Backbone Infrastructure (NOFBI). NOFBI is intended to link 80% of districts and rural towns (Government of Kenya, 2013b). Figure 3.2 shows coverage of the NOFBI, both by the government initiative and commercial players). Most Kenyan universities are located in major towns, therefore likely to benefit from this initiative. However, a need to increase coverage to more parts of the country is noted, to allow operators reach more citizens in remote areas (Government of Kenya, 2013b). Complementing the government efforts, the private sector has equally invested in ICT development, implementing fiber networks and 3G services with coverage in all major towns. This has seen improved access to internet services, with an estimated 12.4 Million internet subscriptions and an estimated 19.6 Million users by June 2013, as compared 7.7 Million subscriptions and 14 Million users in June 2012, and 4.2 Million subscriptions and 12 Million users in June 2011. Of the subscriptions, 98.9 % in 2012 and 99.2% in 2013 were mobile data / internet subscriptions (CCK 2012; CCK 2013). This means that majority of users access the internet through their mobile phone on GPRS/EDGE and 3G networks, consistent with data provided by the United Nations Millennium Development Goals (MDGs) report of 2013 (UN, 2013). Of the four mobile service providers, three are on 3G networks.

### **3.6.2 Internet access for academic institutions through KENET**

KENET (Kenya Education Network) is the National Research and Education Network for Kenya. It was founded in 1999 with a \$1.1 Million USAID grant and incorporated as a non-profit trust in 2000, with seven registered trustees. These include five vice chancellors of Kenyan universities, the Director General, CCK, and the Permanent Secretary, Ministry of Education (KENET, 2014). KENET's main objective is providing affordable broadband internet to its member institutions, collaboration of faculty and researchers, and sharing resources.



**Figure 3-2 NOFBI coverage**

(Source – Communications Commission of Kenya, 2012)

KENET is the second largest NREN in Africa, coming second to TENET in South Africa, providing internet bandwidth to 90 member institutions and 150 campuses (KENET, 2014). Each member institution pays a fee for connectivity, based on capacity required. As a bandwidth purchasing consortium, the large membership gives it the necessary purchasing power to purchase bandwidth at discounted prices and pass it on to its member institutions (IST Africa, 2014). This makes it much more affordable than if the HEI was to purchase

directly from an ISP. As seen in the previous section, improved international connectivity has seen bandwidth prices go down for KENET, from \$2300 per Mb/s to the current \$160 Mb/s (Kashorda & Waema, 2014). This has led to an increase in bandwidth consumption at the universities. For example, Kashorda & Waema (2014) note that the network category indicators from their 2013/2014 e readiness survey show the internet bandwidth per 1000 students within the 17 studied universities had increased from 0.436 Mb/s in 2008 to 4.22 Mb/s in 2013. This indicates universities were purchasing more bandwidth, though they recommend 10 Mb/s for 1000 students for a better internet experience (Kashorda & Waema, 2014).

Apart from bandwidth services, KENET offers to its members other services including network support and design, training for technical staff, network applications including web hosting, e-mail, disaster recovery as well as e learning and multimedia content creation services (Kashorda & Muia, 2013). In addition, it provides a platform for attracting investment (e.g. the IBM Africa research lab set up in 2013 at a member institution) and funding support for research and education community in Kenya, as well as expansion and integration into other NRENs (Kashorda & Muia, 2013). With a \$22.5 Million grant from the government of Kenya through ICT authority, KENET is now investing in building a dedicated network for connecting member institutions across the country that is expected to highly increase the amount of bandwidth an institution can access on the KENET backbone. KENET is also working with campuses to enable wireless infrastructure. By August 2013, KENET had set up EDUROAM at ten university campuses, making it the first African NREN to implement EDUROAM (Kashorda & Muia, 2013).

### **3.7 CHAPTER CONCLUSION**

This chapter has given an overview of background information of Kenya as regards location, demographic information and economic indicators, overview of higher education system and ICT infrastructure. The economic background and research funding information creates a basis for understanding the resource based issues experienced by researchers. ICT plays a major role in supporting distributed research activities, a major component of today's knowledge production processes. Their adoption and use are much dependent on supporting infrastructure, among other factors. The background information provided thus provides a basic understanding of developments and status of ICT infrastructural support,

which may affect integration into research work. Generally, the information provided in this chapter should create a better understanding some of the characteristics of collaborative research in Kenya, which emerge in this research.

## **CHAPTER 4: RESEARCH DESIGN**

### **4.1 INTRODUCTION**

This chapter discusses the methods adopted for the investigation and justification for their implementation in answering the research questions and meeting the study's objective as set out in section 1.3. To recap on the aims, this study is aimed at gaining an understanding of the process of collaborative research in Kenya with a focus on two major aspects; firstly, the organisation of collaborative research including levels, structure of interactions, collaboration practices and associated factors. Secondly, the role of ICT in supporting various collaboration activities, and analysis of the factors contributing to their adoption and use. This culminates in a set of recommendations and strategies for promoting collaborative research in Kenya. A background review of literature and personal interaction with research environments in Kenya led to the identification of the key issues and gaps in literature that this research addresses. Towards meeting the study's aims and objectives, this chapter presents a discussion on the rationale for selection of the methods used (section 4.2), developing the instruments (4.3), the piloting process (4.4), sample selection (4.5) and procedures for data collection (4.6). This is followed by a brief description of the data analysis techniques (4.7), ethical considerations (4.8) validation measures taken (4.9) and the conclusion to the chapter (4.10).

### **4.2 RATIONALE FOR SELECTION OF THE METHODS**

This research adopted a mixed methods design, involving both quantitative and qualitative forms of inquiry, implying both a positivist and interpretative epistemological stance. The positivist/post positivist world view 'hold a deterministic philosophy in which causes probably determine effects or outcomes', thus positivists are constantly seeking causes of outcomes, by reducing the ideas into testable measures in form of variables (Creswell, 2009, p. 7). On the other hand interpretivist/social constructivist 'hold assumptions that individuals seek understanding of the world in which they live and work ... to rely as much as much as possible on participant's views of the situation being studied' (Creswell, 2009, p. 8). In this study, a positivist approach, involving a quantitative survey was necessary to obtain a broad overview of the status and nature of collaborative research in Kenya and reveal the structural aspects of collaboration amongst researchers. An interpretative approach, involving qualitative interviews was adopted to gain a deeper understanding of

the conduct of collaborative work and explore some of the more interesting issues in more detail.

The advantages of using mixed methods approach are highlighted by Creswell & Plano Clark (2007), who see it as a means of providing comprehensive evidence by incorporating use of multiple world views, using both deductive and inductive reasoning. Understanding communication patterns and general trends in the conduct of collaborative work was found best achievable by use of quantitative methods. This approach facilitated coverage of a wider population to yield more accurate, generalisable measures of collaboration patterns and behaviours. This would not have been achievable by targeting a smaller population using only qualitative techniques. Neither would it have been achievable using a case study approach, targeting a particular discipline or institution. Targeting researchers across institutions was considered best in providing this information as well as reducing bias that may be associated with particular institutional cultures and structures. Inclusion of different disciplines brought out the differences in collaboration structures, processes and practices across disciplinary areas, useful in the subsequent analysis.

Qualitative techniques were considered necessary to seek a deeper understanding of collaborative relationships and behaviours. They promoted an understanding of the research context cited as one of the disadvantages of quantitative methods in Creswell & Plano Clark (2007). They also facilitated an understanding of issues that participants considered most important for success of collaborative research based on personal perspectives and lived experiences of the actors in research collaborations themselves. In addition, they provided for an exploration of important upcoming issues not included in the quantitative survey. The conduct of collaborative work and rate of diffusion of ICT to support it is heavily people centred. Consideration for the need to involve techniques that in addition to identifying the general trends incorporate the people's views and perspectives was therefore considered important in this study.

The sequential explanatory mixed methods strategy was employed in this study, defined by Creswell (2009) as procedures in which 'the researcher seeks to elaborate on or expand on the findings of one method with another (p.14). Quantitative methods formed the primary data collection approach, while qualitative methods were used to explain and expand on the results by identifying particular issues for follow up and appropriate participants to conduct

the follow up on, as described by Creswell & Plano Clark (2007). This provided for a better understanding of the findings.

*Methods used in related studies.*

A variety of methods have been used to study organisation of scientific work and use of technologies to support collaborative work. While a number of studies have used bibliometric analysis, to study co authorship networks, including the earlier work in the field by Price and Beaver in the 1960s, others have used other quantitative techniques to study dynamics of collaboration and productivity in science. For example, Bozeman & Corley (2004) used quantitative methods (mail survey) to study American academic scientists' collaboration choices and strategies, while Duque et al. (2005) used structured questionnaires to compare organisation of science across three regions. Walsh et al. (2000) used quantitative methods (mail survey) to explore incorporation of CMC into scientific work. Qualitative methods have also been used to explain certain aspects of scientific work. Interviews were used by Walsh & Bayma (1996 b) to study the effects of Computer Mediated Communication (CMC) on scientists' work, and by Fry (2003) to study the shaping of scholarly communication across a number of academic specialist areas. Other studies have used mixed methods to understand the dynamics of research collaborations. For instance, Melin (2000) used mixed methods design in his study aimed at establishing the reasons for, form and effects of collaboration at the individual level. Birnholtz (2007) use mixed methods to explore the determinants of collaboration propensity, the quantitative survey measuring collaborative behavior and interviews used to aid in interpreting the results. Hara et al (2003) used mixed methods design involving a sociometric survey of academic scientists across distributed centers to identify forms of collaboration and influencing factors. It's therefore evident that a variety of methods have been used in related studies. However, the particular method used is determined by the research questions, and an assessment of what approach would answer the questions best.

### **4.3 DEVELOPING THE INSTRUMENTS**

An online survey was designed (using SurveyMonkey) and tested for collection of the quantitative data. Some of the questions in the questionnaires were adopted from instruments used in past studies. These include those used in surveys conducted by the Globalization of Science project headed by Wesley Shrum and measures used by Lee &

Bozeman (2005) in establishing motives for collaboration, Walsh & Maloney (2007) in identifying problems in collaborations and Walsh et al. (2000) in measuring use of ICT for scientific work. The survey was designed in such a way that it addressed the research questions. This included measures of collaborative activities, factors influencing collaborative research, access to and use of ICT to support research, challenges faced within research collaborations and demographic information. A summary of these measures against the research questions is presented in Table 4.1 (see Figure 1.1 for a mapping of research aims, objectives and methods).

Co-authorship has been used by many studies as a measure of collaborative activity. However, many authors, as seen in the literature warn that bibliometric studies on their own would not be representative enough as an indicator of collaborative activity (see section 2.5). This applies especially in studies of developing areas (Duque et al., 2005; Shrum & Beggs, 1997). Considering the arguments in literature against the various methods as seen in section 2.5, this study therefore employed self-reported measures of collaboration and productivity to improve the accuracy of the data.

The quantitative survey was then followed by a more detailed exploration through the interviews, to derive a deeper meaning to the quantitative data, and follow up on major issues that arose in the quantitative survey such as funding. An interview guide was drawn up, guided by broad themes around the major areas of the study, giving room for exploration of personal experiences and important upcoming issues.

#### **4.4 THE PILOTING PROCESS**

##### ***Piloting the questionnaire***

A list of twelve members identified to take part in the pilot process was drawn. Ten of them were members of the study population, while the other two were chosen for their expertise in the study area as well as research methods. An email was sent to them, with a brief description of the study and request for participation. Ten responded positively, and were sent an email containing the link to access the questionnaire, and general guidelines on the evaluation process. The guidelines included a request for feedback on ‘the effectiveness of the cover letter, the overall layout and design, the usefulness of the instructions, the question wording and length of time it took to complete the questionnaire’, adapted from



Question	Measures
1. How is the academic research community in Kenya organised	<ul style="list-style-type: none"> <li>• Level of collaboration <ul style="list-style-type: none"> <li>○ Involvement (by answering Yes or No to collaboration)</li> <li>○ Degree of involvement (measured by number of collaborative research projects)</li> </ul> </li> <li>• Differences in level of collaboration (measured by number of collaborative projects) across: <ul style="list-style-type: none"> <li>○ Disciplines</li> <li>○ Institutions</li> <li>○ Gender</li> <li>○ Age</li> <li>○ Academic qualification</li> <li>○ Region of study</li> </ul> </li> <li>• Patterns of communication among and/or across disciplines and institutional boundaries <ul style="list-style-type: none"> <li>○ Establish Linkages using details of collaborators including name, gender and institutional affiliation</li> </ul> </li> </ul>
2. What are the factors contributing to its form of organisation	<ul style="list-style-type: none"> <li>• Patterns and differences established in question one above</li> <li>• Motivation for getting into a collaboration</li> <li>• Problems / challenges faced</li> </ul>
3. How have ICTs been adopted and used to support research collaborations	<ul style="list-style-type: none"> <li>• Availability of ICT resources</li> <li>• Frequency of use</li> <li>• Type of use</li> </ul>
4. What are the factors contributing to their adoption and use	<ul style="list-style-type: none"> <li>• Availability of ICT resources</li> <li>• Level of skills</li> <li>• Challenges faced in their use</li> <li>• Differences in use across categories of disciplinary areas / areas of specialisation, gender, age, academic qualification and region of study</li> </ul>
5. What is the relationship between collaboration and productivity	<ul style="list-style-type: none"> <li>• Self-reported publication productivity and other outputs from research</li> <li>• Self-reported number of collaborative projects</li> </ul>
6. What is the relationship between ICT use and research productivity	<ul style="list-style-type: none"> <li>• Frequency of use</li> <li>• Type of use</li> <li>• Self-reported publication productivity</li> </ul>

**Table 4.1 Summary of measures used for each research question**

O’Leary (2010, p. 185). Eight responses were received from the piloting process. Some did an evaluatory assessment of the questionnaire, not filling in and submitting the responses, while others evaluated, filled in and submitted the responses. The main concerns raised by the respondents were:

*Length of questionnaire* - A concern about the length of the questionnaire, 18 pages then, was raised by all respondents, which, according to some, could discourage potential respondents. One respondent suggested that the questionnaire be split into two, with more details to be captured in the second questionnaire as a follow up. Another suggested having a shorter questionnaire followed by follow up interviews with those who would indicate a willingness to participate in the follow up.

*Required questions* - One respondent thought I had very few required questions, and suggested that I make the critical questions required, to avoid the problem of ending up with lots of missing data

*Excessively time consuming tasks* – the last part of the piloted questionnaire required respondents to list their publications in the last 10 years. A respondent thought that people may feel bothered by having to list publications. Another respondent, in the process of filling in the questionnaire, realised that he did not have a list of publications in the computer he was using, therefore submitted the questionnaire without them. I realised this was an indication of what may happen in the actual survey. Another thought I was asking a lot in terms of collaborator details.

*Clarity of questions* – There were some observations on the clarity and ambiguity of some of the questions, and it was also noted that some questions needed more instructions.

Following the concerns raised, I did the following:

- Devised ways of making the questionnaire shorter by assessing the kind of questions whose response could be generalised from the data collected in the qualitative interviews, such as benefits derived from the collaboration. I also deleted questions whose answers could be sought from the study of university documents, records and correlations of data from other sections in the questionnaire. Some

questions were revised to be accommodated in a simplified version in a rating question.

- The question requiring a listing of publications was revised to giving a count, as it took a lot of the respondent's effort and time.
- Redesigned or reworded some the questions to make the instructions more clear e.g. by placing instructions at the exact point where required on the question.

In designing the questionnaire in SurveyMonkey, I had devised some functionality within the application to allow easier data capture (in form of drop down lists and forms). On analysing the responses received, I realised that SurveyMonkey did not show the information intended to be captured with these added functionalities and had to do away with them.

On further consultation with some of the pilot respondents on splitting the questionnaire, there were mixed reactions to the issue. Some felt that a shortened single questionnaire was best, while others felt the idea of one main questionnaire with follow up details was better. I came up with two versions of questionnaires:

- One single shortened questionnaire, including project details, which required a little more time to fill out as compared to other questions in the questionnaire that were mainly close ended.
- Another even shorter questionnaire to be followed up with a second questionnaire requesting project details.

The pilot participants were presented the two and asked for their view on which they thought would be more effective. The majority felt that a single shortened questionnaire was better, as one put it 'people would feel bothered to have to go back to them with a second questionnaire, as they will already be feeling they have helped you out enough with the first'. Therefore the shortened questionnaire including the project details was used as the main data collection instrument.

### ***Piloting the Interviews***

The original proposal was to conduct interviews both in Kenya and the UK, with an aim of recommending adaptable best practices in the UK to the Kenyan situation. However, on

further investigation and consultation, it was decided that firstly, the study was too broad to be conducted within the given time and resources, thus narrowed the study to concentrate more on the issues affecting Kenya. Secondly, much has been done on research organisation in the developed world, including the UK, thus a decision was reached of making reference to these studies instead of involving them in the research.

Based on this initial plan, the first two participants in the pilot interviews were identified from the University of Brighton in the UK. In addition to seeking feedback on the issues that were being explored, this first phase of piloting was intended to give me a feel and some experience in the process of conducting interviews, as it was a first experience on conducting interviews. The interviewees were first requested for participation, and on acceptance, an interview date and time were set. The first interviewee was then sent an email informing him of the major themes that would be covered in the interview, which was to be semi-structured so as to give him time to think about and reflect on the issues. The interview was organised around the major themes of my study, though realising the kind of questions asked in the actual survey could differ as the main survey was intended for Kenya.

Among the major lessons learnt from this experience was that I had to be very flexible in adapting the way of asking questions, as the order may differ from the interview guide prepared. As the interviewees had prior knowledge of the themes under investigation, some ended up discussing the issues even before the questions were asked.

#### **4.5 SAMPLE SELECTION**

The study targeted 450 academic members of staff in selected Kenyan universities and disciplinary areas. Research in Kenya is mainly carried out in a range of settings, including research organisations, institutes and universities. This is an intensive study, and targeting a smaller portion of the wider scientific community seemed manageable in terms of time and resources, thus the choice of academic scientists affiliated with universities. Under this section is a description of the process of selecting the institutions, disciplines and participants for the study.

### *Selection of the disciplines*

A decision of whether to take the disciplinary area or specialist area as unit of analysis when designing studies concerning knowledge communities has been pointed out in literature (Fry, 2003, Becher & Trowler, 2001; Crane, 1969). These studies argue for a lack of clear boundaries between the broader disciplinary fields, thus advocating for use of specialist field as a unit of analysis. Research in most Kenyan universities is organised around the major disciplinary areas in form of schools/colleges/institutes and departments (see section 3.4). The department level reflects an organisation based on various sub-disciplines within the major disciplinary area. However, the organisation and range of departments differ across some universities, making it difficult to identify particular sub-disciplinary areas across the universities.

In this survey, it was found necessary to use the broader disciplinary areas. The main purpose of the research is to identify factors influencing collaboration process. In doing this, it was necessary to identify collaboration networks, deemed important in analysing collaborative work. It was also necessary to identify general trends whose effects could be generalised as affecting collaborative work. This objective was best met by looking at the broader disciplinary areas that capture more actors within this community. This led to a better understanding of factors influencing their collaboration patterns and processes in general. Use of specialist areas, not clearly identifiable across institutions in Kenya, would have limited achievement of this objective.

The Field of Science Classification in the Frascati Manual was adapted for classification of the disciplines. The Frascati Manual is defined as the proposed standard practice for surveys on research and experimental development (Frascati Manual, 2002), described by the OECD as:

Originally written by and for the experts in OECD member countries who collect and issue national data on research and development (R&D). Over the years, it has become the standard of conduct for R&D surveys and data collection not only in the OECD and the European Union, but also in several non-member economies, for example, through the science and technology surveys of the UNESCO Institute for Statistics (UIS). (OECD, 2011)

Given that a wider application of this research is being looked at, adapting an internationally recognised and used classification makes it easy to place the disciplines under study into the major fields recommended under the classification.

The Field of Science (FoS) classification in this manual was revised in 2007 to ‘reflect the latest changes in the science and technology area, especially with regard to emerging technology fields such as ICT, biotechnology and nanotechnology’ (Frascati Manual, 2007; p.2). It classifies fields of science into six major categories:

- Natural Sciences – includes mathematics, computer and information sciences, physical sciences, chemical sciences, earth and related environmental sciences, biological sciences and other natural sciences,
- Engineering and Technology – includes civil engineering, electrical, electronic and information engineering, mechanical engineering, chemical engineering, materials engineering, medical engineering, environmental engineering, environmental biotechnology, industrial biotechnology, nano-technology, other engineering and technologies
- Medical and Health Sciences – includes basic medicine, clinical medicine, health sciences, health biotechnology and other medical sciences
- Agricultural Sciences – include agriculture, forestry and fisheries, animal and dairy science, veterinary science, agricultural biotechnology and food biotechnology and other agricultural sciences.
- Social Sciences – includes psychology, economics and business, educational sciences, sociology, law, political science, social and economic geography, media and communications and other social sciences.
- Humanities – includes history and archaeology, languages and literature, philosophy, ethics and religion, art (arts, history of arts, performing arts, music) and other humanities.

The classification above is recommended for adoption in R & D related studies, but it is noted that its implementation is ‘quite diverse across countries’ (Frascati Manual, 2007, p.3). Though adopting the general framework in this study, other considerations were made in coming up with the final selection of the disciplines. The disciplines selected for study

were broadly classified as agriculture, engineering, computing, and public health. Five of the categories in FoS classification are represented in this choice, with at least one discipline / sub discipline falling under each of the major fields as follows:

- Natural Sciences – computer science
- Engineering and Technology – civil engineering, electrical and electronic engineering, mechanical engineering, chemical engineering, environmental and biotechnology engineering
- Medical Sciences – public and environmental health, tropical medicine, infectious disease and epidemiology
- Agricultural Sciences –agriculture, horticulture, plant and crop protection, agricultural and food biotechnology, land resource management, agricultural economics, animal production
- Social Sciences – social aspects of computing.

The only field not represented here was the humanities. As noted in section 2.4 (disciplinary factors), predominantly theoretical fields are associated with less collaboration, more so determined by the nature of the work. Excluding the humanities is based on the assumption that there is less collaborative research in the discipline, as indicated by the literature review. This was confirmed by a desk based survey of disciplines in the humanities within the selected Kenyan universities. The desk based research involved retrieving publication records of individual researchers across disciplines from CVs uploaded on the university websites, where they were available to identify co-authored publications (co authorship is a commonly used measure of collaboration). It also involved searching through university repositories for research records. This was useful in identifying disciplines and university departments with more collaborative activity, aiding the sampling process, though also noting the poor state of documenting research activities in Kenyan universities. Since this research is focussed on investigating collaborative research, a decision was therefore made to exclude disciplines under humanities.

Selection of the particular disciplines within each field of classification was also based on the following principles:

- Significance of research to the country – research that is seen as solving the most common problems affecting the citizens and geared towards national development is prioritised, e.g. in terms of funding. For example, research in agriculture and tropical diseases generates great interest and funding in Kenya as it is assumed that investing in these fields contributes to alleviating some of the major problems ravaging many parts of Africa, food security and health. An assumption is made here that research geared towards such areas will generate as much interest and applicability within advocates for collaborative research.
- Nature of the discipline – would influence the characteristics and level of collaboration as some disciplines allow for more collaborative activity than others.
- Level of establishment in sampled universities – some disciplines are better established in the sampled public universities (see section 3.4), who are the main source of teaching and research manpower for the smaller private universities. This means more availability of data and participants e.g. in agriculture and engineering.

Practical constraints within each selection, in terms of the size of the target population, (estimated through a preliminary desk based online survey of the university websites) and the availability and accessibility of the data and participants were considered in coming up with the final selection. Agricultural and engineering sciences, which are being looked at broadly, display a number of the different subfields found across the universities selected (as indicated by the departments), and were all sampled as it was found that research across the subfields depended much on each other. In the broader field of health sciences, public health was chosen, due to its applied nature and orientation towards investigating health issues that are a major concern to the country, meeting the first principle used in the criteria of choice above. The wider medical field is too broad, and it was suspected that getting information from some specialist areas within the discipline would be problematic. For example, collecting data from medical practitioners could be difficult due to the confidential nature of their work. Computing, being a relatively newer and upcoming discipline, and associated with being a major contributor to development of a nation, has lots of interest vested around it from various sectors. A preliminary investigation revealed that few academicians in this field are qualified researchers, at least having a PhD, therefore suspected low levels of collaboration. Including assumed highly collaborative disciplines



(such as agriculture) and assumed low collaborative discipline (computing) makes the sample size more diverse and generalisable across various disciplines.

### *Selection of the universities*

Four major public universities in Kenya were selected for the analysis. These are the University of Nairobi (UON), Jomo Kenyatta University of Agriculture and Technology (JKUAT), Kenyatta University (KU), and Moi University (MU). These are some of the oldest Kenyan universities, established between 1963 and 1994 and offering a range of disciplines (see section 3.4). Their choice was based on their level of establishment within the Kenyan higher education system which impacts on establishment of the particular departments/disciplines within them, and size of the target population. They were therefore found representative of the academic research community. University of Nairobi and JKUAT were found to have well established departments representing all the disciplines under study, Kenyatta University was selected for agriculture, public health and engineering, while Moi University was selected for public health and engineering.

Private universities were excluded from the sample because they are mainly known to support newer market driven courses such as business education and information technology (see section 3.4), thus smaller population of researchers in the chosen disciplines. This was confirmed in a preliminary desk based study that indicated that most of the private universities did not have established departments in the chosen disciplines, as most of the programs offered are mainly aligned with the goals of their sponsors. The majority of trained researchers (with a PhD qualification) in the selected disciplines are found in the public universities and research institutes, thus the decision to focus on public universities. Three of the chosen universities are located closer to the capital city of Kenya, Nairobi, and within commuting distance from each other, thus offered the added advantage of ease in accessing and following up on the participants.

### *Selection of the participants*

It was necessary to include all academic members of staff within the chosen departments and disciplines because of the intensive nature of the study. Considering the benefits of collocation in forming collaborative relationships found in literature, this approach identifies both internal collaboration networks formed with colleagues in the same institution as well as external ties with those not affiliated to their institutions. It therefore

yields a more accurate collaboration network and deductions of the collaborative relationships generalisable to the academic community. This is unlike past studies in the region, (Shrum, 1997; Duque et al, 2005), that targeted fewer individuals spread over a wide region (across three nations), and did not consider ties internal to an organisation or institution in their identification of professional networks.

A preliminary desk based survey of university websites identified the departments within each disciplinary area under study and academic members of staff affiliated to a department. This list gave an idea of the numbers involved, though this changed in some departments when fieldwork started and I got the actual lists from the departmental heads. This points to the fact that information derived from the university websites may not be very reliable as some are not frequently updated.

The initial plan was to conduct an online survey. Given its ease of collecting data, and reaching a wider population, targeting the 450 academic members of staff identified as being affiliated with the chosen universities and disciplines was deemed feasible. The preliminary study of the university websites also indicated that the academic members of staff in some departments were quite few, thus further sampling within the department was deemed not necessary. Though focusing on all members in selected universities and disciplines, the study realises that not all academic members of staff were research active. The questionnaire was therefore structured into different sections for the two main groups of people, those that were involved in collaborations and those that were not (see Appendix 3). Thus the respondents were supposed to answer only questions that were applicable to them, thus more specific, focussed responses.

Participants in the interviews were selected from this sampled population. Their selection was based on the role they played in the networks, for example the number of collaborations they were involved in, their professional qualifications, institutional affiliations and the disciplinary area or sub area they belonged to. However, the need to follow up more on issues of funding made it necessary to interview one person external to the sampled population, an official from the funding arm of the government, the National Commission for Science, Technology and Innovation (NACOSTI).

## **4.6 PROCEDURES FOR DATA COLLECTION**

### ***Obtaining permissions***

As per legal requirements, a research permit was sought and issued by the National Council of Science and Technology (NCST), later renamed to NACOSTI, which is the major arm of the Ministry of Education, Science and Technology that deals with research issues in Kenya. NCST advised that I contact the Vice Chancellors of the target universities before embarking on the research. I therefore applied for and was granted permits from the four target universities (University of Nairobi, JKUAT, Moi University and Kenyatta University). Getting a permit from two of the universities was easy, but it took a month to secure the permits from the other two. This was expected, so arrangements to get the permits had been made a little earlier, before the data collection exercise commenced. With these, I was set to embark on the data collection exercise.

As noted before, this research adopted the sequential explanatory mixed methods strategy. The data collection exercise started with quantitative data (this being the primary source of data). A preliminary analysis of the quantitative data, interaction with the participants and study environment, in addition to the pre-determined themes formed the basis for further exploration through the interviews, with a few selected individuals.

On getting to the field, the first step was to confirm the names and contact details of the academic members of staff, in each department within the disciplines under study. Access to individual members was sought through the help of heads of department. They were approached, to provide contact details and help in facilitation of the study, through an introduction to the members of the department. I felt that going through someone familiar to the respondents would to some extent improve the response rate. The majority of heads of departments were very willing to help. However, one particularly difficult case, who insisted that the people who had issued the permits should contact him personally with details of the kind of assistance they required him to give, was encountered. Another, from public health, insisted on my getting additional permits from the Ministry of Health and a major organisation they were partnering with. This was found unnecessary because of the processes involved, therefore a decision was made to go ahead with those who were willing.

### *Quantitative data collection procedures*

An initial online survey involving all members of the target population, using the lists provided was done. An email was sent, specifically addressed to the individuals by their names so as to have an anticipated effect of a ‘personal touch’. This email contained a brief introduction of the researcher and the study, assurance of confidentiality, the approximate time it would take, and a link to access the survey (see Appendix 1).

This survey was characterised by low response rate, and after sending reminders two weeks later, yielded 19.2% response rate. Some of the participants indicated they were not accustomed to participating in online surveys, while a few pointed out that they could not respond to someone they didn’t know, associating it with junk mail. Others cited problems with internet connectivity, which required that personal touch to have the patience of going the extra mile of dealing with slow internet connection or doing it at a personal cost.

It was realised that a follow up on the online survey was necessary to elicit more responses, therefore printed a number of hardcopy questionnaires and as advised by some of the heads of departments, changed the strategy to hand delivered questionnaires. The follow up mainly involved those with PhDs, as it was suspected that being the more trained researchers, they were more likely to be involved in collaborative research. Those whose profiles on university websites and repositories indicated they were involved in collaborative research were also specifically targeted in the follow up. The purposed follow up was therefore intended to gather information from those who were actually part of the main issue under investigation. This was intended to minimise response bias, defined by Creswell (2009) as the effect on survey estimates if non respondents had responded. The follow up was not easy as I realised researchers/lecturers are very busy people, and sometimes had to make several visits to an office before getting the person or response.

However, this was found quite rewarding, as the one to one interaction made people more willing to participate. The majority requested I leave the questionnaire and collect at a later agreed date or time. This gave them time to provide most of the details that were requested, especially in Section E of the questionnaire, which required the participant to list details of collaborative projects they were involved in. Having had contacted them before on email, perhaps the guilt of having not responded then, and my persistence (as pointed out by one of the participants) had an effect on their responding. Being a member of staff in one of the

universities under investigation brought about the feeling of ‘being part of us’, thus some were able to relate with me at the level of a colleague. The fact that the issues being investigated had an assumed direct bearing on their research career in a positive way made majority of them very willing to participate, thus the good response despite the length of the survey.

Self-reported collaboration was the major method used to identify links between researchers, leading to identification of collaboration networks within the target population. One section of the questionnaire asked respondents to give details of up to three research projects they were part of in the last ten years, including the collaborator name, gender and institutional affiliation. A few expressed discomfort at providing names as they hold the belief that a questionnaire should be anonymous. Meeting them personally gave me a chance to explain why the names were required, assuring them of confidentiality and anonymity in the report, and most responded positively. For the network data, the period under observation was limited to ten years, the rationale behind this being that ten years makes a ‘long enough period’ to observe patterns of communication, and short enough to give the respondents a reasonable time frame within which to remember the details of a collaboration.

To supplement the self-reported collaboration data, and confirm or obtain details faced with a situation in which a respondent pointed to a collaborator who did not respond or was not part of the sampled population, I embarked on a study of the university repositories to extract the data. In the process, it was realised that most universities did not have centralised databases or repositories of ongoing or past research projects. Only one university had a research management information system, which was in the early stages of roll out and lacking in lots of information. In one case, an administrator at the office of the DVC dealing with research matters in one of the universities cautioned that ‘universities in Kenya are now in the process of building up centralised records of research activities, and you are unlikely to get that information anywhere’. In two out of the four universities visited, I was referred to the accounts or grants section of the university for the data, as most project money was disbursed through these offices. Therefore the assumption was that these offices would have details on the project participants. However, some of the records in these offices did not hold details of the people involved in the projects, other than the

principal investigator. Surprisingly, some departments did not keep records of research done in their department. One head of department, for instance informed me that they only kept research records for their post graduate students, and not members of staff, advising me to talk to the individual researchers to get the information. Therefore accessing concrete research information from secondary sources was quite a task due to the limited data sources. However, this did not have much effect on the results as it was to play a supplemental role, the main source of data being the participants in the survey.

### *Qualitative data collection procedures*

As mentioned above, the online survey described above and questionnaires distributed on a one to one basis formed the major part of data collection exercise. This was then followed by a more detailed exploration, through interviews with a few selected individuals (see section 4.5-selection of the participants). An introductory email was sent to the intended participant. This email contained a brief explanation of the purpose of survey and a request for participation, outlining the broad issues that would be addressed (see Appendix 2). This was to let the participant know what to expect and have time to reflect on the issues beforehand. For those who responded, an interview date and time were set. With others, a follow up to the email was made by a personal visit to the intended participant, most of who responded positively.

All interviews were conducted face to face, in the participant's own offices, apart from one that was conducted in a restaurant at a conference centre, at the request of the participant. An open ended conversational style was adopted for the interviews to allow the participant the flexibility of bringing in important issues not on the interview guide. It was easy to develop a good rapport with some participants, especially those I had interacted with previously at the university, and the conversation flowed easily. Two interviews were done in an impromptu manner. A participant approached with the questionnaire said that he believed in collecting data through interviews, thus in respect of his view, complied. The other wanted me to read him the questions in the questionnaire and fill in his responses, and in the course of doing this realised that he had a lot to say on almost every question, thus converted it to an interview.

A total of 15 interviews were conducted, 14 with researchers in the four disciplinary areas across the four universities, and one with an official from the main research funding arm of

the government, the NCST/NACOSTI. Each discipline was represented by at least three participants from different departments as it is assumed that each department represents a particular sub discipline within the broader discipline, thus a good representation of the views across. The choice also included participants across the universities, as it was assumed that different university structures probably represent different contexts, which could impact on the characteristics and behaviour of the group under study.

The main aim of the interviews was to gain a deeper understanding of collaborations based on the participant's personal experiences. This included management and organisation of the various activities in the collaboration, problems experienced, and how they were handled, role played by the institution and the government in facilitating, supporting and encouraging research collaborations. Personal views on access to and use of technology, effects on the collaboration, and challenges faced in its adoption and use were also sought. Upcoming issues were followed up in subsequent interviews. Among these was the issue of funding, which prompted for arrangement of an interview with an official from the arm of the government dealing with research funding. All interviews, other than one (the participant declined recording), were recorded for later transcription and analysis.

#### **4.7 DATA ANALYSIS**

Data derived from the questionnaire-based survey was analysed, using statistical analysis software, IBM SPSS Statistics Version 20. This meant devising a coding scheme representing the various variables for data entry. Descriptive analysis provided general profiles of the respondents and basic indicators for research work environments, productivity and ICT availability and use. Chi-square tests of association, correlation tests and regression analysis were used to analyse the type of relationships between the various variables, thus an understanding of how the various factors interact to influence and shape the collaborative practices of researchers. Correlation tests included an assessment of the relationship between problems experienced and collaboration and productivity levels, use of ICT and collaboration and productivity levels, and in reducing problems of management and control, and the relationship between collaboration and productivity. A logistic regression modelled the effects of a number of variables in predicting involvement in collaboration while a multiple regression analysis modelled the effect of a number of

variables in predicting publication productivity. Varying dependent variables<sup>12</sup> were used in the regression models, including involvement in and level of collaboration, publication productivity and internet use. A number of controls/independent variables<sup>13</sup> were used for the regression models including the disciplinary area, nature of the area of specialisation<sup>14</sup>, institutional affiliation, ICT use, and personal factors such as age, academic qualification and the country where highest degree was attained. The dependant variables would assume the role of independent variables in subsequent models. Factor analysis was used to identify related variables that group together, simplifying further analysis.

In the survey, there were measures of links between researchers, for the purpose of identifying and understanding collaboration networks. Social network analysis (SNA) methods were used for this purpose, described by Dimitrina & Koku (2009), as a powerful tool for representing the connections among people and providing a precise picture of the structure of a community of practice.

SNA software, UCINET 6 was used to illustrate and provide a visual image of the networks formed. Of interest in this visual representation were the levels of connectedness in the network and general collaboration patterns between individuals, disciplinary areas and institutions. This includes connections to those outside the academic research community, as the participants were not limited to identifying links internal to the community. This visual representation therefore gave way to a better understanding of the patterns of interaction of the group under study, revealing important details of the links formed, and subsequent deeper exploration of the factors underlying the observed links and structures.

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<sup>12</sup> ‘A *dependent variable* is the presumed effect or response that is measured’ <http://www2.uncp.edu/home/collierw/ivdv.htm>

<sup>13</sup> ‘An *independent variable* is the presumed cause’ <http://www2.uncp.edu/home/collierw/ivdv.htm>

<sup>14</sup> The different specialisation categories were partly derived from the description of R&D research areas in the Frascati Manual. This manual classifies theoretical work as part of basic research ‘undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view’, and applied research as ‘original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific practical aim or objective’ (Frascati Manual, 2002, p. 30). Experimental research in this study is defined as that which mainly consists of experiments and practical laboratory testing. Respondents were asked to indicate nature of the area of specialisation, with the choices being predominantly experimental, predominantly theoretical, predominantly applied, or theoretical and experimental/applied components are somehow equal. The categories are not mutually exclusive, as for example, work that is applied in nature or geared towards solving a particular prevailing problem could involve experimental components. However, the main categories used were disciplinary. Categories under area of specialisation were therefore mainly used to explain the possible effects of nature of the work on collaborative work, without posing strong claims based on them.



Qualitative data analysis was guided by the broader themes under investigation in the quantitative survey, which were also the subject of exploration in the interviews. Major themes included describing the nature of the collaborations (such as local vs remote or international, academic vs industrial, and interdisciplinarity), motivation for collaboration, use of technology to support collaborative research and challenges faced. The approach used for coding of the qualitative data therefore involved assigning the data to the pre-determined themes. The broader thematic categories allowed for upcoming issues not included in the quantitative survey, such as the wide range of problems affecting collaborative work and required support for collaborative work to fit into the existing categories. Qualitative data analysis software QSR NVivo 8 was used to help organise and sort the data within and across participant interviews. Such use included the generation of nodes through which all data relating to a certain theme could be contained in one place, while enabling the creation of sub-themes (child nodes) within the major theme (parent node). To protect the identity of participants in the interviews, and at the same time bring out the differences in views across disciplines, a coding scheme whose first part identifies the disciplinary field and second part (separated by a hyphen) is a numerical value representing the participant was devised. In this coding scheme, COM-1 represents first participant from the computing, AGR-2 represents second participant from agriculture, ENG-3 represents third participant from engineering, PH-1 represents first participant from public health, and F-1 represents the participant from NCST.

The two sets of data (qualitative and quantitative) were synthesised at analysis. The findings were organised around the pre-determined themes, mainly drawn from the literature and the data collected.

#### **4.8 ETHICAL CONSIDERATIONS**

Ethical issues considered important in a research include:

- Making clear the purpose of the study and if applicable sponsorship, important in establishing trust and credibility (Creswell, 2009).
- Participants give informed consent – making them aware of the nature the research, type of involvement, time commitment, type of questions or topics to be covered and potential risks (O’Leary, 2014; Creswell, 2009; Oliver, 2008)

- Anonymity and confidentiality issues – anonymity refers to protecting the identity of those providing data, and confidentiality refers to ‘the range of people who might have access to the data being provided’ (Oliver 2008, p. 116).
- Ensuring no harm to the participants, whether emotional, psychological or physical (O’Leary, 2014), and respect for research sites (Creswell, 2009)
- Seeking authority of those in authority to provide access, and in the case of online surveys, seeking permission from the participants before sending out the survey (Creswell, 2009)

Creswell (2009) advises on researchers having their research plans approved by their institutional review boards. This research went through the University of Brighton’s ethical review process for approval. In meeting the requirements listed above, a request for participation in the study was accompanied by a cover letter. The cover letter contained my identification (name, institutional affiliations and sponsor), a brief description of the purpose of the survey, and the questions and topics the survey addressed. The participants were also given the approximate time it would take, informed that the necessary permits had been secured, and a copy of the permits attached to the request. The participants were assured of confidentiality, and anonymity was taken care of in the coding process (see Appendix 1).

Interviews were tape recorded. However, prior consent was sought from the participant. The participants were also informed that they should feel free to withdraw from the survey any time if they considered it necessary, to free them from emotional or psychological stress. The participants were the determinants of where the interviews would be carried out, considered a way of making them comfortable and relaxed with the surrounding. In this case, majority chose the interviews be carried out in their offices. I also made sure the interview did not take longer than the communicated time, so as not to inconvenience them in their time schedules. The only exception to this was when the participant indicated he wanted the discussion to go on past the communicated time.

Authority was sought to conduct the survey from all necessary individuals, including the NCST, university vice chancellors and heads of schools/departments (the process is described in section 4.6). In addition, I would pass through the administrative office before

knocking on the door of a researcher, to let them know I was around, and confirm the researcher's availability.

#### **4.9 ESTABLISHING VALIDITY AND RELIABILITY**

Bryman (2004) proposes three criteria as being important for evaluating social research: reliability, replication and validity. He describes reliability as 'the question of whether the results of a study are repeatable' and can be replicated, and validity as the integrity of the conclusions drawn (p. 28). He distinguishes four types of validity: *Measurement validity* – addressing the question of if the measures devised for a concept actually denotes the concept; *Internal validity* – addressing the question of if a conclusion drawn from a causal relationship between two or more variables is reasonable or sound; *External validity* – referring to generalisability of the study beyond the specific research context and *Ecological validity* – referring to applicability of the study to people's social settings. (Bryman, 2004, pp. 28–29). The section below describes measures taken towards improving validity and reliability of the data.

##### ***Quantitative study***

On developing the initial instrument, an expert in statistics department at the University of Brighton was sought to review the questions and advise on their measurement validity and testability using SPSS. In addition, a pilot study (as described in section 4.4) was done before the main survey to test for validity of the instrument. A number of clarity, interpretation and presentation issues as well as length of questionnaire were raised, and attempts were made to address them.

Adopting measures from past instruments with established validity and reliability scores improves validity and reliability of their use in a study (Creswell, 2009). Appropriate measures with dependable reliability scores from past related studies (as seen in section 4.3) were adopted for some sections in the quantitative survey. In addition, their use allows for comparison of results with past studies. Where measures were not available from prior studies, new variables were developed from important factors that needed to be tested as identified in literature. In addition to the measures taken above, the statistical software used to analyse the data, SPSS, has inbuilt mechanisms for testing both internal and external validity of the data (e.g. significance testing), discussed in details in the analysis chapter. A

detailed documentation of research procedures is provided, thus meeting the reliability and replicability test.

### *Qualitative study*

Bryman's criterion above is most applicable to quantitative research. Creswell (2009) discusses methods of enhancing validity in qualitative research as including: data triangulation; use of member checking to determine accuracy of the findings; use of 'rich, thick description to convey the findings'; reporting researcher biases and spending more time in the field to develop a deeper understanding of the 'phenomenon under study' (pp.191 – 192).

Data triangulation involves use of multiple data sources to build a justification for a particular theme, in which a theme built on several converging data sources is said to be more valid (Creswell, 2009). The use of sequential explanatory mixed method, starting with quantitative survey, study of university repositories and websites, document review as well as direct interaction with participants provided for use of multiple sources on which the predetermined themes were built.

In the report, use of verbatim i.e. participants exact words, is used to better explain the findings by giving the reader a *raw* experience of the participant perspectives. Use of member checking to determine accuracy of research finding has been noted as a way of improving validity (Creswell, 2009; Bryman, 2004), and considered a sound ethical principle (Oliver, 2008). However, Oliver (2008) notes that it can create 'several potential difficulties' (p. 120). The difficulties include the logistics involved, in for instance transcribing the interviews and passing tape and transcription notes to respondents for confirmation, which can be quite time consuming. If respondent was to be consulted on analysis and conclusions drawn, disagreements may arise, putting the researcher in a dilemma of if to re-write the thesis, or just note the observations and do nothing, which could create a feeling of being ignored on the part of the respondents (Oliver, 2008). Oliver therefore notes that though the consultation is inspired by best ethical motives, at times the researcher may need to 'take over control for the data and analysis' (Oliver, 2008; p.120). On consideration of the issues raised by Oliver, and particularly the time it would take to involve the respondents and get their feedback, I decided to take over responsibility for data and analysis. I am mainly based in the UK and the 'not very encouraging' communication

over distance (as realised in the online survey) was considered an extra source of potential delays. To reduce problem of misrepresentation in transcriptions, I got a fellow PhD student to listen to the interviews and confirm that what was said is what was in the transcribed notes. To reduce the problem of misinterpretation, as much as possible of the respondent's exact words are used to convey the information as intended.

#### **4.10 REFLECTION ON THE ROLE OF THE RESEARCHER**

Being Kenyan, and an academic member of staff in one of the public universities sampled for the study, it was easier to understand and identify with the institutional context within which the researchers worked. Trust and respect were easily built due to this identity, and it was easier gaining access to participants and documents that were not in the public domain. It was easy to develop a rapport with majority of the researchers, who in many cases regarded me as a colleague. However this familiarity became a disadvantage in one case where a participant felt he was not happy with the university management and was unwilling to disclose much information to someone who was associated with the system, even on being assured of confidentiality. However, others saw the research as a good opportunity to voice their concerns and share experiences that they could personally relate to. Part of the motivation to do this was voiced as the relevance and anticipated impact of the research in improving their research and work environments. Familiarity with the research context made it easier to understand and discuss issues related to socio-technical environments within which researchers work. However, familiarity can also be a source of personal bias in conducting the survey and interpreting the findings. I dealt with this by focussing mainly on the participants' perspectives and interpretations of the issues being discussed, carefully documenting them and using them to support the quantitative findings, arguments and conclusions.

#### **4.11 CHAPTER CONCLUSION**

This chapter has reviewed the research methods used in the study, giving a justification for their use and detailed procedures for the data collection exercise. A sequential explanatory mixed methods research design was used, with the quantitative survey forming the primary data collection exercise, and a further exploration using interviews and document review. The quantitative survey yielded 248 responses out of the targeted 450 (a 55.1% response

rate), and a total of 15 interviews were conducted. The next chapter presents the detailed analysis and research findings.

## **CHAPTER 5: RESEARCH COLLABORATIONS IN KENYA –ANALYSIS AND FINDINGS**

### **5.1 INTRODUCTION**

This chapter presents a detailed analysis of the empirical evidence collected by questionnaires and interviews, to explain organisation of the academic research community in Kenya, use of ICT to support research collaborations and effects of collaboration and ICT use on productivity of academic scientists in Kenya. The chapter is organised around answering the research questions thus meeting the study's objectives, reflected in the main sub-headings of the chapters (see Figure 1.1 for a mapping of research questions to objectives and aims of the study). This includes an analysis of data that explains organisation of the research community (5.3), including a detailed analysis of collaboration levels and patterns. Section 5.4 presents an analysis of factors that could be used to explain the form of organisation, including the demographic factors, motivation for collaboration and challenges faced. Section 5.5 presents an analysis of availability and use of ICT to support collaborative research and the possible determinant factors. Section 5.6 analyses the effects of collaboration and ICT use on productivity of academic scientists. The chapter begins with descriptive statistics that provide a summary of the basic features of the sample.

### **5.2 DESCRIPTIVE STATISTICS**

Four major Kenyan universities and four disciplines were sampled for the study (see section 4.5). A total of 248 responses out of the estimated 450 were realised, representing a 55.1% response rate. Of the total responses, 41.5% were from JKUAT, University of Nairobi (UON) 31.1%, Moi University (MU) 16.9% and Kenyatta University (KU) 10.5%. Of the four disciplines sampled, 49.4% of the respondents were from engineering, 27.5% from agriculture, 13.0% from public health and (10.1%) from computing. All disciplines were sampled from JKUAT and UON (which contributes to the high percentage of responses from the two institutions), while public health and engineering were sampled from MU, and public health, engineering and agriculture from KU (see sampling criteria in section 4.5). The lower participation from KU could be attributed to the fact that the disciplines are relatively newly established in the institution, thus relatively smaller departments and numbers of academic members of staff. Computing, being a relatively new

discipline as compared to the others had a smaller population of academic members of staff in most university departments, contributing to the lower percentage of responses.

Table 5.1 shows a summary of basic demographic, research work involvement and ICT support indicators for the participants. The 41-50 age bracket constitutes 30.7% of the respondents, 28.9% in the 31-40, 25.4% in the 51-60 and 7.5% in the 25-30 and over 60 categories. Males are 79% of the total respondents, 55% of the respondents have a PhD and 65% are involved in collaborative research projects.

<b>Variable</b>	<b>N</b>	<b>Mean</b>	<b>Mode</b>
<b><i>Personal Characteristics:</i></b>			
Age (25–30=1; 31-40=2; 41-50=3; 51-60=4; over 60=5)	228	2.96	3
Gender (1=Male, 0= Female)	247	.79	1
<b><i>Educational Background:</i></b>			
Has a PhD (1=Yes, 0=No)	225	.55	1
Where trained ( Africa=1, Developed country = 0)	211	.48	0
<b><i>Scientific Collaboration</i></b>			
Involvement in collaboration (1=Yes, 0=No)	248	.65	1
Current projects	149	1.80	1
Past projects (in 10 years)	145	2.43	2
<b><i>Publication productivity</i></b>			
Publications in the last 10 years	221	7.46	10
Coauthored publications	214	4.69	0
<b><i>ICT Availability and Use</i></b>			
Computer/laptop in work place (1=Yes, 0=No)	248	.81	1
Computer/laptop at home (1 = Yes, 0 = No)	248	.85	1
Internet connection at work place (1=Yes, 0=No)	248	.87	1
Internet connection at home (1=Yes, 0=No)	248	.51	1
Mobile phone (1=Yes, 0=No)	248	.89	1
Internet on mobile phone (1=Yes, 0=No)	248	.55	1
Level of skills (1=sophisticated, 2=more than basic but not sophisticated, 3=basic, 4= do not use computers)	235	1.94	2
Frequency of use of the internet in hours (1=0-5, 2=6-10, 3=11-20, 4=over 20, 5= not at all)	235	2.22	1

**Table 5.1 Summary of basic descriptive statistics**

The majority have access to basic ICTs, with over 80% having access to a computer or laptop at work or at home, mobile phone and internet connection at work place. However, a smaller percentage has internet connection at home (51%) and internet on mobile phone (55%). A majority (58.3%) of the respondents indicated having more than the basic skills



but not sophisticated in use of computers, while 24.3% see themselves as sophisticated users. Only 0.4% do not use computers.

### **5.3 ORGANISATION OF THE RESEARCH COMMUNITY**

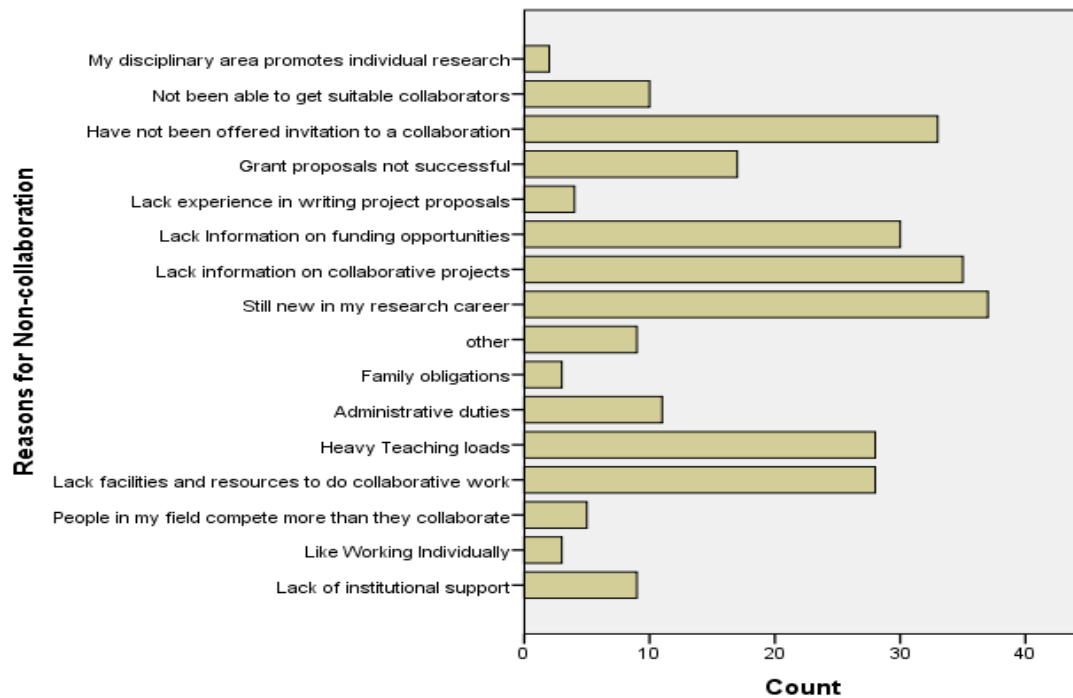
Question one (*how is the academic research community in Kenya organised?*) relates to the second objective (*to understand the basics and mechanisms of collaborative research in Kenya in terms of form, levels and processes involved in academic networking*). Towards meeting this objective, this section presents an analysis of data indicating levels of collaboration, structure of collaboration networks and indicators of the differences in levels and structures observed. SNA methods were used to give a broad overview of communication patterns within the community, with a major focus on ties within and across disciplines and institutions, as shall be seen in section 5.3.3.

#### **5.3.1 Collaboration levels**

The level of collaboration was generally measured by a question on whether or not one was or had been involved in any collaborative research project over a period of ten years. The degree of involvement in collaboration was measured through self-reported number of collaborative projects one had been involved in, both current and in the past ten years. Surprisingly, a relatively high number (51.6%) of the studied population was involved in collaborative research at the time of data collection while 64.9 % had been part of a research collaboration in the last ten years. This is in contrast to past studies that have indicated low levels of academic networking in Africa (Gaillard & Tullberg, 2001; Harle, 2007; Adams et al., 2010). However, this is largely dependent on the disciplinary area. A Chi-square test of association between disciplinary area and involvement in collaboration shows that there are significant differences in levels of collaboration between the different disciplinary areas ( $\chi^2 = 28.01$ ,  $p < .001$ ). Agriculture had the highest levels of collaboration, with 89.7% of those in agriculture responding *yes* to involvement in collaboration followed by public health (65.6%), computing (60%) and engineering (51.6%).

The mean number of current projects was 1.8 and positively skewed, meaning that most respondents had research projects less than the mean. 35.6% reported having been involved in one current collaborative research project, 23.5% in 2 and 18.1% in 3 projects, with less than 8% having been in more than 3. Similarly, 27.6%, 33.1% and 11.0% of respondents reported having been involved in 1, 2, and 3 or more collaborative research projects in the

past 10 years respectively. Therefore, though majority responded *yes* to involvement in collaborative research, the degree of involvement is at a relatively low level. For those responding *no* to involvement in collaborative research, reasons for non-involvement in collaborative research were captured using a multiple response question with 16 choices as shown in Figure 5.1. The most commonly cited reasons for not being involved in collaborative research were: being new



**Figure 5-1 Reasons for non involvement in research collaborations**

in research career; lack of information on collaborative projects; lack information on funding opportunities; lack of facilities and resources to do collaborative work; heavy teaching loads; and not having been offered an invitation to a collaboration, as shown in Figure 5.1.

### 5.3.2 Differences in collaboration across some categories

Differences in collaboration rates were tested across categories of disciplinary areas, institutions, gender, age, academic qualification and region of study to see how they applied in the case of the sampled population. Using data derived from the survey on self-reported

level of collaboration<sup>15</sup>, a Kruskal Wallis test<sup>16</sup> revealed significant differences in the distribution of number of current research projects across disciplines ( $\chi^2 = 18.57$ ,  $p < .001$ ), academic qualification ( $\chi^2 = 4.29$ ,  $p < .05$ ), and region where last degree was attained ( $\chi^2 = 4.75$ ,  $p < .05$ ). Participants in agricultural field had highest mean number of collaborative research projects (2.38), while those from public health had the least (1.14). Engineering had a mean of 1.50 and computing 1.62. Collecting data from those in public health presented special challenges, with a number of them not willing to disclose details of their collaborations. This could probably be attributed to the ‘secretive nature’ of the discipline, and perhaps contributed to the recorded low level of collaboration. Those with a PhD had a higher mean number of current research projects (1.98) as compared to those without (1.39). Those who studied in a developed country had a mean number of 2.12 current collaborative research projects, while those who studied in Africa had a mean number of 1.50 current projects. However, the same test is not significant for distribution of current research projects across institutions, though significant for past projects ( $\chi^2 = 10.10$ ,  $p < .05$ ). This could be an indication that more institutions are getting into collaborative research, or there is more of cross institutional research, thus diminishing differences between institutions. No significant differences are observed in level of collaboration across age group and gender categories.

### **5.3.3 Patterns of communication within disciplinary areas and institutions**

A social network analysis software, UCINET 6, using data on collaborative ties derived from section E of the questionnaire (see Appendix 3), was used to visualise the structure of the collaboration networks formed. The nodes represent individual researchers, their different shapes and colours represent the different disciplines or institutions to which they are affiliated. To maintain anonymity of individual researchers, the nodes are not labeled. A collaborative tie is represented by an arrow joining two nodes. The direction of the arrow shows who indicated they collaborated with whom, though the relationship is mutual, given the definition of collaboration employed in this study.

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<sup>15</sup> The respondents were asked to state the number of collaborative research projects they are currently actively involved in, and those they have been part of in the last ten years.

<sup>16</sup> A Kruskal Wallis test is a non-parametric test used to test for differences between groups in an independent variable if the dependent variable is not normally distributed (in this case is positively skewed) or is ordinal.

Figure 5.2 shows ties within agriculture. The different shapes and colours of the nodes represent the different institutions to which the participants are affiliated. The network diagram reflects agriculture, which has the highest rate of collaboration (see Table 5.13), as having a more connected network as compared to engineering (Figure 5.3), public health (Figure 5.4) and computing (Figure 5.5). More ties are observed between individuals from the same institution, though a number bridge between institutions contributing to the level of connectedness in the network. The network seems dominated by researchers from two institutions, the University of Nairobi and JKUAT, a reflection of the level of establishment of the discipline within the two institutions out of the four sampled for the study. The level of connectivity for individual researchers differ. Some individuals display a higher level of degree centrality, defined in Borgatti (2005) as the number of direct connections a node has, a possible reflection of their level of activity and status in the network.

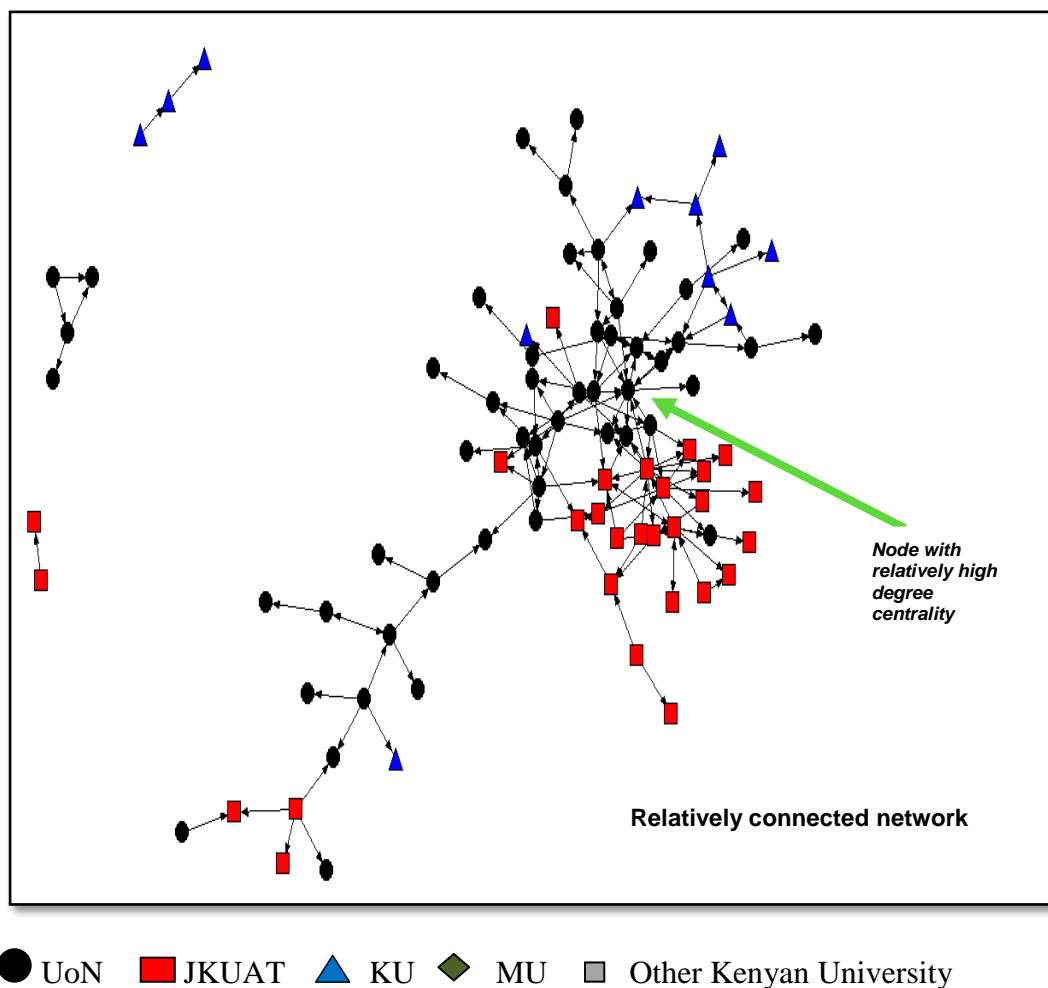
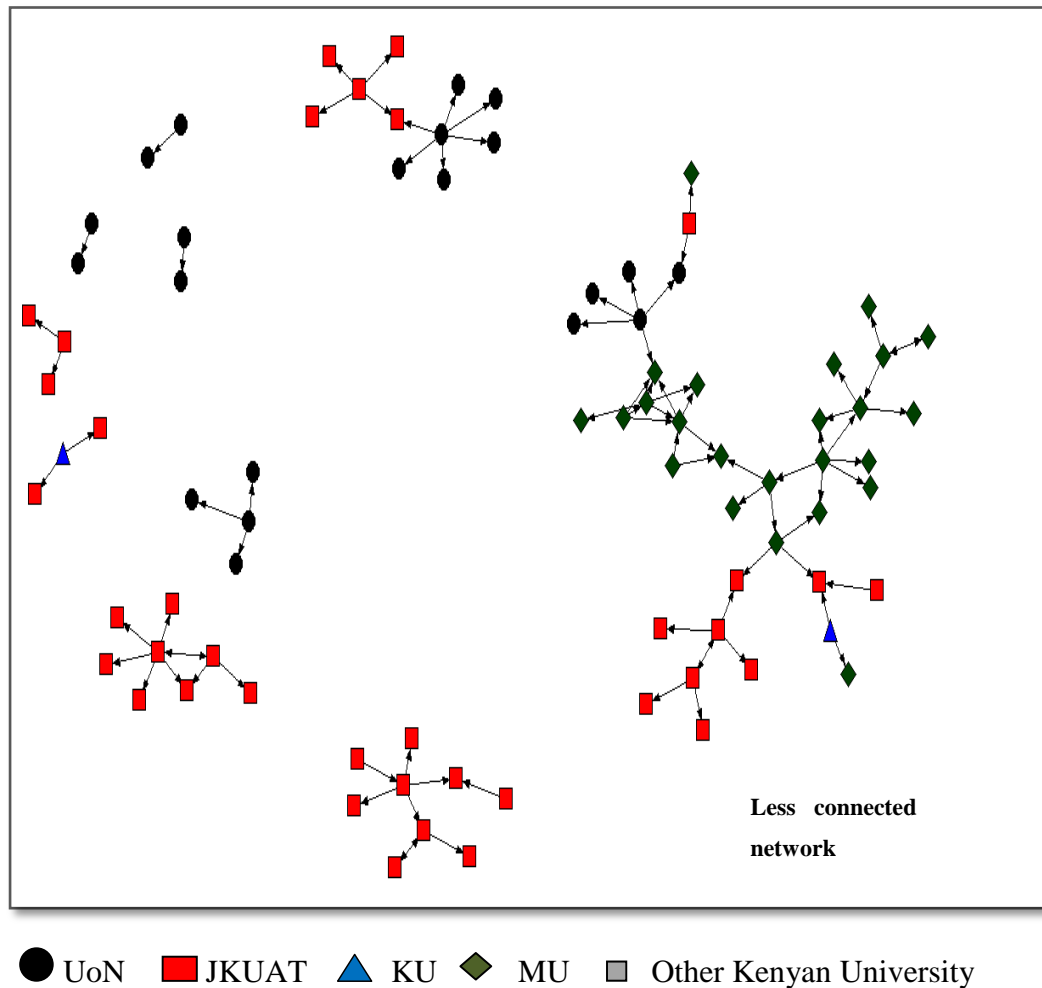


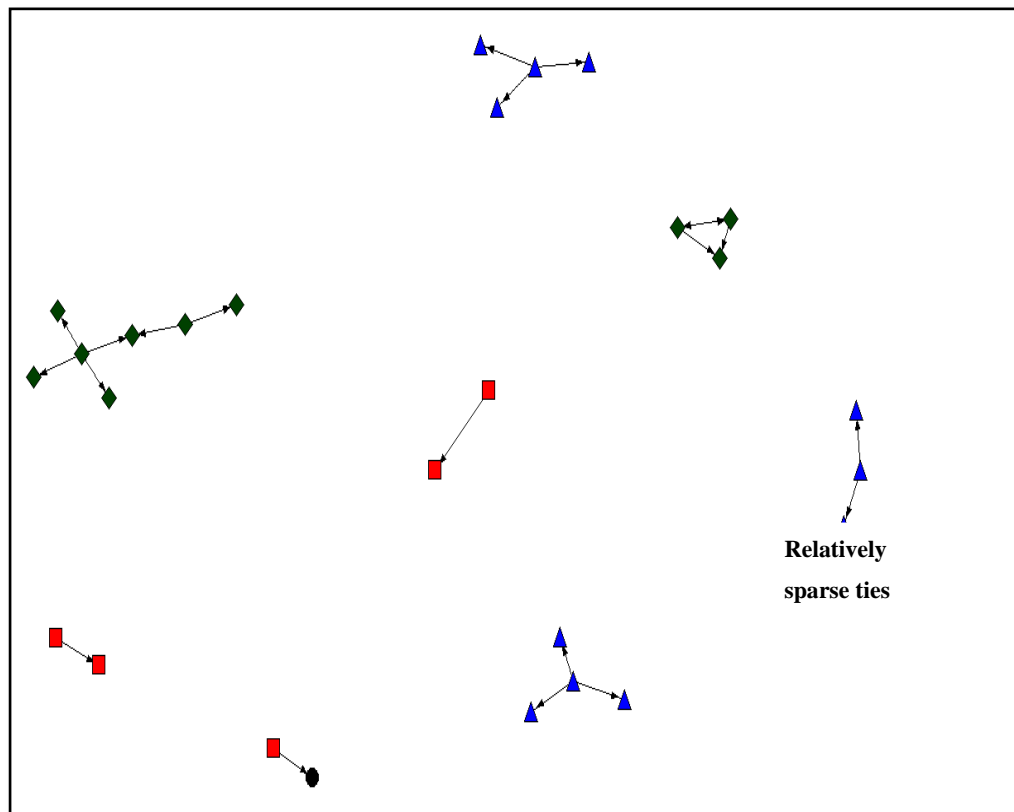
Figure 5-2 Ties within Agriculture

Engineering reflects a less connected network, as compared to agriculture (see Figure 5.3). Even though relatively well established in three out of the four studied institutions, fewer individuals bridge across institutions in comparison to agriculture. Like agriculture, the network reflects some individuals with relatively high degree centrality, though most ties are within an institution.



**Figure 5-3 Ties within Engineering**

Public health reveals even more disconnected ties within the study participants (Figure 5.4). However, it is interesting to note that individuals in public health, though displaying few ties within themselves, have quite a number of connections with the *others* category, as can be seen in Figure 5.6. Those grouped under others could be those in a disciplinary area

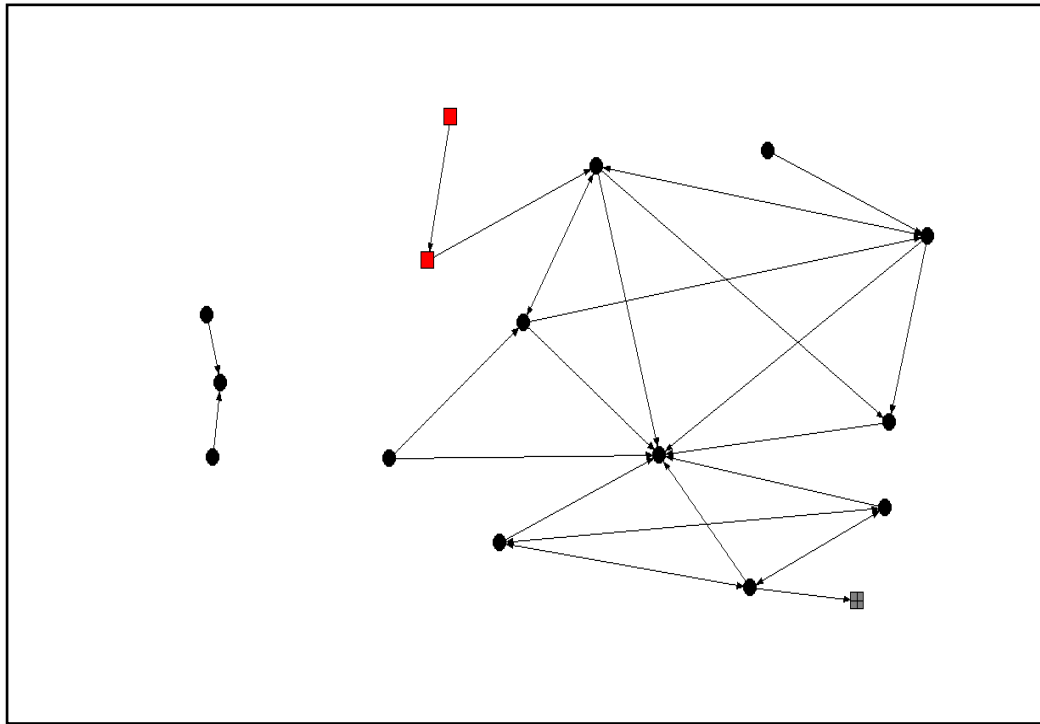


● UoN   ■ JKUAT   ▲ KU   ◆ MU   ■ Other Kenyan University

**Figure 5-4 Ties within Public Health**

not part of the sample, though part of academic community or those not part of the academic community.

Computing exhibits a relatively connected network (Figure 5.5). However, it is interesting to note that collaborations in computing are dominated by researchers from one university, with only two links to a different university. This possibly reflects the level of establishment of the discipline in this particular university, in comparison to the other sampled universities. It was observed that most trained researchers in computing were based in this university, likely to have an effect on their levels of research activity and thus structure of the networks formed. One of the other sampled universities, though having a computing department had no member of staff holding a PhD, and little research was going on in the department. A participant from computing attributed the limited collaborative work in the discipline to the fact that the discipline is relatively newly established in Kenyan universities:



● UoN   ■ JKUAT   ▲ KU   ◆ MU   ■ Other Kenyan University

**Figure 5-5 Ties within Computing**

Computing research is still not very well structured. Even research areas sometimes are still not very well structured, like for example, some of the things I am doing simulations and thermo-smart systems, it's very hard to tell you who else is doing that around here so that I collaborate with him or her. So it's still not very well structured since this is an area that is fairly green in this part of the world... [COM\_1]

The network diagrams above reveal that more ties are within members from the same institution. The low collaboration with individuals from other academic institutions was partly attributed to competition and some individuals wanting to dominate a certain field, making them not seek collaborations with others from what they see as competitors or 'inferior' institutions. A participant from computing observed that:

There is some misconceived competition going on even among faculty... and some misguided sense of pride with regard to certain faculty, that they think they are the mothers of that discipline so then we are the ones who had this discipline first then it moved to KU or where else. Like good example could be, look at even medicine, there is no collaboration between the health science here and maybe the health science in KU. And yet we are training the same people and students. There is some competition, so to say. (COM\_3)

Figure 5.6 shows ties between participants grouped by disciplinary areas. A noticeable number of interdisciplinary collaborations are observed, especially between agriculture and engineering. This could be an implication of the interrelated nature of research between the two disciplines, though it is evident that the two constitute majority of the respondents. All disciplines display a number of ties with members outside the sample, grouped in figure 5.6 as others. These could be individuals belonging to other disciplinary areas, or those outside of academic research.

A network diagram of collaboration patterns between institutions (Figure 5.7) reveals that quite a high number of participants have connections outside the academic research community. The highest number of ties is observed with international organisations (O\_IO), and other Kenyan research institutions (O\_KI) and organisations (O\_KO). Fewer ties are observed between the academic institutions. In one participant's view, universities choose to collaborate with organisations offering funding, each concentrating on where they will benefit in terms of end product and funding thus leaving little room for inter university collaboration:

... if for example Google is in partnership or is collaborating with JKUAT in the area of mobile application computing, and another multinational say yahoo is collaborating with Moi university in research about search engines. Now there's no way JKUAT is going to collaborate with Moi, because Moi is focusing on where they are getting the funds and they want to deliver that product, JKUAT is also committed to Google and they want to deliver that product. So this leaves very little room for collaboration between JKUAT and Moi [COM\_2]

This claim is supported by data from the quantitative survey, which indicates that 65% of research projects the participants are involved in are funded by international organisations (see Table 5.5). Another participant observes that less collaboration between academic institutions was due to competition, each wanting to outshine the other:

local universities are making lots of MOUs with institutions outside and very far who don't seem to be a threat to them, and not within themselves [ENG\_1]

..here we are still competing and perhaps even from upstairs there is still competition with - the structure is that we have to compete with KU, compete with Jomo Kenyatta... [COM\_3]



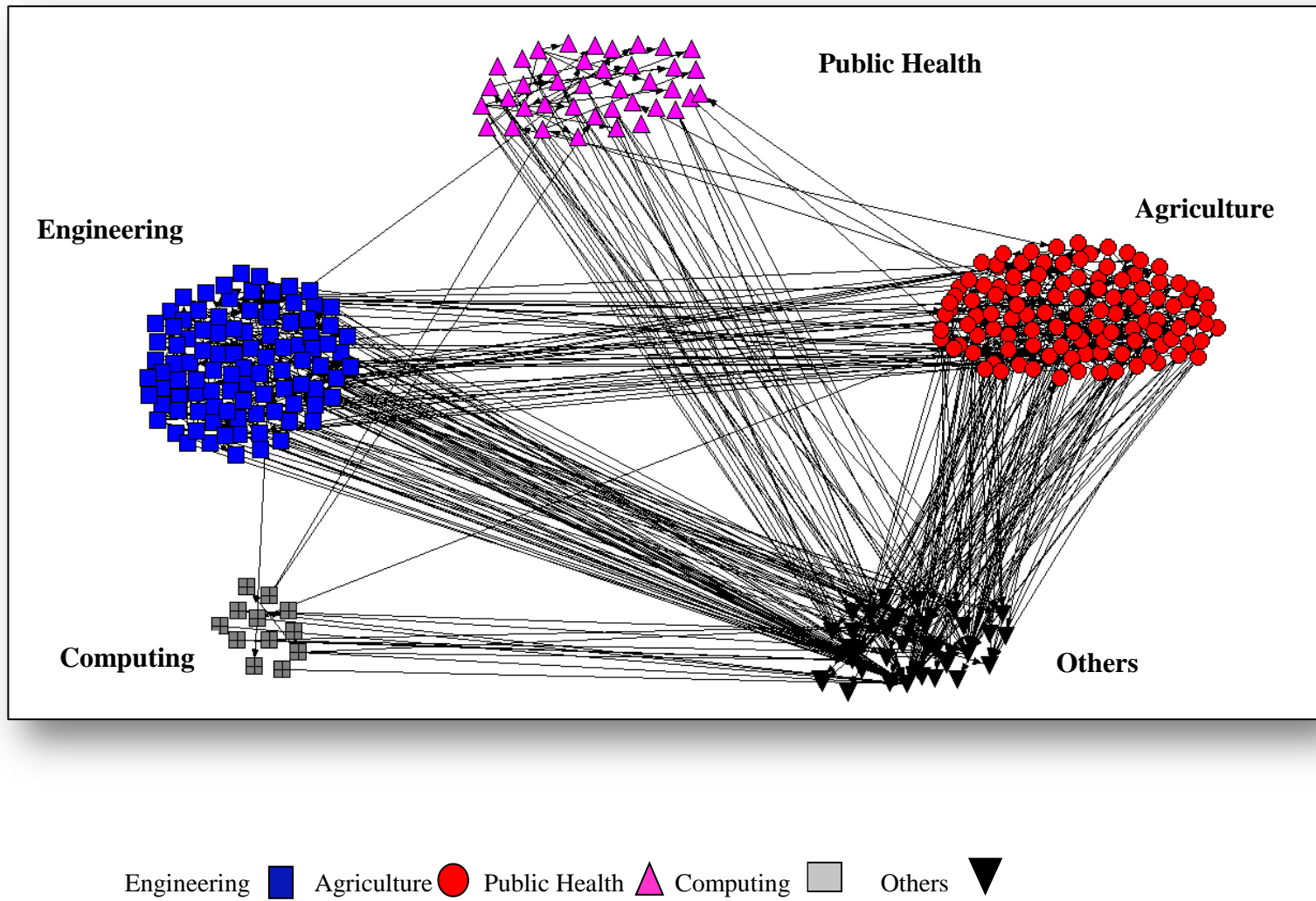


Figure 5-6 Ties between disciplines

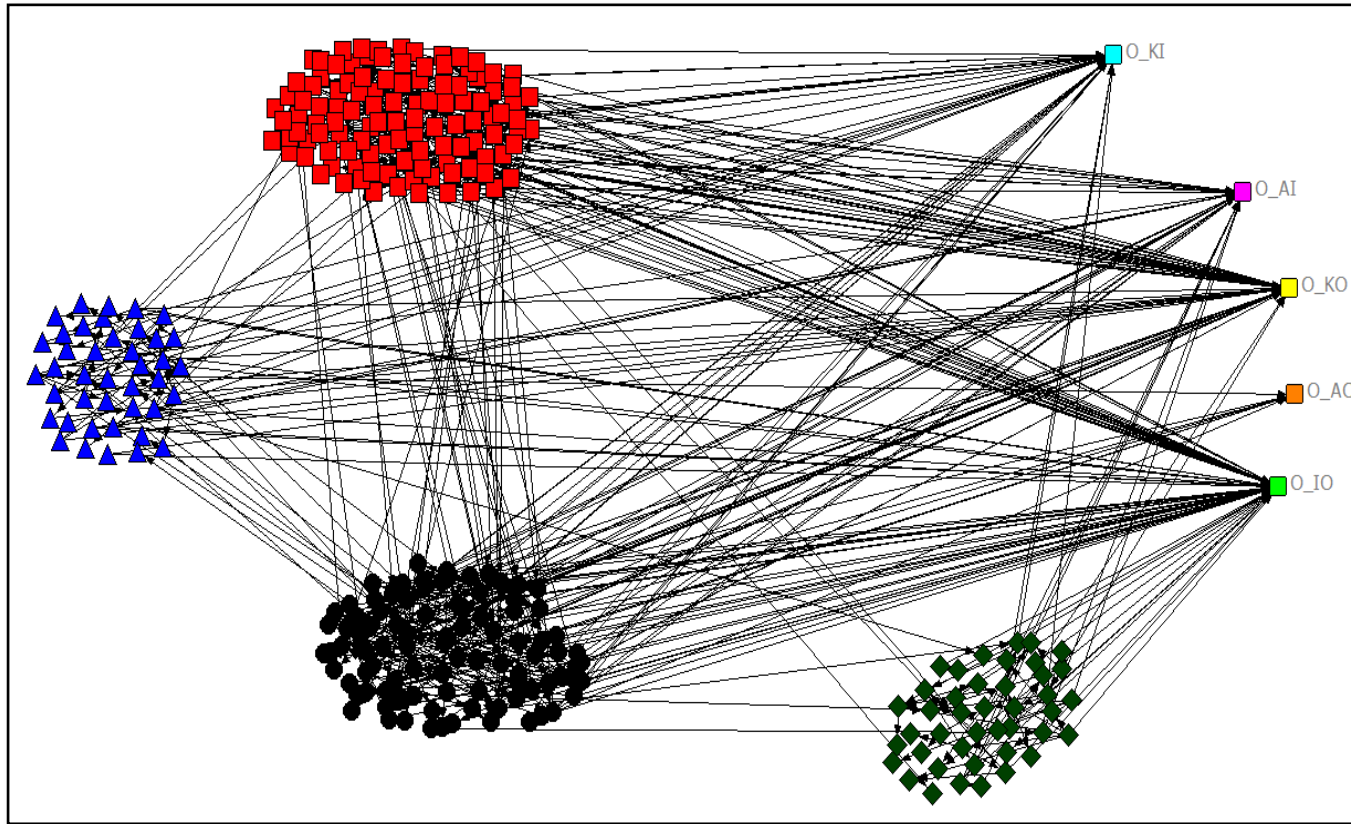
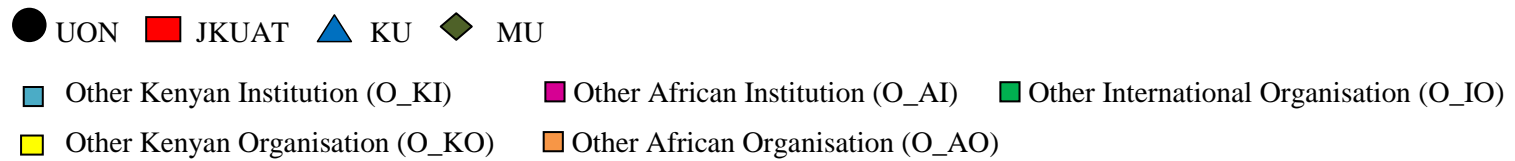


Figure 5-7 Ties between institutions



The universities lack a common research platform from where problems /common activities that call for involvement of researchers from the different universities, addressing research themes that are of interest to all would encourage the inter-university collaboration. NCST is doing a commendable job as a starting point by funding research that is multidisciplinary and cross institutional, but participants felt that they need to go a step further and identify themes, and make calls that push universities to work together. Some international organisations and funding bodies are also keen on encouraging cross-institutional collaborations by funding only projects across institutions as indicated by the following participant:

I happen to have been involved in assessment of some of the research concepts for KARI, and in KARI, there is some funding for research. So you find there will be certain themes of interest, but that theme, you cannot win alone as an institution unless you collaborate with other people, so that if you all come from JKUAT, even if you are coming from different departments, you don't do it because we like to see you working with the community (ENG\_3)

#### **5.4 FACTORS CONTRIBUTING TO INVOLVEMENT IN AND LEVEL OF COLLABORATION**

The structure and form of collaboration for academic research community in Kenya has been presented in section 5.3 above. In identifying factors that contribute to the form of organisation, this section begins by presenting an analysis of the variables that can be used as predictors of whether one is in a collaboration or not against the measure of involvement in collaboration<sup>17</sup> in section 5.4.1. This is followed by a modeling of the effects or the weight of each of the significant variables in determining involvement in a collaboration, using logistic regression, to determine those that have most impact. This is followed by an analysis of motivation for collaboration (section 5.4.2), to help understand what is important in seeking collaborations for the studied group, and problems experienced (section 5.4.3), thus give more understanding of the form and conduct of collaborative research. The quantitative analysis results are supplemented by data from the participants' views in the interviews. The data presented in this section is towards answering question two, *what are the factors contributing to the form of organisation of academic research*

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<sup>17</sup> Involvement in collaboration was measured by the question 'Have you been involved in any collaborative research project(s) in the last 10 years?' with the answer choices as Yes or No.

*collaborations in Kenya?*, that relates to the third objective, *To analyse factors affecting the levels, structure and conduct of academic research collaborations in Kenya.*

#### **5.4.1 Predictors of collaboration**

Cross tabulation and Chi-square tests were done to establish the association between involvement in collaboration and a number of categorical variables identified in literature as affecting collaborative research. These include disciplinary area; institutional affiliation; nature of the area of specialisation (experimental and applied fields have been associated with more collaboration than theoretical fields); personal factors such as age, academic qualification and the country where highest degree was attained (developed vs. undeveloped country); and publication productivity. The Chi-square tests of association were significant for disciplinary area ( $\chi^2= 28.010$ ,  $p<.001$ ), nature of the area of specialisation ( $\chi^2 = 6.014$ ,  $p < .05$ ), academic qualification ( $\chi^2= 57.535$ ,  $p<.001$ ), publication productivity ( $\chi^2 =68.78$ ,  $p<.001$ ) and region where highest degree was attained ( $\chi^2= 7.014$ ,  $p = .008$ ). Thus these variables can be used as predictors of involvement or non-involvement in collaboration. Institutional affiliation, gender and age did not emerge as significant predictors of involvement in a collaboration for the studied group.

To model the effect of each of the significant factors in predicting collaboration, a logistic regression<sup>18</sup> using Forced Entry method was done, the dependent variable being involvement in collaboration. The logistic regression yielded the results presented in Table 5.2. The predictor variables are taken to be significant at  $P<.05$ <sup>19</sup>. In the table, the value B

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<sup>18</sup> Logistic Regression is used to model dichotomous outcome variables i.e used when the dependent variable is binary – in this case Yes or No to collaboration), as a function of given predictor variables, whether continuous or categorical, and can be used if the data is not normally distributed (Field, 2009), thus its choice in this case. Field (2009) advises use of factors that are known to have an effect on the dependent variable, from literature, as inputting too many insignificant variables into the model may have a great impact on the resulting model. However, if not sure of which variables to include, he advises on use of Forced Entry method of variables into the model, then repeating the regression with those that turn out to be significant (p. 225)

<sup>19</sup>  $P<.05$  means that the probability of obtaining the value of the test statistic by chance is less than .05. Generally, if  $P<.05$ , then the experimental hypothesis is accepted as true (Field, 2009)

<b>Variable</b>	<b>B</b>	<b>Wald</b>	<b>Exp(B)</b>
<i>Discipline</i>		9.581	
Engineering(1)	-1.430**	6.836	.239
Public Health (2)	-.448	.427	.639
Computing(3)	-.556	.607	.573
<i>Nature of Area of Specialisation</i>		5.365	
Experimental(1)	1.957*	4.181	7.080
Theoretical = Applied / Experimental(2)	.370	.112	1.448
Applied(3)	.549	2.117	1.732
Academic Qualification(1)	1.398***	10.515	4.047
Study Region(1)	.311	.687	1.364
Publications	.133**	6.830	1.142
Constant	-.491	.618	.612

**Table 5.2 Variables in the model for predicting involvement in collaboration**

P<.05\*, P<.01\*\*, P<.001\*\*\*

R<sup>2</sup> = .438(Nagelkerke); Model  $\chi^2 = 78.873$ , P<.001

represents the change in the logit<sup>20</sup> of the outcome variable associated with a unit change in the predictor variable (Field, 2009). That is, it measures each predictor's partial contribution to variations in the outcome. The value of the Wald statistic indicates the unique contribution of each predictor in determining the outcome. The greater its value the more the weight of predictor. The Exp (B), referred to as the odds ratio, provides for an easier interpretation of the regression coefficients. Similar to B value in functionality, an odds ratio greater than 1 indicates that an increase in predictor value results in the odds of the outcome occurring increasing, while 'a value less than 1 indicates that as the predictor increases, the odds of the outcome occurring decrease' (Field 2009, p.289).

The odds ratio for academic qualification (b = 1.398, p<.001) which is 4.047 as seen in Table 5.2 indicates that the odds of being involved in a collaboration for one with a PhD are approximately 4 times the odds for those without. Discipline (using agriculture as the reference category) and nature of the area of specialisation (using theoretical field as the reference category) were dummy coded. Only engineering was significant less the agriculture category under disciplines, while only experimental field was significant under

<sup>20</sup> 'The logit of the outcome is simply the natural logarithm of the odds of it occurring' (Field 2009, p.286)

area of specialisation. The odds ratio for discipline 1, engineering ( $b = -1.430$ ,  $p < .01$ ) which is 0.239 indicates that the odds of being involved in a collaboration for one in engineering are 0.24 times the odds for one in agriculture i.e. for every one point increase in engineering, there is approximately 4 times odds of one in agriculture being involved in a collaboration. The odds ratio for publications ( $b = 0.133$ ,  $P < .01$ ) is 1.142, meaning the odds of being involved in a collaboration increase by a factor of 1.142 for a unit increase in publication. Those whose nature of the area of specialisation is experimental ( $b = 1.957$ ,  $P < .05$ ) are approximately 7 times more likely to be involved in research collaborations than those whose area is theoretical. Nagelkerke R Square gives estimates of the percentage of the dependent variable that can be accounted for by the included predictor variables (which is 43.8%). The model Chi-square ( $\chi^2 = 78.873$ ,  $P < .001$ ) is an indicator that the model with predictors is better than one without (Field 2009, p. 286).

The results of the logistic regression reflect that four variables investigated are most significant predictors of whether one is in a collaboration or not, disciplinary area (in this case agriculture and engineering, nature of the area of specialisation (in this case experimental), academic qualification (PhD holders) and publication productivity. Study region turned out not to be a significant predictor in the model.

#### **5.4.2 Motivation for collaboration**

It can be assumed that the reasons that lead people to collaborate can contribute to the number of collaborations they form or get involved in. Information on motivation for collaboration was captured in a question asking the respondents to indicate how important each of the given variables listed in Table 5.3 was in criteria of choice of a collaborator<sup>21</sup>. The mean importance of each of the variables in criteria of choice of collaborator is shown in Table 5.3, from most to least important. The results indicate sharing a common goal, knowledge and resources, and work ethics have most importance in criteria of choice of collaborator. Nationality and friendship are of less importance. The choice depends on personal preferences and need. A number of participants indicated that their collaborations involved working with students. This could be due to requirements of the collaboration

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<sup>21</sup> The responses were measured on a likert scale ranging from very important – important – a little important – not important – not applicable.

<b>Motivating factors</b>	<b>N</b>	<b>Mean</b>	<b>Std. Deviation</b>
Sharing a common goal	147	1.34	.530
Collaborator has special skills and expertise	151	1.51	.729
Access to funding	149	1.70	.844
Strong work ethics	144	1.79	.835
Access to special equipment	147	1.95	.968
Institutional/organisational affiliation	151	2.01	.909
Strong reputation	147	2.03	.914
Value of previous collaboration with person	148	2.13	1.133
Mentoring junior colleagues	152	2.21	.960
Friendship	144	3.21	1.010
Nationality	148	3.56	.984

**Table 5.3 Criteria of choice of collaborator**

/sponsors, or part of supervisory role defined by their departments. Others simply prefer to engage students within their own research for personal reasons. Such is a participant who felt students have more flexibility and commitment to accomplishing tasks as compared to colleagues:

I have very little success working with faculty members. It's usually easier to work with students. PhD students or masters students. Faculty members can get very complicated. Like UoN has a linguistic department - they are quite a number, I only succeeded in working with one lady, but even then she is so busy still a little bit difficult to work with even when you have something to do with her it really takes a lot of effort.(COM\_3)

The nature of the problems addressed by today's kind of research calls for collaborative effort, which in the view of one agriculturalist, an individual or single department may not have the expertise, capability and capacity to address the problem:

.. In our work on iron and zinc concentration, when people eat beans for example, you know one of the reasons you want to eat is to get the iron and zinc from beans, so one of the big questions was, how effective the human body is in extracting the nutrients from the beans. We can produce the grain, but some other people need to monitor, what happens to that grain when it gets into the human body, so we had to collaborate with KEMRI, in Kenyatta hospital, because they are the ones who have the expertise of feeding and taking blood samples and that kind of thing to track the uptake of the nutrients, so you see now those are two different types of expertise. The other thing is an example still coming from the iron and zinc work, is that... for example if we are analyzing bean samples, we can only do maybe, probably our capacities maybe 2000 or 3000 samples a year, but sometimes we have more than 10000 samples to do, so you need people with automated systems which are very expensive, in that case we can work with people in other countries – to send samples to them to analyse, and they give you their response (AGR\_2)

A participant from public health described some options for gaining access to special equipment:

Depending on the study that you want some equipment are very expensive. Think – an example of a PCR or machine like that, these are very expensive things, so you find only isolated people have them. Now, two things do happen, you can either incorporate a member who has access to that into your research, so that when there's need for you to use that equipment, there is no problem. The other one is just to request - at least we have done this a few times – that please, we have this material, which we want to examine, or some material we want to process using your PCR machine... (PH\_2)

The credibility of a person, work ethics, interest, commitment, value of contribution and right chemistry were mentioned as important in the choice of a collaborator. The problem of dealing with people was emphasised in the interviews, especially for early career researchers who had not been around long enough to identify the kind of people they could team up with from past experience. The importance of trustworthiness and work ethics and commitment was stressed:

Sometimes you look at the CV of who are working with...the credentials, yes, truthfulness, because when you are doing a research that is problem solving, you really want to get the actual result, not a cooked result. So it's not just the result, and of course as we say not just anybody. That's one, the degree of perfection. There are also people who put you on the program, because they want to use you. To get money, they have been told that they have to collaborate with someone. So I always ask ... what is the background of this? So when I hear that you have been told that you must have a collaborator then I know here someone is just coming in because he has been told by the financier that he must have this, so at the end of the story they may end up not even talking to one another (PH\_2)

At times, one really has no choice over whom to collaborate with. Sometimes the head of the department or school may be called upon to appoint individuals to join a research team. This may not guarantee personal compatibility, an important ingredient for success in collaborative research, as exemplified by a participant:

.. some collaborations, particularly some of these donor funded projects, where you are forced to be bedfellows, and it's not always guaranteed that the chemistry will be there. Sometimes it could be a funded project for instance and so what happens is that you simply get a letter on your desk telling you Petronilla, now you have been nominated to represent this faculty in this new collaboration, then you find yourself in a meeting and you well, without intent you find you just can't get out (COM\_3)



### 5.4.3 Problems in collaboration

Problems experienced in research could have an adverse effect on the level and nature of collaboration. Table 5.4 presents descriptive statistics of problems in a collaboration<sup>22</sup>, presented in order of magnitude of problem.

<b>Problem Dimension</b>	<b>Mean</b>	<b>Median</b>	<b>Mode</b>
Ease of getting funding	1.96	2.00	1
Amount of funding	2.02	2.00	2
Availability and access to special equipment	2.17	2.00	2
Availability of time to commit to research	2.34	2.00	2
Administration of the funding	2.60	3.00	3
Timely delivery of results	2.60	3.00	2
Coordination of member's activities	2.91	3.00	3
Leadership and control	3.10	3.00	3
Availability of skilled personnel	3.17	3.00	4
Information security	3.26	3.00	4
Authorship inclusion and order	3.31	4.00	4
Defining roles	3.32	3.00	4
Diverse disciplinary training of collaborators	3.32	4.00	4
Selection of a publication forum	3.32	3.00	3
Scientific competition	3.49	4.00	4
Resolving conflicts	3.52	4.00	4
Cultural differences	3.68	4.00	4

**Table 5.4 Descriptive statistics of problems in a collaboration**

The statistics above indicate major problems in funding, access to special equipment and availability of time to commit to research. A factor analysis using Varimax Rotation of the 17 problem areas within collaborations listed in Table 5.4 extracted three factor dimensions (see detailed factor analysis in Appendix 5). Problems that loaded under first factor dimension were diverse disciplinary training of collaborators, cultural differences, resolving conflicts, scientific competition, information security, authorship inclusion and order, and selection of a publication forum. Those that loaded onto second factor dimension were coordination of member's activities, timely delivery of results, defining roles, availability of time to commit to research, leadership and control, availability of skilled personnel and administration of funding. Those that loaded onto third factor dimension were ease of getting funding, amount of funding and availability and access to special

<sup>22</sup> The problems areas as listed in Table 5.4 were measured on a likert scale ranging from 1-5, whereby 1= major problem, 2 = problem, 3 = minor problem, 4 = not a problem, 5 = N/A,

equipment. Emerging themes from the three factor dimensions seem to address the following areas:

- Factor 1 = Socio cultural factors
- Factor 2 = Management and control
- Factor 3= Availability of Resources

The factor scores associated with each dimension were used to assess the relationship between problems in the collaboration and rate of collaboration, internet use and productivity (discussed further in sections 5.5 and 5.6). A correlation of the factor scores produced with number of collaborative projects was only significant for the third factor score, availability of resources ( $r = .149$ ,  $p = .05$ ). This implies that a decrease in the problem of availability to resources<sup>23</sup> (in this case ease of getting funding, amount of funding and availability and access to special equipment and facilities) leads to an increase in collaboration. The correlation was insignificant for publication productivity. There was a negative, though weak (hence non-significant) correlation between factor score dimension one (socio cultural problems) and two (management and control) and number of research projects and productivity, meaning those in more research projects experience more problems of each kind. The data on problems identified above was supported extensively in the qualitative survey, discussed further below.

## **Funding**

The descriptive statistics in Table 5.4 above indicate that funding for research is one of the major problems experienced by the group under study, a finding echoed by a number of participants in the qualitative survey. Some attributed this to lack of commitment on the government's side to increase research budgets, thus much reliance on donor support:

... one of the most serious problem is funding. Collaboration is not just the science of what you want to do, those will become just dreams if you have nobody to support your work ... the biggest problem so far is that investment within the country for research has been minimal. For years and years we have had to depend on donors to support our research. I think that's a challenge, a very big challenge... (AGR\_2)

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<sup>23</sup> With the coding used, the bigger the score the less the magnitude of the problem

The observation on reliance on donor support is supported by results of the quantitative study presented in Table 5.5. Data provided by the respondents indicates 64.8% of the funded projects are funded by international organisations, 14.8% by own institution while the Government funds 17.6% .

Project funder	Frequency	Valid Percent	Cumulative Percent
My institution	16	14.8	14.8
Government organisation in Kenya	19	17.6	32.4
NGO in Kenya	2	1.9	34.3
International organisation	70	64.8	99.1
Other	1	0.9	100.0
Total	108	100.0	

**Table 5.5 Research funding in Kenya**

Some felt that the funding mechanisms favored some disciplines, an observation that others disagreed with, attributing funding availability to writing of relevant and convincing research proposals. Where a certain research project is funded, the issue of insufficient funds to complete a project was also raised, with one participant blaming this on poor proposal review processes:

More often than not, you find the challenge is, maybe because of lack of expertise, the people who review proposals maybe don't really understand what needs to be done. Like they can say they want something on value addition. But since they think value addition is you go make juice or jam, but they really don't know what it entails to put a juice on the shelf of supermarkets. There are so many costs involved that unless you are a food scientist, you may not really get. So you find that they don't know - they don't understand why you need a lot of money. So they chop the budget (AGR\_1)

Proposal writing and review takes time, and sometimes there is variation in the international money markets and exchange rates, and inflation rates go high. In the eyes of one participant, this could affect the price of equipment, and lead to a previous correctly stated budget going short. To minimise the shortfall of funds, one participant advised on the need for drawing an initial correct budget, by doing a feasibility study of the much that can be accomplished with the funds offered before committing to do it. Participants called on universities to increase their research budget, because, in the view of some participants, the manpower is available, but lack tools (funding) to do the job:

... researchers are there, very good quality researchers, like the universities, more than anything else represent a huge pool of really top quality scientists, and it's

both biophysical and social sciences, but the challenge is to use this enormous national resource, because people are willing, it is a part and parcel of the mandate of all public universities, but where's the money? (AGR\_2)

... only 3% of the overall budget goes to research. As a university you need to grow but they assume people are writing proposals and sourcing outside (PH\_1)

### **Access to special equipment**

Access to special equipment, emerged as one of the important factors in choice of collaborator and was indicated as one of the major challenges in collaborative research. The problems are not only in acquiring the equipment, but also in the processes involved in gaining access to equipment in other institutions. One participant expressed frustrations at the rigid bureaucratic processes involved in allowing collaborators from outside to use a particular university's equipment. This was also noted as a problem in some research organisations.

I have to go and seek a lot of approvals yet it is a research that we are doing together. The fact that I am allowed or given the mandate to carry research and I am allowed to incorporate any person I think should just be a straight forward thing - that I want to work with this person...let's work with him then whatever equipment facilities are here they should be available to this person am working with (ENG\_1)

some institutions are closed - they don't want outsiders to use their equipment for example KARI in some areas ... they don't want people to go there and use their equipment, unless you give them money to do it for you, or they become your collaborators (AGR\_3)

Some participants expressed more desire to collaborate with people who have access to the equipment from institutions with less stringent rules and processes on access, to avoid such problems. The NCST is trying to address the problem by acquiring facilities that are shared by a number of institutions in the region, through their acquisition of facility grant (NCST, 2012). However, some participants cited problems in logistics of access (the distance one has to travel) and use (sometimes the demand may be quite high) of such equipment.

### **Time for research**

Availability of time to do research emerged a major problem in the quantitative survey. A number of participants cited heavy teaching loads as leaving them little time for research. A participant observed that 'although in the university they say your assignment is research,

teaching and service provision, you may find that teaching takes a lot more than any of these other, and some people might not have time to give to research' (PH\_3). Another expressed the frustrations of being assigned administrative duties in a public university:

As you graduate you feel successful, the next thing they do they give you an office. You have been trained to become a researcher only to end up becoming the head of the department or the chairman. I don't think that was the plan, to be bogged down by administrative duties. That doesn't help - if anything it makes life very difficult. Like I can see my boss is always in ad hoc meetings and if he doesn't go he gets a very bad review. Being a head of department in these public universities is just a nightmare. And you get co-opted into all this committee for this, committee for that, ISO committee...things you don't need, so there's hardly time for research (COM\_3)

### **Diverse disciplinary training**

Though diverse disciplinary training scored lowly on being a problem within a collaboration in the quantitative survey, some participants in the interviews were of the view that differences in the cultures of disciplines can be a challenge in collaborative relationships. The individuals involved would need to learn how to deal with them:

... communication across disciplines is usually a problem ...we have to deal with that challenge first ... it isn't easy, because the way an engineer will define success will be different from the economist, will be different from the doctor – so we have to learn how to listen to each other, we have to learn how to get to know what other people's definition of issues are (PH\_3)

A participant observed the need to instill an aspect of multidisciplinary at an early stage in the undergraduate programs, for people to 'appreciate that you need somebody from a field other than your own to be able to become credible in your research and also for your output to be much more valuable' (COM\_2). This need is exemplified by the following sentiments from a computer scientist:

Everybody has their strengths and for us to build something or to understand our world we need to look at it together and indeed it makes a lot of difference. For example, when we have computer science students alone and one other discipline alone and we give them a challenge people go out in all sorts of direction. Computer scientists I must say are very difficult people to deal with - sometimes they look at things from very technology point of view. So we had those groups doing the worst. But when they work with others, they are able to look at the problem in a specific more focused way as opposed to looking at the technology first then looking at the problem (COM\_3)

## **Personal differences**

Lack of commitment, trust, chemistry, adherence to research ethics, timely delivery of results and different schedules were some of the issues pointed out in the qualitative survey as presenting challenges for collaborative research. Some of the participants were of the opinion that some people look at collaborations in terms of the gains, not the value they will be adding to the project and the much they have to put in for it to be a success. Thus when things do not turn out to their expectations, they may end up jeopardising the flow of the project. One participant, for instance, gave an example of problems of working with partners in the private sector:

.. some people may not really be genuine. A case in point is a project where we involved the private sector, working with some producers. So you see the mindset of producers is to make money at any cost. So you find sometimes that kind of compromises quality. You find that what they do is not really what is supposed to be done. But since for them they are not accountable to anyone - it's not like us - in the university setting, I need to give progress reports to the university. For them they don't have to account to anyone. So they can easily do things that are not supposed to be done and they get away with it. So you find that like when you tell them, it's like they sometimes they don't take it positively (AGR\_1)

Research was pointed out as not being very rewarding financially, therefore some opted for easier and quicker ways of getting money:

It takes long to get these collaborations working. For example it took us as a university long to get Google into some kind of collaboration with the university. And even then the conditions that comes with these collaborations they are so tight that you don't see yourself benefiting substantially or benefiting significantly as an individual from that kind of partnership or rather collaboration. So what you do you say let me go and teach part time somewhere else, make my money because I have my financial obligations to fulfill (COM\_2)

Cases of lack of accountability and transparency as regards research funds were cited whereby some individuals put project money into personal use, which usually resulted in conflicts, delayed schedules or non-accomplishment of project tasks and objectives.

### ***Other problems identified from the interviews***

In addition to the problems investigated in the quantitative survey that were supported by qualitative interviews as discussed above, a number of other challenges emerged in the interviews with regard to the process of collaborative research, as discussed below.

## Poor proposal writing skills

Some participants were of the opinion that the problem of funding could partly be overcome by writing good, relevant and convincing proposals. However, it was pointed out that many researchers lack proposal writing skills. Some expressed the desire to have universities support researchers in the proposal writing process:

I have seen an institution whereby, let's say there's a call for proposals...then universities internally say all proposals - all people or researchers who want to submit to that call should submit at least four weeks before that deadline. Then they moderate those proposals internally and they really enrich them. If that is done, you find that you are able to get more ideas than what you have and that really beefs up the proposal such that when it's submitted, it's much better. Your chances of winning a grant is just more than when you write it and submit it on your own (AGR\_1)

Some participants faulted the proposal review processes for government funded research, which at times are seen as not very transparent. Lack of feedback on submitted proposals is viewed as demoralising to the researcher, with a participant citing the need to be aware of the aspects that made it not be accepted so as to try and improve on them

One time we challenged National Council for Science and Technology, what they do is they advertise a call for proposals. People submit, you don't get any comments. You don't know why it wasn't funded; you don't know what was really wrong with it. So we challenged them ... I told them surely, if these things are truly going to reviewers, there must be some form of report. And it's only worth to tell someone that well, your proposal was not funded because of 1, 2, and 3, so you know ... was I really off or this is a proposal that I can improve and submit again? Proposal writing is really an effort. So when you don't receive any comment, or receive these general comments that we received so many applicants, you are one of those who were not funded ... (laughs) it really doesn't help. Well, they said they were really going to improve and be sending people comments but they still don't do that. I am comparing that because I have also tried applying for funds outside the country. Outside the country the good thing is you'll definitely get comments (AGR\_1)

Ensuring a transparent proposal review process would minimise incidences of unethical conduct like described by the participant below:

I know somebody... you submit a proposal to xx then you are told it cannot be funded. Then a few months later, you find somebody with the same proposal. Then you wonder but surely there's no way these people could have been thinking the same and writing the same as me. They definitely maybe had access....and see it's now very hard for you to prove that it was your idea (AGR\_1)

## **IP right issues**

Some participants expressed concern over IP right issues, an area that some participants felt is not well addressed and understood in Kenya. In university industry collaborations, issues come up on ownership of the final product, and some researchers expressed dissatisfaction at the gains or recognition they got after putting much effort in realisation of the final product. For example, according to the JKUAT IP policy, innovators get 30% of net royalty income accruing from an innovation made with university support. The university owns all IP over innovations developed by any member of the university, or innovated as a result of participating in university programmes, support facilities or by funds channeled through the university (JKUAT IP Policy). Some researchers feel dissatisfied with the conditions in such policies:

If am involved in some collaboration, say whose ultimate aim is to produce a software system, and we are so many of us and I come up with this excellent idea within that framework of collaboration- how do I stand to benefit from this excellent idea?.. Maybe all that I get is 1000 dollars or 2000 dollars for that innovation, that's it! Yet my solution is worth millions of dollars. So I would shy off from getting into these collaborations, instead I would go and get like-minded people from a company, make sure I patent my systems I have copyrights to it and I stand to gain more as opposed to taking part in such an endeavor (COM\_2)

Academic dishonesty was pointed out a vice that was common with academic researchers whereby some individuals wanted to claim all credit for jointly done work, as pointed out by a participant:.

Very often some people want the credit and disregard their partners, that definitely happens and we have had it here in Kenya, you know, maybe with the AIDS vaccine and that kind of thing ... people are just dishonest, you give them materials they say oh I want to do some trials with your materials, and before you know they are claiming your materials, and they don't want to recognise that in the first place they came from you (AGR\_2)

Or people not disclosing what they were to do with materials collected, though a participant noted that procedures involving handling and use of genetic materials had recently improved:

..some guys especially in the developed world would come and collect genetic materials here and don't disclose what exactly they are going to do with them. Take an example of the aloe vera, you see, people here didn't know its value - this is a plant that grows here in the wild in the dry areas, but the other guys knew. Now I



think there is an international treaty to govern those things. And of course everybody has learnt the hard way that if you are going to work on genetic material there is something called the study material transfer agreement, you don't send anybody materials any more, unless they sign they are going to abide by those regulations. And that is not only international, even at the national level. (AGR\_2)

A need for properly structured agreements between collaborators before embarking on the research was noted to avoid misunderstandings and conflict over ownership of IP. To illustrate this, a participant gave an example of a project that had to be put to a stop because the industrial collaborators and the university could not agree on the share of IP rights:

... the main problem was that after sometime we were told that we have to come up with an IP document so that we sign the IP, but the company wanted a bigger share of the IP. So the university collaboration department you know, DVC RPE's office was of the stand how come we even appear to be giving away the entire IP. So that one became quite rocky and we just ended the collaboration (COM\_1)

### **Weak links with industry**

Most participants were of the opinion that there are weak links between universities and industry. This was attributed to 'the fact that there have not been too many interesting things shared by the academia to interest the industry and the industry being reluctant to come to the university' (COM\_3). This was attributed to outdated curriculum offered at universities:

... the curriculum that is followed by a lot of institutions largely classified under the academia is not in tandem with the contemporary practices of the world thus bringing about some disconnect between the industry and the academia (COM\_2)

The participant felt that the universities needed to market themselves by producing graduates who were relevant to the market, and 'ensure we don't just produce paper graduates.... we need to see engineering products, excellent software systems for example, coming out of the universities, not just graduates with papers year in year out' (COM\_2).

Problems of lack of trust between the two players were pointed out:

..There is just this suspicion that oh these people will steal my idea. So because of that, the industry tends to be much closed. They don't want to disclose anything they are doing. They will always be suspicious, even if let's say there is a processing line and you want to know the ingredients they add - you see it's good for you to know so that you can advise them on where there is weaknesses but sometimes they don't want to disclose (AGR\_1)

Others shy away because of unpleasant prior experience:

One time we were talking to Delmonte, and they said why they can't really involve the universities in some of their research. They said that one time they gave a certain university money to solve for them some issues they were having on one of their products. The university took the money and of course a lecturer was appointed to do the work. They never saw the report; they never saw anything and the thing costed them Ksh 2 million. So from that bad experience they don't want anything to do with the university (laughs) because they think we are just after the money, we'll not do anything (AGR\_1)

With many industries owned by people from outside Kenya, Some participants felt that industries do not trust local researchers with solutions or designs - they want to look for solutions outside the country:

We are supposed to be consumers according to them. Yet again, consumers and not producers. Even if we go to the industry, they don't allow local designs to come in. They are industries yes, manufacturing industries, but the designs come from elsewhere, they just implement them here (ENG\_1)

...The industry wants expatriates from out. Most of these industries are owned by Indians who believe in getting expatriates from their own country or elsewhere. They don't give us (universities) a chance. There is need to educate these people (those in industry) to appreciate what universities can do (ENG\_4)

A number of respondents recognised that strengthening the links between universities and industry would be beneficial to all players. One participant saw collaborating with industry as an avenue for creating a market for products produced at the university. He looked at it as a 'value chain that goes beyond the institution to the consumer, and all of us must play a role, whether you are an IT expert, engineer, or a farmer' (ENG\_3). Suggestions made on strengthening links with industry included doing research that is relevant to the industry or solves specific problems in the industry. One participant gave an example of Strathmore, a private university that has managed to provide space for the industry in their campuses by encouraging them to 'create laboratories or support certain brands' (COM\_3). Strathmore was doing very well in industry/academia integration in his view. He further observed that 'Strathmore is new, is able to move very quickly and able to make decisions fairly quickly and they are able to see opportunities better than us'. This probably points to the limitations imposed by public universities in accommodating change. The need for universities to be proactive in publicising and showcasing what they can do was pointed out:

It's us (the academia) to show the industry what we can do. But if you do not show them what you can do, then they'll never invite you to solve their problems. I'll give you an example. It is a recent case. Kenya Power consulted some people from South Africa to solve a certain problem in the power industry. Those people came, they provided their solution, and it failed. The same Kenya Power engaged JKUAT staff. They solved the problem. Can you tell me the expatriates are the best? In fact the minister was surprised that we have so much capacity here that we can solve these problems and yet industry is saying that expatriates are the best people to solve the problems. He changed his mind (ENG\_3)

The need to do research that is relevant or leads to production of commercially desirable products was echoed by a number of participants. This was seen as a way of generating income, that goes towards funding more research, which in the eyes of one participant was a 'more sustainable way, of supporting research' (AGR\_2)

### **Conditions and restrictions imposed on international collaborations**

Tight conditions and international regulations in some countries especially where exchange or transfer of materials is involved was pointed out as discouraging some international collaborations:

.. for example if you are sending samples to Australia, there are a lot of conditionalities to sending material there, the same thing with the US. You can't just ship things, especially blood material. One of the big things which is global, is phyto-sanitary services, the international regulations of the movement of plants and animal material. So that is one big thing that can hinder collaboration. In other places they say anything from that country is prohibited. For example beans in countries like Columbia, that's in America, they say no, you can't get beans from Africa, you see, (laughs), because they say we have some diseases they do not have there and they are afraid of them, so that also constrains your collaboration (AGR\_2)

### **Lack of implementation of research findings**

A participant observed that at times the government commissions a study to look into a certain issue, but lacks commitment to implementation of research findings, which is quite demotivating for the researcher:

Many researches are done and they are very good. They come up with very good results and recommendations. But that's it. Sometimes it can be very humiliating for you. For example, we used to do operational research, we want to do work, something that is going to stop an epidemic from happening. You do some very nice work – surveillance. Then you go to the Ministry of Health PS, Director of Medical Services, you present the data – beautiful – this is nice, we should implement this ... One year down the line, there is an epidemic. So it can be

humiliating when you want to advise policy makers on an issue, and they don't take it seriously (PH\_2)

### **Lack of cooperation from the community / study participants**

The corrupt nature of some study participants was pointed out as a problem when doing research involving human participants. One participant lamented that a lot of campaigning is sometimes needed to persuade participation in a community based study. Some people want to extort money from the researcher, as narrated by this participant:

at one time I remember I was working in kilifi, and some *wazees* (men) came into my office, and said excuse me xxx, do you know us? I told them of course I know you. They said – ‘we hear the blood we are giving you, you are selling it. We don't want to stop you from what you are doing, but all we want is a part or token of that money you are getting’. I was very shocked. I don't know where it had come from. Fortunately, you learn never to discard your specimen until all is clear, so I called one of the technicians and I told him to bring all the specimens that we had collected for this study. So he put all the specimens in a trolley. I told them to look for each of their specimen. Of course when you remove about 300 micro litres, and use very little, it is still there - ‘does this look like what I removed from you? – yes – and you? – yes’. So I told them now, no one has sold your blood.... so such things do happen with stakeholders, and I call them major stakeholders in a project... (PH\_2)

### **Institutional structures, processes and support**

Some participants felt that the university was not very supportive in terms of providing an environment conducive for conducting research, be it in provision of resources, time, remuneration, incentives and rewards. As one participant put it, ‘scientists are not very well looked after in terms of welfare, salaries and remunerations’(PH\_3) leading them to engage in other income generating activities, such as consultancy at the expense of research. Teaching loads for those in research, no matter the work involved remained the same, which was seen as quite demotivating.

Universities are entrenched in bureaucratic structures and processes that at times undermine the collaboration process. Many levels of decision making and paper work involved, especially as concerns disbursement of project funds was seen as slowing down the accomplishment of tasks, and a source of misunderstanding and conflict. This is made more complex by universities that put limits to the amount of money that can be released at a time.

.. you find like after your proposal gets funded, the money comes to the university. As soon as it comes to the university, it's the university's money and accessing it might be not be easy... So you find your collaborators do not understand why the money was transferred to you and you can't start the activities. And they don't understand that once the money comes, I have to chase it in finance.... they have to track, look at the records and confirm. Then they have to open for you a vote...etc. Accounting systems are different like you can find that let's say a place like KARI, if you are a collaborator, you only need one signatory for you to get the money. But you see, us we have to take imprest which has to go through many processes. And then there's a fixed amount you can be given at a specific time. So for instance the maximum is Ksh 300,000 - suppose I want to buy an equipment of Ksh 500,000, I need to justify, it needs to be approved and it's really a problem. Whereas in some institutions, that's not a big deal. They can withdraw as much as they want ... so you find really the differences in systems tend to be more of a challenge. (AGR\_1)

The bureaucratic processes within communication structures were pointed to as leading to delays and missed opportunities.

You can have your proposal ready then it has to be signed by your VC, who may not be available, or doesn't see the urgency amongst all the other priority things he needs to do. But you need his signature so you can dispatch the document either in hard copy or scanned. So you can do a proposal that doesn't meet the deadline just because the VC or some office didn't do their bit (COM\_3)

Some of the university communication structures were also cited as hindering access to information on opportunities for collaborative research. This lack of transparency in communication finds information only getting to specific individuals, resulting in the same individuals being appointed to certain research teams, especially those offering substantial benefits. Perhaps this accounts for the high percentage of respondents who cited lack of information as a reason for non-involvement in collaborative research as seen in Figure 5.1. Lack of a division that deals specifically with research issues has accelerated such problems, though some of the institutions have only recently established such an office.

### ***Suggestions towards support for collaborative research at institutional level***

A number of suggestions were made towards how institutions can support collaborative research. These included:

#### ***Support for proposal writing process***

A call for support on proposal writing was echoed by a number of participants, with one university being hailed for its efforts towards this, and a call on other universities to follow suit.

we have to write competitive proposals, and the universities here like Nairobi have really tried to train staff in writing quality proposals because it's a very competitive field just like any other area of trade or something else, you have to be competitive (AGR\_2)

### *Creating an enabling environment*

Universities were called upon to create an enabling environment, perhaps by reducing the bureaucratic processes involved in the research processes

If I want to collaborate with somebody from maybe, a company or industry, and he comes here he has to be known by the administration. He has to be allowed to do this and that, and seek a lot of approvals yet it is a research that we are doing together...The process is just so cumbersome because it's not an employee of this institution (ENG\_1)

### *Need to create research teams and specialise*

One of our weakness is that we still don't have research teams such that ... you see in the developed world, it's very easy to know so and so works on this, Well, in Kenya that one really has not really worked. People will do anything. For instance am in food science but tomorrow if a donor says I want... I have money I want project on frogs, I will definitely raise some proposal (laughs) not because am an expert but because there's money. So you see research teams and then to know who is working on what, it's still really...it's a grey area people work on anything (AGR\_1)

### *Policies and their implementation*

A participant felt that though policies were there, their implementation was poor and not motivating, though motivation is looked at in different ways by individuals. For example, while one felt that the best motivation was in promotion – ‘I don't expect the university to pay me money to motivate me; my motivation is getting the promotion’ (PH\_1), others would value monetary benefits. Another felt that existing policies did not encourage production and consumption of local research.

Its policy that can encourage local research – local products from research, and of course the incubation of those products, so that they can be consumed within the country. Look at these developed countries, they are proud of their own products,

and those products are coming from the local research. Like Japan, it's growing because - of course they have borrowed a lot from outside, but it's their own people who are doing research - that research is consumed within their own country. It's not consumed by America, it's consumed within Japan. So if we cannot consume ours, however bad it is, who else is going to consume? Because if we consume, then we will see that we have a market, and we'll work hard to ensure that our products actually reach certain standards, international standards (ENG\_3)

### ***Suggestions towards support for collaborative research at the national level***

#### *Creation of forums where researchers can meet and share*

A scarcity of platforms for networking, sharing and disseminating research was noted. Efforts by NCST at promoting this were noted, though a participant observed much more was needed towards their organisation:

NCST is holding those workshops every two years or so, but we need more of these and we need sub themes ... One time I took one of my students to an NCST workshop, we went there and presented. And it was just so general- you find people in agriculture presenting, we had some research on SMEs and IT security. So you know somebody from KARI for example has just presented and he's been talking about maybe organic foods or any indigenous foods and then you come in and start talking about IT security and encryption...and... You know to the same audience! You basically find them lost so it's an initiative the Ministry has made but on top of that it needs to be further improved so that you can have themes. So that if you have many people in ICT they can have their own forum - you create those forums which have conserved themes (COM\_1)

Conferences, open days and workshops were suggested as 'a way of communicating what is going on to the scientific community' (PH\_3), and are a good forum for creation of links. However, a participant felt that they were 'a small affair – it is more like local' (AGR\_1). This, he blamed on the introduction of performance contracts that see every university wanting to organise their own 'small' conference to include in their performance contracts. He notes that this is not good to the researchers as 'you end up meeting the same people, so there's not much criticism' (AGRI\_1)

#### *Creating access to information on researchers and their areas*

The need to have a source of information on the kind of research going on in various fields, and access researchers' profiles was expressed. This, according to one participant, would make it easier for those seeking collaborators to identify them. 'Sometimes the international collaborators actually complain they don't know who to work with... and it will be good for

all researchers within the country to know each other to avoid duplication' (AGR\_1). Some initiatives addressing the issue exist, such as the notable efforts by the University of Nairobi to have academic members of staff upload their profiles and CVs onto their university website. A participant noted efforts by other private research organisations, such as *BecA*<sup>24</sup>, though it was 'still low key'(AGR\_1). Another participant felt that the NCST and universities had a duty to make such information available:

The NCST should be able to tell the scientific community, who is doing what and where they are, so that people can know where to go hunting for collaborators. Similarly, the universities should also be able to do the same, say we have this discipline, these people are working in this area, a way of getting the information around, of who is doing what and where they are and what they are working on, so that people can look them up (PH\_3)

*Establish a common research body (centralisation of research issues):*

A need for establishing a central research body to handle research matters in which the private sector were members was noted, with a participant giving an example of countries such as Australia and China where that was the case. This led to easier identification and solving of problems that were relevant to the society:

... the government establishes a body, which has players in the private sector, they are also part/members. So you find the private sector or the industry - they know the problems that needs to be solved, for instance the challenges that are facing the dairy industry. So all dairy players contribute some money to the coffer and then they advertise that we have this problems let's say in milk production. So we'd like researchers to propose solutions. So the universities then come in to solve that specific problem. So you see, there's kind of a direct link you don't just do research for the sake of doing it. You are solving a particular problem within the industry (AGR\_1)

An official from the arm of the ministry entitled with the mandate of coordinating research expressed their frustration at coordinating research activities in a decentralised system, with each of the research institutions being funded from different sources and doing their own thing:

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<sup>24</sup> *BecA* – Biosciences Eastern and Central Africa, an initiative hosted and managed by the International Livestock Research Institute (ILRI) in Nairobi, Kenya, to ' increase access to affordable, world-class research facilities and to create and strengthen human resources in biosciences and related disciplines in Africa' (*BecA* website: <http://hub.africabiosciences.org/>)



In Kenya we have that model that the co-ordination is not so centralised. You see the institutions get their funding and they are doing their own thing depending on their mandate. KARI has their research mandate in agriculture. Now we have a mandate to co-ordinate all these things, but they are still doing their own things, getting money through their ministry direct. So policy wise, Kenya we have that weakness - it's not so well coordinated. It would appear like the National Council is coordinating research in all these institutions, it is not. You see like the universities today they have their own charters - in as much as we have a mandate to co-ordinate, these guys will tell you us we are following our charter. So what do we do? (F\_1)

*Avail Funding and appropriate remuneration*

If they allocate enough funds for research and remunerate the researchers appropriately, both within the universities and elsewhere, and they convince people that they are being paid well – you know the problem is how much is enough, but I believe if you can pay well such that people feel there is no discrepancy between so and so whatever, then you tell them to produce, I believe they can be able to produce. So, allocate enough funding for research work, in all research institutions in the country (ENG\_3)

A question in the quantitative survey seeking to find out the importance of listed factors to improvement of the Kenyan research system, on a likert scale in which the responses ranged from 1 = very important, 2 = important, 3 = a little important, and 4 = not important yielded the results shown in Table 5.6. The data in the table shows that the issues presented in the table are quite important to the group under study, most of which were identified as challenges in the interviews as discussed above. This is probably an indication of the immature nature of research support systems, with most of them in dire need for improvement.

<b>Factors for improvement</b>	<b>N</b>	<b>Mean</b>	<b>Std. Deviation</b>
Importance of increasing salaries	225	1.49	.702
Importance of increasing funding for research projects	228	1.10	.310
Improving electronic communication networks	228	1.29	.528
Institutional Support in provision of resources	228	1.18	.411
Improving communication between researchers and policy makers	227	1.30	.498
Improving communication between researchers and industry	227	1.29	.544
Improving links with international research organisations	227	1.29	.552
Improving communication about grants	228	1.36	.566
Reducing bureaucracy within the work place	228	1.38	.614
Improving access to digital resources	225	1.31	.534

**Table 5.6 Factors for improvement of Kenya research system**

## 5.5 ICT AND RESEARCH COLLABORATIONS

Past studies have associated use of ICT with reduced problems and increased productivity for collaborative research. It was therefore found important to assess the extent to which use of ICT has been integrated within research collaborations, and the factors affecting their adoption and use. Towards meeting the fourth objective (*to investigate how ICTs are being used to support research collaborations in Kenya*) this section presents an analysis of availability of ICT resources (section 5.5.1), type of use (section 5.5.2) and extent of use (section 5.5.3). An assessment of differences in use across various categories of participants and challenges faced in adoption and use as seen in sections 5.5.4 and 5.5.5 address the fifth objective, *to analyse factors shaping the adoption and use of ICTs for research collaborations in Kenya*.

### 5.5.1 Availability of ICT Resources

A measure of the resources available to the respondents was through a multiple response question, where they were to select from a list of ten common ICT resources those that are available to them. An analysis of the responses yielded the results presented in Table 5.7.

ICT Resources	N out of 248 cases	% of the cases
Computer / laptop at work place	200	84.4%
Computer / laptop at home	210	88.6%
Internet connection at work place	215	90.7%
Internet connection at home	126	53.2%
A Fax Machine	13	5.5%
A scanner	124	52.3%
A printer	184	77.6%
A Telephone	89	37.6%
A mobile phone	221	93.2%
Internet on mobile phone	136	57.4%

**Table 5.7 Availability of ICT resources**

The results indicate that majority of the respondents (over 80%) have access to a computer, internet connection at work place, and a mobile phone, which are essential tools for communication. About half of them have internet connection at home (53.2%) or on mobile phone (57.4%), while a fax machine is not common(5.5%). However, as most interviews were done in participant's office, extensive sharing of computers in some offices, which was not captured in the quantitative survey, was noted. A cross tabulation of resources

against institutions and disciplinary categories indicates no significant difference in distribution of the resources across the institutions and disciplines.

### 5.5.2 Use of ICT for the various activities in a collaboration

ICT use was measured by use of a multiple response question, asking the respondent to choose the kind of ICT(s) used to perform the various activities in collaboration. The results are presented in Table 5.8. The tabulation presents the percent of cases that chose a particular kind of ICT for a given activity.

Activity	Email	Phone	VOIP	Web Forum	Chat	Fax	Face to Face	Other	N
Contacting members within locality	88.4	87.8	3.7	2.4	7.3	0.0	64	0.6	164
Contacting members outside locality	97.6	63.0	12.7	4.2	9.7	1.2	9.7	0.6	164
Planning activities within locality	86.3	72.7	3.7	1.9	3.1	0.6	59.6	1.9	161
Planning project activities remotely	92.5	59.4	11.2	5.6	6.2	0.0	10.0	1.2	160
Monitoring progress	85.7	72.0	6.8	3.7	4.3	0.6	49.1	1.9	161
Soliciting input for a decision	88.8	69.6	6.2	5.0	4.3	1.9	46.0	0.0	161
Giving updates on progress	93.8	60.2	7.5	5.0	4.3	1.2	48.4	2.5	161
Sharing documents and information	96.9	32.3	5.6	5.0	2.5	3.7	36.6	5.6	161
Communicating results	95.7	38.5	4.3	5.0	5.0	2.5	50.9	8.1	161
Average use	91.74	61.72	6.86	4.2	5.19	1.3	41.59	2.49	

**Table 5.8 Percentage ICT use for various activities in a collaboration**

The data presented in Table 5.8 indicates that email is the most commonly used means of communication among academics. The respondents are more likely to use email for all the tasks listed, whether for local or remote communication. Phone comes second to email, their most popular use being for local contact. VOIP, web forums chat and fax are less commonly used.

### 5.5.3 Level of skills and frequency of use of computers

A measure of the level of skills in using computers shows that majority of the participants are comfortable with using computers, with 24.3% characterising their use as sophisticated, 58.3% as more than basic but not sophisticated, 17% as basic. Only 0.4% did not use computers.

Majority of respondents (63.4%) spend up to 10 hours on the internet per week (32.3% spend 0-5 hours and 31.1% spend 6-10 hours), 20.4% spend 11-20 hours, and less (14.5%) spend more than 20 hours. Only 1.7% do not use the internet for research related activities at all<sup>25</sup>. A test for correlation between frequency of use of the internet and both publication productivity and number of collaborative research projects was non- significant, so was the logistic regression of frequency of use of the internet and whether one collaborates or not. This could probably mean that use of the internet is common to majority of the scientific community, whether they collaborate or not.

To assess the effect of frequency of use of ICT on reducing problems in a collaboration, reference is made to the results of a factor analysis of the problems in a collaboration in section 5.4.3. The factor analysis extracted three problem dimensions: socio cultural factors, management and control and availability of resources. A correlation of the factor scores produced and frequency of use of the internet was significant for problems related to management and control ( $r = .231, p < .01$ ). This is an indication that frequent use of the internet significantly reduces problems of management and control (on the scale used, a bigger value means decreased problems). Those who use the internet more than 20 hours a week reported less problems in coordination of member's activities (mode = 4 - Not a problem), as compared to those who use the internet less.

Majority of respondents regard email and phone as the most important means of communication in their research work, scoring a mean of 1.23 and 1.81 respectively on a five point likert scale<sup>26</sup>. Web forums, blogs and wikis, instant messaging services (IMS), voice over IP (VOIP), social networking sites, fax and postal mail were regarded as less important.

#### **5.5.4 Differences in Email use within selected categories**

Literature shows that adoption and use of ICT varies across various categories including groups or individuals, institutions, regions, and disciplinary areas. A Chi-square test of

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<sup>25</sup> The question was "How many hours do you spend in a typical week using the internet for research related activities?" and the response choices: 0-5 hours, 6-10 hours, 11-20 hours, over 20 hours and Not at all.

<sup>26</sup> Importance of 8 common means of communication, phone, email, web forums, IMS, VOIP, social networking sites, fax and postal mail was measured on a 5 likert scale, ranging from 1 = very important, 2=important, 3=A little important, 4=Not Important and 5 = N/A .

association of email use against disciplinary areas, institutional affiliation, nature of the area of specialisation, level of academic qualification, region where highest degree was attained, age, and gender produced results shown in Table 5.9.

Category	$\chi^2$	Asymp. Sig (2-sided)
Categories of disciplinary areas	8.672	.034
Area of specialisation	10.490	.015
Categories of academic institutions	2.217	.529
Level of academic qualification	25.900	.000
Region where highest degree was attained	5.740	.017
Gender	7.732	.005
Age	6.177	.186

**Table 5.9 Cross tabulation of use of email against various categories**

The results indicate significant differences in email use across disciplines. For example, agriculturalists have the highest likelihood of using email for remote and local contact at 77.9% and 72.1% respectively, and surprisingly, computer scientists have the least (52% for both remote and local contact). The Chi-square test also shows significant differences in use across areas of specialisation. Experimental and applied fields have a higher percentage of use of email for remote and local contact at 78.6% and 74.1% respectively, as compared to theoretical with 54.7%. Those with a PhD are more likely to use email for communication (at 83.1%) than those without (at 51.1%), possibly because they are involved in more collaborations thus more need for use of communication support technologies. There are significant differences in email use across region where highest degree was attained, with those who studied in a developed country being more likely to use email (at 75.2%), than those who studied in Africa (at 59.9%). The results also show that males are more likely to use email (at 69.6%) than are females (at 49.1%). There were no significant differences in use across age groups and academic institutions. These results are summarised in Table 5.10.

### 5.5.5 Factors determining ICT adoption and use

The statistics in Table 5.8 are largely supported by data from the qualitative survey, which indicates that email, phone and face to face meetings are the most common modes of communication. Some participants attributed high usage of email and phone to availability and convenience in use. However, like in a number of past studies (Walsh & Bayma, 1996b; Finholt & Olson, 1997; Vasileiadou, 2009; Cummings & Kiesler, 2005) it also

Category	Email use for local contact	Email use for remote contact
<i>Disciplinary area</i>		
Agriculture	72.1	77.9
Engineering	52.1	59.5
Public Health	59.4	68.8
Computing	52.0	52.0
<i>Nature of Area of Specialisation</i>		
Experimental	64.3	78.6
Theoretical	50.0	66.7
Applied	71.3	74.1
Theoretical = Experimental/applied	46.2	54.7
<i>Institutional affiliation</i>		
UON	55.3	60.5
JKUAT	55.3	64.1
KU	65.4	73.1
MU	69.0	71.4
<i>Academic Qualification</i>		
PhD	74.2	83.1
Not PhD	47.5	51.5
<i>Study Region</i>		
Africa	52.0	59.8
Not Africa	71.6	75.2
<i>Gender</i>		
Male	63.4	69.6
Female	41.5	49.1
<i>Age</i>		
25-30	64.7	70.6
31-40	48.5	59.1
41-50	70.0	78.6
51-60	67.2	69.0
>60	58.8	64.7

**Table 5.10 Percentage use of email across some categories**

emerged in this study that face to face meetings were still valued for communication, with one engineer indicating that their kind of work was best done with face to face meetings:

Some of the things are really difficult because there are things you have to explain on paper and drawing and so on. Really you need to be there and discuss (ENG\_1)

Poor ICT infrastructure, awareness of and access to the various technologies, costs involved in their use and skill acquisition were cited as some of the barriers to use of ICT for communication. The discussion below expounds on these findings.

## **Lack of awareness and exposure to some technologies**

Low usage of other technologies like web forums and VOIP was attributed to factors such as lack of awareness and exposure, or their unavailability. Others felt that the kind of communication they were engaged in had not called for the need for use of 'sophisticated technology', especially for local communication.

Maybe I have not been exposed to that kind of environment, though I may really need it. If for example it was necessary and I needed to use it perhaps I would use it. I'd say maybe not out of choice, maybe the environment has not required me to use it (ENG\_3)

Sometimes you would meet a client who talks of a technology that is not yet home so to speak is not available locally. Though you appreciate what that technology does, and you would wish to really embrace it, and they want you as people who are knowledgeable in that particular field in, but you don't have that technology around...those are the kind of things that we are struggling with. We hope we can be able to surmount them as we go along (COM\_2)

Differences exist in level of awareness and use of various technologies between individuals, with most of those involved in international collaboration showing a higher level of awareness and use. There was an indication that where there were differences in levels of skills between the members, they usually resorted to the most common, easily available technology. The members of a collaboration therefore had to agree on what was best for them, as narrated by the participant below:

One of the projects we have a portal hub. What we decided to do to make it effective is that we use the Dropbox. So you invite people and it's like, it's a system where when you want to send a document, you won't have to email, so you drop it in the Dropbox in your desk top and it appears to all the people who are connected. So that way it's very easy. And people can see it at their own pleasure, it just shows you on your laptop or your desktop that the Dropbox has been updated so if you are expecting something you just go there and check (PH\_1)

To embrace technology, the need to create awareness, provide for their accessibility, and encourage adoption of technology within all university departments was emphasised.

... for people to consume these products, then they must be aware of them. Maybe some of us are not aware that these technologies do exist, so there is need for more awareness, so that people can embrace the latest technology in terms of communication. But being aware also is an issue of is it free, or how much do I need to pay to use it? (ENG\_3)

## Internet connectivity problems

Unreliable internet connectivity and computing systems were cited as some of the major challenges faced by majority of the participants. A measure of the dimension of problems in use of the internet is presented in Table 5.11. Sites and material that require payment for use and internet downtime lead in problems in use of the internet. Finding desired information was a minor problem for the majority of respondents.

<b>Problem dimension</b>	<b>Major problem</b>	<b>Problem</b>	<b>Minor problem</b>	<b>Not a problem</b>	<b>N/A</b>
Time taken to connect to the internet	22.8%	37.5%	26.7%	12.1%	0.4%
Internet down time	36.2%	39.6%	19.1%	5.1%	0.0%
Cost of connection	21.2%	27.3%	31.2%	16%	4.3%
Finding desired information	8.3%	24.1%	44.3%	22.8%	0.4%
Sites and materials that require payment for use	50.9%	29.6%	12.6%	4.3%	2.6%

**Table 5.11 Problems in use of the internet**

Using ICT for the various activities in the collaboration does not pose major challenges, for the majority, as evident in Table 5.11. This can partly be explained by statistics in Table 5.1, indicating that majority have the basic skills in using computers, an essential prerequisite to use. Statistics in Table 5.8 also indicate the main mode of communication for the majority of respondents is email and phone. It is therefore possible that the most likely form of ICT the majority could be referring is email and phone, which do not require specialised skills for use.

Connectivity to the internet was pointed out as one of the major hindrances to ICT uptake. A number of participants pointed to the unreliable nature of the university ICT systems and infrastructure.

<b>Challenge</b>	<b>Major challenge</b>	<b>Challenge</b>	<b>Minor challenge</b>	<b>Not a challenge</b>	<b>Not applicable</b>
Using ICT for contacting members?	6.2%	15.4%	42.6%	35.2%	0.6%
Using ICT for planning project activities?	8%	28.4%	36.4%	25.9%	1.2%
Using ICT for monitoring progress?	6.2%	29.2%	38.5%	23.6%	2.5%
Using ICT for sharing documents and information	2.5%	19.1%	40.1%	36.4%	1.9%
Using ICT for communicating results	1.9%	18.2%	37.7%	40.9%	1.3%
Security of data / information	12.3%	26.5%	35.2%	22.8%	3.1%
Lack of skills in using appropriate technology	4.9%	17.9%	35.8%	37.0%	4.3%

**Table 5.12 Challenges in use of ICT**



One participant had been appointed to head a newly established department whose office spaces did not even have cabled or wireless internet connectivity. The excerpts below point to some of the frustrations faced in accessing the internet:

... we are still struggling with internet access here. Clearly the kind of work that we do...its difficult without steady stable internet connectivity. You have to dash to a cyber cafe from time to time. You have got to cough lots of money to buy data bundles from the service providers...(COM\_2)

... the infrastructure here isn't good and at the same time it also costs money you know. Some of my students maybe have to spend money to go to a cyber to access Skype, so why? He can as well come here or we talk on mobile phone (COM\_1)

... the problem is the maintenance, sometimes it's ok, sometimes it's down. because like in the university here you know, the user numbers is very high, everybody is into the internet, so you can imagine the demands on the equipment. You see the ideal situation - because I have worked with some international organisations at least, you see they have very stable systems and they have a dedicated team for ICT for example, a very dedicated team, the moment you complain, they are there to sort it out. So they have maintenance and these are really experts of the internet and other communication solutions. That however lacks in public organisations (AGR\_2)

It is therefore not unusual to find academic members of staff /researchers in public access computing venues, that Gomez (2014) notes have become common in developing countries and are favoured due to good customer service and support for information needs. Majority of the participants reported using private devices to connect to the internet such as the broadband modems, as a way of dealing with the unreliable internet connectivity at the university. The need for investing in 'self-infrastructure' was also pointed out as a way of improving communication. With the high penetration of mobile internet connectivity, one participant was of the view that smart phones would be of much assistance in resolving communication problems.

Most people access mail either at the work places or they access it maybe because they have a Safaricom<sup>27</sup> modem or something like that. One of the things I think will help in future, since in this part of the world people like using phones a lot, is the issue of the Smartphone. If more people continue adopting the Smartphone or using maybe at least a web-enabled phone you can be able to access mail, you can be able to do a number of things. I think that it would be a good gadget to support collaboration in research and things like that in the future for this part of the world

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<sup>27</sup> Safaricom is one of the major mobile as well as internet service providers in Kenya

where you find that many do not have cabled infrastructure at home. But they definitely have a phone. If it's a web enabled phone then I think that we are going to get improved communication. Using that you can check your mail from wherever you are (COM\_1)

### **Access to necessary software**

Acquiring necessary software was cited as a problem for most people. Asked if the university does not provide, one participant was of the view that the university was not in a position to afford the various software requirements for the diverse kinds of research done. So much of the burden was left to individuals, which was seen as contributing to the problem of piracy.

The nature of software, if you look at the university community it is very diverse. It's not like a center focusing on one area. Here you are talking about people from engineering, architecture, business, veterinarians, crop scientists, biologists, physicists, you can imagine the tasks and the range of tools or software- what they need, and even within one department like ours, there are breeders, there are statisticians, pathologists, microbiologists, etc and everybody has something specialised in their area. So you can't expect the university to cope and supply you with everything that you need (AGR\_2)

The participants expressed a desire by most researchers to warm up to what would be seen as supporting and facilitating their work, if they were made aware of it, if it was availed to them and the supporting structures put in place:

I can tell you most of the people who have embarked in conducting research are ready and willing to use technology. The challenge is access to these technologies, one. There is also the challenge of the requisite skills, skills upgrading and our technology infrastructure is still relatively weak. The cost associated with accessing for example the internet relatively high in my view as we speak - Cost issues still .... for example if you want to use SPSS statistics to analyse your data, first of all you don't have the money to get the license or a copy of the software, number 2, you don't have the skills necessary to help you be able to use that package and those skills furthermore don't come easy so you have to pay for them (COM\_2)

Other challenges cited included ignorance on acquiring skills and time differences for international collaborations. There are those who will not be in a hurry to acquire new skills, with one respondent noting that at times the director of ICT would sometimes call for training, but some people were too busy to attend. Or it could be a question of them being comfortable using what they are used to? One respondent noted that the resulting differences in level of skills was limiting for those who wanted to use certain technologies,

but find their collaborator lacking in the necessary skills, thus forcing them to rely only on the most common, email. Time differences especially for collaborators separated by continents become a problem for Skype or video conferencing. When mid-day is an appropriate time for one, it may be three o'clock in the morning for another, so organising an appropriate time becomes a challenge. A participant described how he ran into problems with an arranged meeting with his collaborators in the US, due to the issue of time differences. In the hope of getting home in time for the conference, he got stuck in traffic for hours and had to have his Skype meeting on the roadside, running into more other problems in getting home.

Some participants felt that adoption and use will depend on the type of collaboration. Being involved in remote international collaborations calls for one keeping pace with the modes of communication being used by the remote collaborators, as pointed out by a participant: 'If you are going to operate internationally you have no choice, because that's the mode of communication, but if locally you might not desperately need the internet' (AGR\_2).

## **5.6 COLLABORATION, ICT USE AND PRODUCTIVITY**

Increased productivity has been referred to as one of the major benefits derived from research collaborations, as noted in section 2.2.2. However, some studies have found that this relationship may not be very clear (Duque et al, 2005; Lee & Bozeman, 2005). Therefore this section sets out to test this relationship for the target population, towards meeting the sixth objective (*to assess the benefits of collaboration and ICT use on research productivity*). The section begins with statistics on collaboration and productivity profiles of the respondents in section 5.6.1. This is followed by a test for collaboration and productivity relationship in section 5.6.2, and an analysis of factors that affect this relationship in section 5.6.3. Collaboration is measured by self-reported number of collaborative projects one has been involved in the last ten years, while the measure of productivity is self-reported number of publications and other forms of research output, within the same period. Other factors contributing to research productivity are also explored in this section.

Variable		Collaboration		Productivity				
		% Response	Mean of Current projects	Mean of Past projects	Mean Publications	% publication	% Reports	% innovations
Involvement in collaboration (1=Yes, 0=No)	65	1.80	2.43	7.45	47.8	36.6	11.8	19.3
<b>Discipline</b>	<b>N = 248</b>				<b>N =77</b>	<b>N=59</b>	<b>N=19</b>	<b>N=31</b>
Agriculture	27.5	2.38	3.13	11.57	45.5	43.1	42.1	58.1
Engineering	49.4	1.50	2.00	5.97	35.0	39.6	36.8	22.5
Public Health	13.0	1.14	1.67	5.37	13.0	12.1	-	19.4
Computing	10.0	1.62	2.62	6.09	6.5	5.2	21.1	-
<b>Institutional Affiliation</b>	<b>N = 248</b>				<b>N=78</b>	<b>N = 59</b>	<b>N = 19</b>	<b>N = 31</b>
UON	31.1	1.72	3.42	9.12	32.1	32.2	21.1	54.8
JKUAT	41.5	2.02	2.11	7.02	41.0	28.8	68.4	29.0
KU	10.5	1.65	1.94	6.69	14.1	16.9	5.3	6.5
MU	16.9	1.56	1.74	5.97	12.8	22.0	5.3	9.7
<b>Age</b>	<b>N = 228</b>				<b>N = 77</b>	<b>N = 58</b>	<b>N = 18</b>	<b>N = 31</b>
25 - 30	7.5	1.71	1.69	2.0	3.9	6.9	5.6	3.2
31 - 40	28.9	1.75	2.75	5.41	23.4	20.7	22.2	9.7
41 - 50	30.7	1.82	2.35	9.67	40.3	39.7	44.4	51.6
51 - 60	25.4	2.05	3.00	8.78	23.4	27.6	27.8	29.0
Over 60	7.5	1.27	3.10	7.38	9.1	5.2	-	6.5
<b>Gender</b>	<b>N=248</b>				<b>N=78</b>	<b>N = 59</b>	<b>N = 19</b>	<b>N = 31</b>
Male	79	1.89	2.47	7.76	83.3	79.7	89.5	74.2
Female	21	1.38	2.23	5.66	16.7	20.3	10.5	25.8
<b>Educational Background:</b>	<b>N=225</b>				<b>N= 76</b>	<b>N =58</b>	<b>N = 18</b>	<b>N = 31</b>
Has a PhD (1=Yes, 0=No)	55	1.98	2.72	10.93	76.3	82.8	77.8	12.9
No PhD	45	1.39	1.79	3.14	23.7	17.2	22.2	87.1
Trained in developing country =1	48	1.50	2.13	5.78	43.3	49	26.7	50
Trained in Developed country = 0	52	2.12	2.66	8.65	56.7	51	73.3	50
<b>Frequency of Use of Internet</b>	<b>N=235</b>				<b>N= 78</b>	<b>N = 59</b>	<b>N = 19</b>	<b>N = 31</b>
0 – 5 hrs	32.3	1.83	2.13	6.28	28.2	20.3	26.3	25.8
6 – 10 hrs	31.1	1.86	2.98	8.51	28.2	35.6	52.6	38.7
11 – 20 hrs	20.4	1.75	2.19	7.67	25.6	25.4	15.8	19.4
More than 20 hrs	14.5	1.95	2.23	8.40	16.7	18.6	5.3	12.9
Don't use ICT	1.7	0.00	1.33	2.50	1.3	-	-	3.2
<b>ICT type of use within collaboration</b>	<b>N = 161</b>				<b>N=78</b>	<b>N = 59</b>	<b>N = 19</b>	<b>N = 31</b>
Use Email	87.5	1.88	2.47	8.97	94.9	93.2	94.7	90.3
Don't use email	12.5	1.00	2.00	4.19	5.1	6.8	5.3	9.7
Use VOIP	13.1	2.14	2.05	9.65	17.9	16.9	15.8	12.9
Don't use VOIP	86.9	1.74	2.49	7.24	82.1	83.1	84.2	87.1
Use Web forums	3.8	1.83	1.83	6.00	3.8	6.8	0	6.5
Don't use web forums	96.2	1.80	2.45	7.50	96.2	93.2	100	93.5

**Table 5.13 Collaboration and productivity profiles of respondents**

### 5.6.1 Collaboration and productivity profiles of respondents

Table 5.13 presents collaboration and productivity profiles of the respondents. The mean publication rate for an academic scientist over a ten year period is 7.45. However, the mean publication levels vary across disciplines, with agriculture having the highest at 11.57 over the ten year period, and public health the least at 5.37. Agriculture too has a relatively higher percentage of other outputs, as evident in Table 5.13, columns 7 - 9.

Most productive age group in all forms of output is 41 – 50, closely followed by 51 – 60. Those over 60 have the lowest mean number of current research projects, though the highest number of past projects, an indication they were more productive in their 50s. Significant differences are observed in productivity levels in all forms of output between those with a PhD and those without. Those who studied in a developed country reflect a higher mean number of publications as well as innovations as compared to those who studied in a developing country. No significant differences are observed in productivity based on frequency of using the internet. However, those who indicated usage of email and VOIP for their collaborations reflect higher levels of publication productivity. A Kruskal Wallis test was carried out to determine if the differences in publication productivity across these various categories were significant. Disciplinary area ( $\chi^2 = 35.09$ ,  $p < .000$ ), academic qualifications, ( $\chi^2 = 90.36$ ,  $p < .001$ ) study region ( $\chi^2 = 14.69$ ,  $p < .001$ ), gender<sup>28</sup> ( $\chi^2 = 4.27$ ,  $p < .05$ ), and age ( $\chi^2 = 35.11$ ,  $p < .001$ ) turned significant. Differences across institutional affiliation and surprisingly, nature of the area of specialisation were not significant.

The motive for collaboration determines collaboration and productivity rates. As seen in Table 5.14, considerable differences are observed in the mean number of publications for those who consider special skills, sharing equipment, strong work ethics and institutional affiliation important as compared to those who do not. While those who consider sharing

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<sup>28</sup> Though only 21% (53 out of 248 respondents) in the survey were female (see Table 5.1), the mean number of collaborations and publication productivity rate for females are calculated relative to the total of female respondents. Similarly, the mean collaboration and publication productivity rates are calculated independently for each sub category under disciplinary area. For example, 34 out of 53 (64.2%) of the female respondents reported having been involved in a collaboration in the last ten years, with a mean number of 2.23 projects and 5.66 publications. On the other hand, 126 out of 194 (65%) of male respondents reported involvement in collaboration in the last ten years, with a mean number of 2.47 projects and 7.76 publications over the same period.

skills as an important motive have higher rate of publication productivity, those who collaborate to share equipment have lower rates of publication productivity. Those who consider institutional affiliation not important also reflect higher rates of productivity.

Motivation for collaboration	% Response	Mean Current projects	Mean of Past projects	Mean of Publications
Common goal - important	97.3	1.87	2.44	9.60
Common goal less important	2.7	2.0	2.25	8.67
Special skills important	92.7	1.86	2.49	10.0
Special skills less important	7.3	1.89	2.13	7.75
Sharing equipment important	78.9	1.86	2.26	9.32
Sharing equipment less important	21.1	1.72	3.05	12.20
Mentorship important	67.1	1.7	2.15	8.07
Mentorship not important	22.9	2.05	2.06	11.50
Funding important	87.2	1.79	2.44	9.77
Funding not important	12.8	2.3	2.3	9.4
Strong work ethics important	84.7	1.85	2.54	9.43
Strong work ethics not important	15.3	1.59	2.12	11.80
Strong reputation important	75.5	1.90	2.43	10.00
Strong reputation less important	24.5	1.81	2.78	9.01
Institutional affiliation important	77.5	1.92	2.44	8.5
Institutional affiliation not important	22.5	2.02	2.24	12.8
Friendship important	25.7	1.86	2.72	9.83
Friendship not important	74.3	1.78	2.31	9.38

**Table 5.14 Publication and productivity profiles based on motive for collaboration**

Though research productivity is usually measured by publications as an output, some studies as discussed in literature show that other outputs count when considering research output, as research may not automatically result in publications (see section 2.5). In view of this, participants were asked to list other forms of output emanating from their collaborations<sup>29</sup>. Results of the details of outputs from project one show that 41.7% of respondents indicated publications as their form of output, reports 31.5%, products 10.2% and others 16.6% (note that the results are not mutually exclusive – one could have indicated more than one of the listed forms of output).

### **5.6.2 The relationship between collaboration and productivity**

A test for normality of both number of current collaborative research projects and number of publications (productivity) in the last 10 years indicates that the data is not normally distributed (is positively skewed), thus requiring the use of a non-parametric test. The

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<sup>29</sup> Section E in the questionnaire requested for details of three most recent/significant projects, including the sponsor, type of output and collaborator details.

Spearman's Rank correlation between the number of collaborative research projects and number of publications in the last ten years was significant, yielded a correlation coefficient  $r = 0.418$ , at  $p < .001$ . The coefficient of determination<sup>30</sup>,  $r^2$  equals 17.47%, meaning that only 17.47% of the variance in publications is related to number of collaborative projects. A correlation of number of past projects and publications yields an even smaller value of  $r$  ( $r=.254$ ,  $p < .001$ ), meaning a weaker correlation accounting for only 6.45% of variance in publications being related to the number of past research projects. The differences in the value of  $r^2$  for current and past projects indicate some improvement in publication productivity associated with collaboration. However, the values indicate a relatively weak<sup>31</sup> though significant correlation, meaning other factors also determine the collaboration levels. The next section explores the other possible determinants of publication productivity.

### 5.6.3 Other determinants of publication productivity

ICTs use to support research collaborations has been associated with a number of benefits, including support for productivity. A Spearman Rank correlation between the importance given to most commonly used means of communication<sup>32</sup>, and publication productivity shows that only two modes of communication have a significant effect, phone ( $r = -.160$ ,  $p < .05$ ) and email ( $r=-.208$ ,  $p < .01$ ). The negative coefficient in  $r$  can be interpreted to mean the more important the value attached to the mode of communication (represented by a lower rank on the likert scale), the more the publication productivity. For instance, those who indicated email as very important have higher publication rates. However, this accounts for only 4.33% ( $r^2 = (-.208^2)*100$ ) of the variance in publication productivity. Web forums, blogs or wikis, instant messaging services, VOIP e.g. Skype, fax and postal mail did not yield a significant correlation, an indication that they may not be regarded as

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<sup>30</sup>The *coefficient of determination*,  $r^2$ , gives the proportion of the variance (fluctuation) of one variable that is predictable from the other variable. It is calculated by squaring  $r$  (in this case 0.418), then multiplying by 100 to get the percentage value (Field, 2009)

<sup>31</sup> The strength of a correlation is normally measured on a scale ranging from -1 to +1. Anything above 0.5 is regarded as a strong correlation, while a value approaching 0 indicates the absence of any relationship. In this case,  $r$  is less than 0.5, therefore a relatively weak relationship

<sup>32</sup> The Question was: 'Thinking of the following means of communication, please indicate their importance to your research work' with the choices of Phone; Email; Web forums / blogs / Wikis; Instant Messaging Services/Chat; VOIP eg skype, Google talk; Social Networking sites eg Facebook, Twitter; Fax and Postal mail. The responses were measured on a likert scale ranging from 1=very important, to 4=not important, and 5 not applicable

important for research within this population. Table 5.8 shows them as having a relatively low rate of usage. A Spearman Rank correlation of importance attached to modes of communication and time spent on the internet was significant for web forums ( $r = -.136$ ,  $p < .05$ ), VOIP ( $r = -.157$ ,  $p < .05$ ) and social networking sites ( $r = -.189$ ,  $p < .01$ ). This indicates that those who regard web forums, VOIP applications and social networking sites as important to their research work tend to use the internet more frequently. The non-significant relationship between frequency of use and publication productivity could mean the diversified use of ICT was important in supporting their collaborative work, but this did not necessarily result in publications.

A multiple regression analysis was carried out to model the effect of a number of variables in predicting publication productivity (see details of the regression in Appendix 6). Table 5.15 presents the standardised regression coefficients ( $\beta$ )<sup>33</sup>, and significance levels (column 2) for the resulting model that explains 34.1% of the variance in publication productivity ( $R^2 = .341$ )<sup>34</sup>. This model shows academic qualifications, number of collaborative projects and disciplinary field (agriculture) as most significant predictors of publication productivity. Thus in this case, academic qualification has the greatest effect on publication productivity, followed by the disciplinary area and then level of collaboration<sup>35</sup>.

Email use is positively associated with publication productivity for both local contact ( $r = .345$ ,  $p < .001$ ) and remote contact ( $r = 0.365$ ,  $p < .001$ ). The correlation between email use and current level of collaboration was significant, both for local communication ( $r = .169$ ,  $P$

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<sup>33</sup>  $\beta$  represents the standardised version of the b values and give the change in std deviations of the outcome due to a change in one std deviation of the predictor. The b value gives an indication of the degree to which the predictor associated with publication productivity affects the outcome

<sup>34</sup>  $R^2$  is the square of the coefficient for Multiple Regression.

<sup>35</sup> The variables in column one, including disciplines and gender, are independent variables, defined as the presumed cause of an effect on the dependent variable in Field (2009). In this case, they are the predictors of the rate of publication productivity. As seen in footnote 27, the mean publication rates are calculated independently for each of the categories under the variables listed. Under disciplinary area, agriculture, for instance, displays highest mean publications in comparison to the other disciplines (Table 5.13), and produces a significant result as a predictor of publication productivity when disciplinary area is fitted into the regression model. That means individuals in agriculture are more likely to have higher publication productivity as compared to those in the other categories under disciplines. Similarly, those with a PhD (under academic qualification) and those with higher rate of collaboration are more likely to have higher publication productivity rate, thus significant predictors.



< .05) and remote communication ( $r = .196, p < .01$ ). This is an indication that an increase in use of email has positive effects on both publication productivity and collaboration. It could also mean that the demand for more communication in collaborations result in more use of email. When fitted into the multiple regression model, email use turns out non-significant in predicting publication productivity. This could mean that email is still a preferred mode of communication by those who don't publish much. Age and gender differences, region where highest degree was attained, frequency of using the internet and motivation for collaboration are non-significant in predicting productivity when fitted into this model.

<b>Predictor / independent variables</b>	<b>B</b>
<i>Discipline</i>	
Agriculture	.214**
Engineering	-.074
Public Health	-.062
<i>Personal and professional characteristics</i>	
Age	.050
Gender	-.087
Academic Qualification	.395***
Region of study	-.034
<i>ICT Use</i>	
Frequency of use of internet	-.020
Email use	.098
<i>Choice of collaborator</i>	
Personal characteristics	-.109
Sharing of knowledge and resources	-.010
Shared vision	-.006
Collaboration	.193*
Constant	3.89
R <sup>2</sup>	0.341

**Table 5.15 Multiple Regression results for publication productivity**

P<.05\*, P<.01\*\*, P<.001\*\*\*.

## **5.7 CHAPTER CONCLUSION**

This chapter has presented an analysis of data indicating the state of research collaborations in Kenya, including level and their structure. Differences in levels of collaboration across a number of categories reflecting the role of individuals, disciplines and institutional structures were analysed. This, together with a comprehensive analysis of the challenges facing collaborative research gives a better understanding of status and processes involved in academic research collaborations in Kenya. Given the crucial role ICTs play in supporting collaboration processes, this chapter also provided an analysis of availability and use of ICT for this purpose, as well as identifying some of the factors that go into adoption and use.

Surprisingly, the results presented indicate relatively high levels of collaborative research. This is contrary to the initial presumption of low level of collaboration indicated in literature (see section 2.8). However, the results consistently point to disciplinary differences in form and level of collaborative research. The network structures indicate a relatively high number of members of the academic research community are collaborating with those not part of academic research community. For example, it is interesting to note that though there are relatively few ties within public health, the respondents form quite a number of ties outside the studied population. The same trend is observed in the distribution of ties across institutions with a number of scientists collaborating with those outside the studied population. Several factors were identified as affecting the form and conduct of collaborative research. A number of these point to a major influence of external environment factors, including access to funding and special equipment, and institutional and national support structures. Personal characteristics such as level of academic qualification, region of study as well as attitude and motivation for collaboration were also found to determine collaboration levels and type.

This study established significant benefits of ICT use in collaboration processes, including reduction in problems of management and control, flexibility offered in access to information and accomplishment of tasks, and increased productivity. Basic ICT resources are available to the majority of respondents. However, ready access still remains a problem. Though majority of respondents reported having integrated use of ICT to support their collaboration activities, most are limited to use of email and mobile phone. ICT supported

communication is constrained by poor ICT infrastructure, lack of awareness of various technologies and existing cultural practices. Use also varies between disciplinary areas and nature of the area of specialisation, and is also determined by individual characteristics such as level of qualification, culture of use and gender. The next two chapters present a discussion of the results reported in this chapter, focusing on two major aspects of research collaborations, their organisation (Chapter 6), and role of ICT in supporting collaborative research (Chapter 7).

## **CHAPTER 6: ORGANISATION OF THE ACADEMIC RESEARCH COMMUNITY**

### **6.1 CHAPTER OVERVIEW**

Chapter 5 presented an analysis of data derived from the mixed methods empirical study, with regard to the organisation of academic research collaborations in Kenya, role of ICT, and issues and challenges faced in the conduct of collaborative research. This chapter presents a discussion of the findings that explain the form of organisation and influencing factors. The chapter starts with a discussion of collaboration levels and nature of the collaborative relationships established in Chapter 5 (section 6.2). Nardi (2005) notes that most studies of CMC focus on the media themselves, neglecting the process of building relations that define ‘communicative readiness in which fruitful communication is likely’ (p.91). Likewise, many studies of research collaborations have focused on the collaboration process itself, overlooking the conditions and processes involved before the actual collaboration takes place (or pre-collaboration phase). This study therefore addresses issues that affect the collaboration process as well as those that lay the foundation for the collaboration to take place. Section 6.3 presents a discussion of the collaboration process divided into two major phases: the “pre-collaboration” phase which includes the facilitating conditions for building relationships that lead to collaborations; and the “in-collaboration phase”, which highlights the major processes involved once the collaboration has been established, as introduced in section 2.3.5. This is then followed by a detailed discussion of factors influencing collaboration processes (section 6.4), grouped into five major categories: personal factors, resource availability, disciplinary factors, institutional factors and technological factors. These factors are then summarised in form of an explanatory model in section 6.5.

### **6.2 COLLABORATION LEVELS AND PATTERNS**

Surprisingly, the findings of this study indicate that research collaboration levels are relatively high in Kenya. A majority of respondents (64.9 %) indicated they had been part of research collaboration in the last ten years. This is in contrast to the original presumption that collaboration levels were low, based on past studies pointing to little networking for scientists in developing countries (Gaillard & Tullberg, 2001; Harle, 2007; Adams et al., 2010). On the contrary, the network structures show some well-connected networks in

academic research in Kenya, though dependent on disciplinary area. Though some disciplines do not display many connections within academic research, they exhibit a number of connections outside the academic research community (see section 5.3.3). These findings corroborates Shrum & Campion (2000), who found that the concept of *isolation* for developing country scientists as indicated in other studies did not hold, as the scientists had their own professional networks that were more local than international. As seen in section 2.5, collaboration and productivity measures have mainly been based on bibliometric analysis of publication and co authorship entries in international databases, widely criticised for their underrepresentation of developing country scientists. Using self-reported measures, this study captures information that may not be available in international databases, offering a more accurate representation of collaboration profiles of Kenyan scientists.

However, it should be noted that this does not imply research levels in developing countries are comparable to those in developed countries. As will be seen in the sections that follow, the context within which research is done differs, thus affecting the knowledge production processes in various ways. Research systems in Kenya are faced with various problems that in turn affect how research is conducted, its levels and its impact. However, amidst the various problems, possibly out of the recognition of the importance of research in achievement of national development goals (AAU, 2011), collaborations are continuously being sought both at the individual, institutional and national levels.

### **6.3 THE COLLABORATION PROCESS**

The emerging new mode of knowledge production (Mode 2) as described by Gibbons et al. (1994) has generated considerable interest in collaborative research at the interpersonal, institutional and national levels. However, collaborations operate within different environmental conditions which shape the processes involved. While there are similarities in conduct of research globally, differences exist across regional, national and even institutional environment contexts (Duque et al, 2005; Mouton, 2008). The discussion in this section therefore focuses on the collaboration process for academic research within the Kenya context in greater detail. This is followed by a discussion of factors influencing the processes, and how they interrelate to contribute to success or failure of collaborative research.

### **6.3.1 Pre-collaboration phase**

People are brought together in collaborative relationships by various elements such as common interests (Hara et al, 2003, Maglaughlin & Sonnenwald, 2005; Kraut et al., 1987) and dependency for work and resources (Luo, 2008; Birnholtz , 2007; Whitley, 2000; Melin, 2000). Consistent with these studies, common goals and capability defined by resource and work dependency emerged as most important in scientists' collaborator seeking behaviour in this study. Resource availability, for both funding and special equipment emerged as a major problem in collaborative research, and participants indicated this was a major consideration in their collaboration decisions. This probably accounts for the relatively high number of connections with international organisations that fund much research, corroborating the views of Harle (2009), Shrum & Beggs (1997) and Mouton (2008) on donor dependence.

In the pre-collaboration phase, scientists seek suitable partners with whom they can work, whether for resource, knowledge or work dependence reasons. This section points out some of the facilitating conditions to the processes of creating and maintaining collaborative relationships.

#### ***Facilitating conditions in establishing relationships***

##### *Physical proximity*

Past studies have documented the importance of collocation and physical proximity in establishing ties that lead to collaborative work as well as the influence of distance on collaboration processes (Kraut et al., 1988; Olson & Olson, 2000; Lee & Bozeman, 2005; Cummings & Kiesler, 2005). Consistent with Lee & Bozeman (2005) and Kraut et al. (1987), the network structures of disciplinary ties between academic researchers in Kenya, as seen in section 5.3.3, show that most clusters are made of researchers from the same university. Kraut et al. (1987) associate collocation with greater chances for informal meetings and communication, from which research ideas sprout and ties are established. This may have contributed to more collaboration within a university in this study.

Like the organisational structure of the centre studied by Kraut et al. (1988), the organisational structure of university departments studied is in most cases along disciplinary lines that are usually concentrated within same physical locations. This brings

together people with common interests from whom the collaborative ties may emerge. The frequent interactions, promote building of trust and commitment between the collaborators. For instance, trust can be built in that you get to know the actual work ethics of a collaborator out of physical interactions and observation of their working styles, thus creating better mutual understanding and willingness to share. This creates a better chance for future collaborations based on prior experiences. In addition, consistent with Kraut et al. (1988), collocation was reported as cutting down costs of communication. This is exemplified by one participant who wondered why he'd spend money making calls on his cell phone or using unreliable internet when he could just walk down the corridor and discuss anything with the collaborator. Perhaps physical proximity contributes to the surprisingly higher ranking of institutional affiliation as an important factor in criteria of choice of a collaborator as seen in Table 5.3.

#### *Personal Networks*

The size and composition of personal networks are important sources of collaborative relationships. Ynalvez & Shrum (2011) found that the level of involvement in collaboration was related to research and professional network size. Such networks have been noted as playing an important role in diffusion of knowledge (Crane, 1969). Those with bigger professional/research networks are more likely to have more collaborations due to increased access to information or opportunities for collaboration, resources and new ideas being generated within the network. In this study, some individuals emerge as having larger personal networks as indicated by the number of ties to them and their position in the network (see Figure 5.2). Those with many connections were identified as principle investigators in a number of projects, displaying a high level of status and visibility in the network, corresponding to what Milojevic (2010) referred to as stars in the network. Milojevic notes that such individuals are more influential and favoured for funding. Results from the quantitative study indicate that a collaborator having a strong reputation was relatively important to a number of respondents, reflecting the power influence where individuals want to connect to the more productive and influential persons in the network, consistent with Crane (1969). Seeking connections to the 'stars' networks and interacting with them would perhaps heighten the probability of being involved in collaborations associated with them, thus a motivation for attaching to their networks.

The size and range of networks varied across disciplines. Disciplinary areas associated with a variety of disciplinary networks reflect more connections between individuals. For instance, as noted by Gaillard et al. (1997), agricultural research in Kenya has enjoyed more attention and prioritisation since pre- colonial days, leading to the establishment of networks supporting various aspects of agricultural research. Respondents in agriculture indicated involvement in research with individuals from various agricultural research organisations and institutes. This is a possible reflection of their level of involvement in the wider disciplinary networks, which gave opportunities for extension of personal networks. On the other hand, there were indications of fewer establishments of disciplinary networks in computing, as seen in section 5.3.3, which probably contributes to the lower levels of collaboration in the discipline.

Institutional links with other universities and organisations can also act as a facilitator of connections and extension of networks for the individual researcher. Individuals could work closely together with other individuals in the other organisations or institutions, visit their laboratories or centres, organise for exchange programs, all of which give room for creation and strengthening of ties. Luo (2008) found that developing country scientists who were part of a collaboratory<sup>36</sup> had the advantage of visiting and working in laboratories in developed countries. In addition to gaining tacit knowledge from their working practices, they too enjoyed the benefits of meeting new valuable connections.

### *Meeting forums*

Physical proximity, as discussed above is an enabler of creation and extension of personal networks. Forums within which people can meet and socialise and talk about their work such as workshops and conferences were cited in this study as important venues for creating contacts, consistent with Kraut et al. (1987), Luo (2008) and Melin (2000). Gaillard & Tullberg (2001), for instance note that the meeting forums organised for IFS grantees gave them a chance to meet with other international researchers and expand networks, thus they reflected more international collaborations than local. The need to

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<sup>36</sup> Luo (2008), adopting the definition of collaboratory from Olson G, Bos, & Zimmerman (2008) defines it as 'an organizational entity that spans distance, supports rich and recurring human interaction oriented to a common research area, and provides access to data sources, artifacts and tools required to accomplish research' (p. 2)



create such meeting arenas was emphasised in this study. However, it was noted that competition levels among universities and use for enriching individual institutions' performance contracts made organising conferences more of an institutional affair, with less impact on establishing new ties. However, efforts to create meeting arenas can be seen at the national level, with the NCST hosting conference and research dissemination workshops periodically. However, it was noted that such workshops needed to be organised around research themes for it to have more impact on bringing researchers with similar interests together, as opposed to the current organisation that brought together all disciplines.

#### *Access to information*

Access to existing bodies of knowledge is important in identifying potential areas of research and individuals involved, from whom researchers can seek ties that could end up in fruitful exchanges and possibly future collaborations (Maglaughlin & Sonnenwald, 2005). Contrary to Harle (2010), who found that availability of scholarly literature was no longer such a problem in African universities, the majority of respondents rated sites and material that require payment for use a major problem in their use of the internet. This could be an indication that the universities could have subscribed to a number of journals, but may not be inclusive of all disciplinary and research areas. It could also be an indication that what is available is simply not enough, and there's need to expand their digital resource libraries.

Some participants faulted poor information dissemination systems in the universities, with some noting that they hardly learnt of any opportunities to do research from within the universities, consistent with Harle (2007). This is supported by data from the quantitative survey, in which lack of information on available research projects and not having been offered a chance to collaborate scored highly among the reasons for non-involvement in collaborative research. The beneficiaries of access to information on funding opportunities in some departments were said to be a few individuals. This could be a reflection of the social organisation of scientists identified by Price & Beaver (1966) and Beaver & Rosen (1979), whereby a core of professional elites held key positions of power and had major influence on disposition of resources and direction of research. Communication and sourcing for collaborators on what is seen as important or funded research therefore

revolves around these centres of power, and those outside this circle hardly get information concerning the emerging opportunities. Problems of communication on research opportunities can also be attributed to competition among individuals for financial benefits associated with funded projects, identified by Ynalvez & Shrum (2011) as a major motivator for doing research among Filipino scientists. With the hard economic times and poor remuneration packages, research was looked at as a source of much needed income. Participants noted that it was important to give all interested parties a chance to get involved in research, through transparent communication channels and grant awarding processes.

The need to have a central database with information on researchers' areas of interest and ongoing research as a point of reference was raised as important in search of collaborators. Though some efforts exist in Kenya and the region, they are *low key*, in the words of one researcher, and are usually organised along disciplinary lines. Making this information available and accessible at both the university and national level was viewed important, as it would facilitate the process of identification of potential collaborators and areas of research, as well as avoid duplication of research.

### **6.3.2 In-collaboration phase**

This section presents a discussion on the major processes once the collaboration has been established. The major processes highlighted are task allocation and coordination, decision making processes, conflict management, output production and communication processes, as identified by Vasileiadou (2009).

#### *Allocation and coordination of tasks*

Proper assignment of tasks and their coordination mechanisms are important aspects in their successful accomplishment. The amount of coordination required depends on the nature of the tasks, among other factors such as distance and size of the research group (Cummings & Kiesler, 2005; Walsh & Maloney, 2007). The majority of respondents indicated the nature of the work they were involved in as varying from project to project, and so did the coordination mechanisms. However, coordination of tasks did not feature as a major problem among many of the respondents as seen in the quantitative survey (see Table 5.4). This is possibly because researchers are faced with other problems of greater

magnitude, such as the highly rated access to resources which overshadow the coordination problems. However, in the qualitative follow up, participants emphasised the need to plan and allocate tasks appropriately at the onset of the project. Unsurprisingly, majority indicated face to face meetings were most useful for the task, consistent with Walsh & Bayma (1996 b), Finholt & Birnholtz (2006) and Vasileiadou (2009).

Coming from different professional and disciplinary backgrounds can escalate the level of conflicts involving assignment of tasks. For example, in Amabile et al. (2001), it emerged that industrial practitioners felt their capabilities were not being adequately utilised, bringing in feelings of inadequacy and belittlement thus a source of conflict between the two groups. It is therefore important to identify capabilities, allocate tasks accordingly and make clear of expectations right from the start of the project to minimise such conflicts.

#### *Decision making processes*

Aspects of decision making processes influencing collaborative research have been identified as leadership structures (Chompalov et al., 2002; Melin, 2000), levels of authority (Shrum et al., 2007), status differences (Shrum et al., 2001) and state of formalisation of the processes (Vasileiadou, 2009). At the project level, the participants indicated that most projects were headed by a principal investigator (PI), responsible for overseeing the project activities such as allocation and coordination of tasks and resources, delivery of results and output and reporting progress to higher authorities. Though some reported problems in project management at this level, more problems of leadership were reported outside of collaboration rather than within. These included the many bureaucratic processes and paperwork at the university management level especially in disbursement of project funds and sharing of equipment. The decision having to go through many hands for approvals usually impacted negatively on project schedules. One participant noted that sometimes it was a cause for misunderstanding and conflicts for those who did not work within or understand bureaucracies within university systems.

The need to make decision making processes participatory was pointed out by a number of participants, consistent with Vasileiadou (2009). Some pointed to lack of transparency when major decisions affecting their work were left to the principal investigator. This created room for misappropriation of project funds, and sometimes premature end to a

project. The NCST has only recently put in place measures to deal with such cases, including constant reporting of progress and release of project funds bit by bit, based on progress report. Though expected to have a positive impact, such a measure could cause delays in initiation of some tasks. This may also cause misunderstanding between NCST and the researcher as to who should make decisions that concern progress of the project. Such was the dissatisfaction expressed by investigators in computer science and earthquake engineering studied by Finholt & Birnholtz (2006). In their study, the investigators felt the requests by project managers for documentation and justification was demeaning to them, in that they were being treated like 'subordinates or mere contractors rather than leading researchers' in their fields (Finholt & Birnholtz, 2006, p.96).

A number of participants indicated a preference for participatory and less formalised decision making processes over highly formalised processes. This is seen as a solution to the highly bureaucratic processes that slowed down performance of tasks. There were indications that researchers did not appreciate directives coming from the top as to what collaboration to be involved in or role to play, consistent with Melin (2000) and Chompalov et al., (2002). However, even in a participatory less formalised structure, Vasileiadou (2009) advises on a clear authoritative voice especially in times of misunderstanding and conflict. She observes that with no authoritative voice, it took longer to resolve conflicts and get things moving in the groups studied. However, this could have the effect of increasing the levels authority, pointed out by Shrum et al. (2007) as complicating the process. Perhaps having an independent voice to the decision making process, as recommended by Maglaughlin & Sonnenwald (2005), is necessary in reducing the turnaround time of decision making at project level. Similarly, appointment of a strong arbiter, who was conversant with working styles of all groups was found especially useful in resolving differences resulting from expectations as regards deliverables between the computer scientists and earthquake engineers studied by Finholt & Birnholtz (2006).

Status differences have been identified as affecting decision making processes (Shrum et al., 2001). The senior researchers voice is usually seen as more authoritative as compared to juniors, as opposed to when all collaborators are equals, sometimes bringing in issues of competition among individuals. A number of participants indicated their research usually involved working with students. It is not clear if the preference to work with students has

more to do with the competitive nature of researchers of equal status, or if it was just simply 'easier to work with students and avoid complications of faculty members', as one participant put it.

### *Conflict resolution*

In a group of people from diverse disciplinary backgrounds and cultures, conflicts are bound to arise (Sonnenwald, 2007). The important issue is how they are handled and mechanisms in place to deal with the conflicts. Diverse disciplinary training of collaborators, cultural differences, scientific competition, and authorship inclusion and order did not come up as major sources of conflict in the quantitative survey (see Table 5.4). However, consistent with Amabile et al. (2001) and Finholt & Birnholtz (2006), participants in the interviews emphasised the need for understanding the different disciplinary cultures in interdisciplinary research so as to work harmoniously together. Differing expectations among the collaborators, consistent with Luo (2008), Finholt & Birnholtz (2006) and Amabile et al. (2001), lack of formal contractual agreements and lack of transparency were identified as further sources of conflict in this study. For example, a participant cited differences arising between them and industrial collaborators due to differing expectations on gains from collaboration. While those from the university were more concerned about quality, their industrial partners were more concerned about financial gains, consistent with Amabile et al. (2001). Another cited differences between university and industrial collaborators arising from share of IP, which he blamed on lack of agreement on the same before the collaboration began. The differences were unresolvable leading to termination of the collaboration.

To avoid conflict related to IP rights, Sonnenwald (2007) advises on negotiation of IP and other legal issues at the formulation stage of a research project. Similarly, having clearly drawn contracts especially in projects involving partners from different organisations, clarifying roles, responsibilities and expectations at the onset of the project were identified in this study as important in avoiding some of the conflicts. The role of an arbitrator or independent voice as discussed in the previous section could help in resolving conflicts that are beyond the group. In agreement with Finholt & Birnholtz (2006), clear conflict resolution processes that identify the final authority in case of major conflict could help, but the regulations need to be stipulated clearly and made known to all parties getting into a

collaboration. The best that exists at one of the universities studied is a university Ombudsman. His role is more of a social nature, and includes offering advisory services on conflict resolution mechanisms, especially on differences between university and members of staff. Professional issues like the one described above need a more defined process and higher level panel to resolve serious conflict.

### *Output production*

Output production is an important part of the collaboration process as success is mainly gauged against the kind and level of output. Factors identified in literature as determining the form of output produced include the professional background of the collaborators, motivation for collaboration and reward systems (Ynalvez & Shrum, 2011; Lee & Bozeman, 2005).

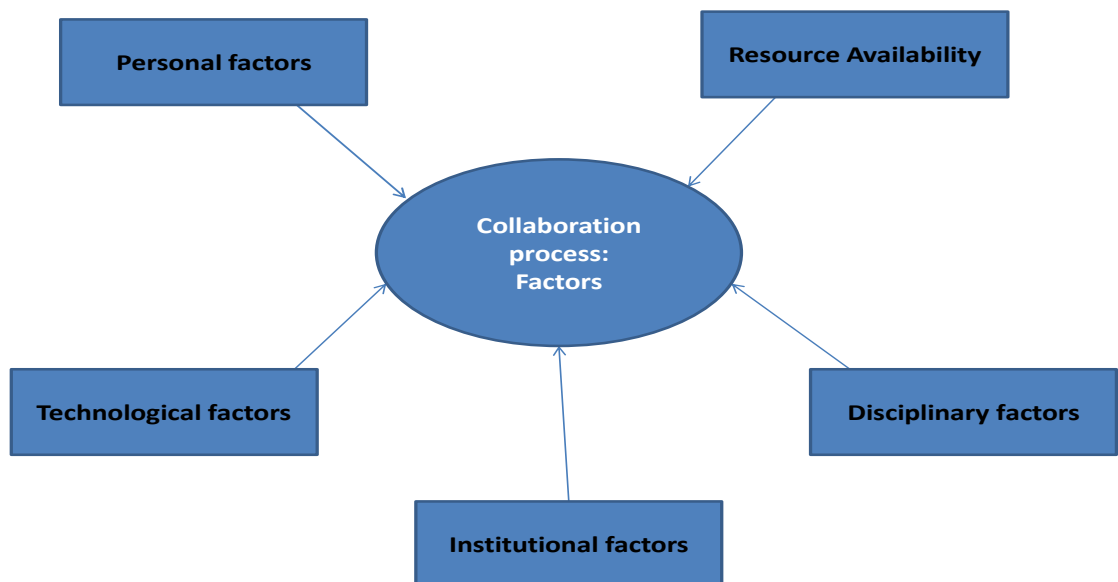
In past studies, output has usually been measured in terms of publications. However, findings from this study indicate that publications were not included as an output by 33% of those who gave the project output details. This supports the views of Van Raan (2005) and Lee & Bozeman (2005), that journal articles may not be the only output of scientific research. Consistent with Ynalvez & Shrum (2011), a number of participants indicated more concern for delivery of project mandate, mainly in form of reports, products and innovations, than for publications. Consistent with the views of Harle (2010), there were indications that financial gains were important to the group studied, as exemplified by the participant who observed that most people come into a collaboration with the question of ‘what’s in it for me?’ Perhaps the situation can be likened to the Filipino scientists studied by Ynalvez & Shrum (2011), who they note were constantly looking for additional research work and collaborations (assuming that the number of projects is proportional to financial gains) to boost their incomes. Publications were of less priority as they did not meet this need. This, coupled with the commonly cited problem of heavy teaching loads hardly leaves them time to publish, partly accounting for relatively low publication levels.

The professional background of collaborators may also affect the output production processes, and as identified by Amabile et al. (2001), can be a source of conflicts. A number of respondents are collaborating with people outside the academia, as seen in Figure 5.7. Such collaborators’ focus may be the delivery of project mandate which rarely

includes publications, as observed by Dimitrina & Koku (2009). The closed nature of industry was cited in this study as one of the problems with industrial collaborations. Those in industry were seen as not usually willing to disclose the processes involved in solving a problem or innovation, as they see it as one of the ways of remaining competitive in their field (see section 5.4.3 – Weak links with industry). This probably affects their attitude towards publishing and dissemination of output, as seen in Amabile et al. (2001). Amabile et al. found that differences in professional backgrounds were a source of conflict for collaborations involving industrial practitioners and academic researchers as concerns output dissemination, as seen in section 2.3.5 (Output production).

#### **6.4 FACTORS INFLUENCING THE COLLABORATION PROCESSES**

The results of this study reveal that research collaborations in Kenya are influenced by a number of factors, both internal and external to a collaboration, consistent with past studies (as discussed in section 2.4). The factors are varied but many of them interact, interchangeably being cause and effect of the other. In this section, the factors are grouped broadly into five major categories, as seen in Figure 6.1, though noting that some may appear across categories.

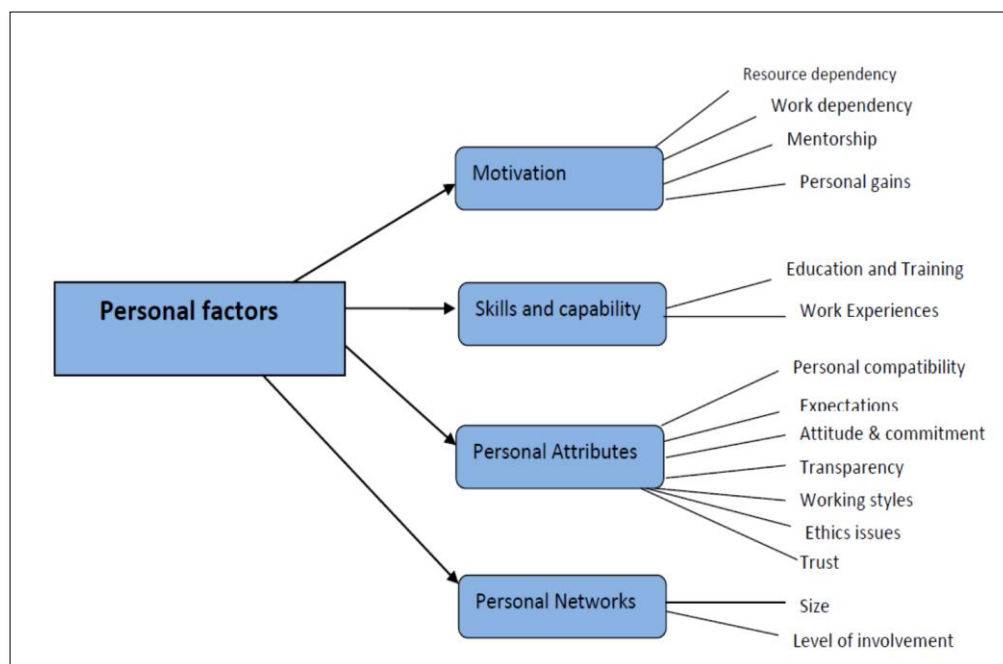


**Figure 6-1 Major factors affecting collaboration processes**

Each is discussed in relation to how they influence the levels, organisation and processes of collaborative research. The categories emerge from the data analysis, directed by a synthesis of various frameworks in literature on factors that may influence research collaborations, including those of Amabile et al. (2001), Sonnenwald (2007), Maglaughlin & Sonenwald (2005) and Sargent & Waters (2004).

#### 6.4.1 Personal factors

Factors under this category are those of a social and professional nature, influencing the scientists' attitude, preferences and choices, level of commitment, interest and working styles. They are summarised in Figure 6.2.



**Figure 6-2 Personal factors affecting collaboration processes**

#### *Motivation for collaboration*

As mentioned before, people get involved in collaborations for various reasons. This can be dependency for work, knowledge and resources (Luo, 2008; Birnholtz, 2007; Whitley, 2000; Sargent & Waters, 2004). It can also be for personal reasons referred to by Sargent & Waters (2004) as intrinsic motivation such as the fun of working together. Consistent with the past studies, this study found that dependence for resources, work, and diversified skills



were rated highly as motivators for collaboration in Kenya (see Table 5.3). Personal preferences were less important. The need for relationships that resulted in mutual gain for the participants was emphasised, with a number of respondents noting that they sought collaborators whose contribution complemented their own, be it resource or knowledge based. This corroborates Luo (2008), who found significant importance attached to mutual gains and a loss of interest if there was an imbalance in the dependence relationship in the laboratories she studied. In this study, this kind of dependence was especially evident in some disciplines. A participant in agriculture, for example, narrated how they relied on Kenya Seed Company<sup>37</sup> for mass production and marketing of the seeds they bred in their laboratories. While the university had the knowhow and laboratories, they did not have the capability to produce and market the seeds, making their collaboration complementary. This kind of dependence possibly accounts for some of the patterns in collaboration observed within and outside the academic research community, mainly with organisations that provide complementary services.

Funding emerged as an important motivator for collaboration in two ways: Firstly, the requirements of funding bodies e.g. the NCST requires a research project to be multi-institutional to win a research grant. This is intended to encourage collaborative research and avoid duplication of research, as observed by the participant from NCST. This is in line with funding policies elsewhere such as those employed by the Research Councils in the UK (RCUK), as evident in the many research grants targeting collaborative research both at national and international levels. For example, in support for international collaboration, the RCUK and National Science Foundation (NSF) in the UK entered into a research funding agreement in September 2013, aimed at promoting collaborative research partnerships between the two countries (RCUK, 2014a). Secondly, researchers seek collaborations with organisations that can provide funding or individuals with access to funding, which may not necessarily impose the requirements above. Perhaps this accounts for the relatively high number of ties with international organisations as seen in Figure 5.7.

As seen in Table 2.2, others get into collaborations for mentorship purposes, personal gains such as increased recognition, increased productivity and as a way of acquiring external

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<sup>37</sup> Kenya Seed Company, is a state corporation mandated with producing and marketing top quality seeds for the country's farming community

rewards. Although a student-mentor relationship was not considered a collaborative research project in the definition of collaboration applied for this study, a number of respondents indicated their collaborations revolved around student supervision. While the number of PhD students supervised is a plus for their career, involving students was seen as a way of speeding up the work. Students, especially those incorporated into collaborative research as part of their graduate studies, will in most cases work enthusiastically to deliver on the project requirements as well as get their qualifications. On the other hand, faculty members were referred to as busy with less time to commit to research, probably accounting for the motivation to work with students.

The motivation for collaboration may influence some collaboration processes, such as output production and productivity levels of scientists (Melin, 2000). Consistent with Lee & Bozeman (2005), who found having complementary skills has significant impact on productivity, those who consider sharing skills an important motive were found to have considerably higher rate of publication productivity than those who collaborate to share equipment. This could be an indication that collaborations targeted at shared intellectual gains are generally more productive than those brought together for material gains.

As seen in Table 5.3, a number of respondents indicated they consider reputation important in their choice of collaborator, thus seek collaborations with reputable individuals in particular research areas. This can be for a number of reasons, including that reputable individuals may have more influence in attracting funding grants (Milojevic, 2010; Beaver & Rosen, 1979), have more experience in doing research collaboratively, or to get access to their networks (Crane, 1969). The anticipation of receiving credit through collaborating with such individuals may thus act as a motivating factor for getting into a research collaboration. Perhaps this can be seen to support Bozeman & Corley (2004) findings that the number of collaborators increases with job rank and status, and accounts for the structures observed in Figures 5.2-5.5, where certain individuals seem to be ‘stars’<sup>38</sup> in the networks.

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<sup>38</sup> Stars in the network are referred to by Milojevic (2010: 1) as ‘highly connected scientists’ who hold many direct connections thus central positions in the network. Such are the people with many connections in the network diagrams.

### ***Skills and capability***

Having special skills or expertise emerged an important consideration in selection of prospective collaborators. The interdisciplinary nature of research, especially observed between agriculture and engineering in Figure 5.6 could partly be a result of search for skills and expertise across disciplines. A positive correlation is consistently attained between level of academic qualifications and collaboration and productivity, consistent with the findings by Duque et al (2005) and Ynalvez & Shrum (2011). Post graduate research training, especially at the PhD level is important in building research capability. However, attaining the qualifications is a complex issue for many. In most cases, academic institutions only sponsor those who work within their institutions to do a PhD. The amount of fees charged for PhD studies is relatively high and unaffordable for those who wish to pursue the studies and are not part of the university community. The problem is compounded by shortage of mentors and PhD supervisors in some disciplinary areas, with the majority seeking to study abroad, as seen in Gaillard & Tullberg (2001). Some of those who study abroad choose the ‘greener’ research careers and opportunities presented there, opting not to take the knowledge and skills back to their countries. This contributes to brain drain, noted as a common problem in Africa in Jowi & Obamba (2013) and Mouton (2008).

However, it should be noted that the qualifications alone may not prepare one enough for the actual experiences as much is learnt in practice. Luo (2008) and Finholt & Olson (1997) note that much knowledge in science is tacit knowledge, usually learnt through face to face interaction, exposure to work practices and cutting edge technology, attitudes towards work, all of which form part of the learning process.

### ***Personal attributes***

Personal attributes are considered important in establishing collaborative relationships, as they influence how one interacts with other members of the collaboration and perform their work, ultimately influencing the success of the collaboration. Trust in one’s capabilities, ethics, level of commitment, interests, attitude and preferences emerged as important factors the participants look for in a collaborator. Prior work experience was seen as important in establishing these characteristics. Its importance is highlighted in Cummings & Kiesler (2008), who found that prior work experience was a significant determinant of collaborative tie strength. Participants expressed the preference of working with those from

within their circles whose work experiences they were familiar with. However, those starting out on a research career may not have past experiences to draw from, thus the need for a common understanding and commitment towards achieving the projects objectives. Transparency and accountability, noted as lacking in some projects, were seen as important in group work. As noted in section 6.3.2 (Decision making processes), it was reported that the universities were trying to counter this by releasing funds in phases, where one has to account for what was previously released before authorisation for the next phase takes place. However, it was observed that this was likely to lead to delays and slowing down of the collaboration process. Mismanagement of funds is an ethical issue, which researchers need to deal with for better collaborations.

Personal compatibility is important for successful collaborations (Hara et al, 2003; Melin 2000; Kraut et al., 1987). Personal chemistry was highlighted in the study as an important ingredient for success. For this reason, university systems forcing people to be 'bed fellows' were faulted, with one participant quoting a scenario where people got letters on their desks informing them they are to be part of collaboration X and Y. Without prior consultation for consent, this may not guarantee interest in the project, neither does it guarantee chemistry between the collaborators. The views expressed are in support of Melin (2000), who observes that researchers should be left to make decisions regarding their collaborations themselves, and not to be imposed by funding bodies and policy makers.

Trust in information security also determines the choices people make with regards to who to collaborate with and how. Consistent with Kraut et al (1987), information security did not emerge as a major problem in collaborative research in the quantitative survey (see Table 5.4). However, issues of mistrust were pointed out, especially as regards collaborations involving industrial partners as in Amabile et al. (2001) study. Problems of lack of research ethics were pointed out as common in Kenyan universities. Similar observations were highlighted at a workshop on authorship, integrity and plagiarism organised by Linkage of Industry with Academia (LIWA), NCST and other collaborators at Laico Regency, Nairobi 23-24 February 2012. In this workshop, it was reported that 'academic dishonesty is rampant today although integrity should be an important component in the academic experience', partly blamed on pressure to publish (NCST,

2012, p.50). Lack of ethics and dishonesty strains a collaborative relationship, and may affect an individual's perception towards collaborative work as they may become very suspicious of future collaborators.

### ***Personal Networks***

A sense of belonging to a certain group or network of scholars encourages sharing and development of new ideas. Luo (2008) notes that being part of and getting involved in a certain network or community of practice helps promote group identity, which in turn gives way to free sharing and information flow, encouraging collaborative activities and growth of stronger ties. The statement of one of the participants that 'after working for some time you get to know who to turn to if you need a collaborator' is an indication that networks grow gradually with time, with the individuals developing mutual dependence on each other for work and advice. Participants expressed concern at the lack of avenues through which they can extend personal networks, such as lack of source of information on other researchers and their areas. Existence of active broader disciplinary networks would facilitate the formation of links with those within the broader network, acting as a source of ties for the personal networks.

### ***Demographic factors***

Unlike other studies that have found gender differences in level of collaboration (Ynalvez & Shrum, 2011; Bozeman & Corley, 2004), this study, consistent with Lee & Bozeman (2005) and Duque et al. (2005), finds gender differences not significant in determining collaboration and productivity. Fewer women than men are involved in collaborative research, possibly because there are fewer women in scientific disciplines. For example, statistics from ten universities in Kenya indicate that in 2010, only 3% of academic members of staff in science and technology related disciplines were female, with equally low enrollment of female students in these disciplines, at 17% in 2009 (Masanja, 2010). However, for those who are, the non-significant result can be interpreted to mean they collaborate relatively at the same level with men.

Unlike Lee & Bozeman (2005), age is not significant in determining collaboration and productivity, though statistics in Table 5.1 reflect the most productive age in all forms of output as being 41 – 60 years, while the earlier and later years are less productive. This

corroborates Lee & Bozeman's finding that research activity peaks at a certain timeline in one's career and gradually falls with age.

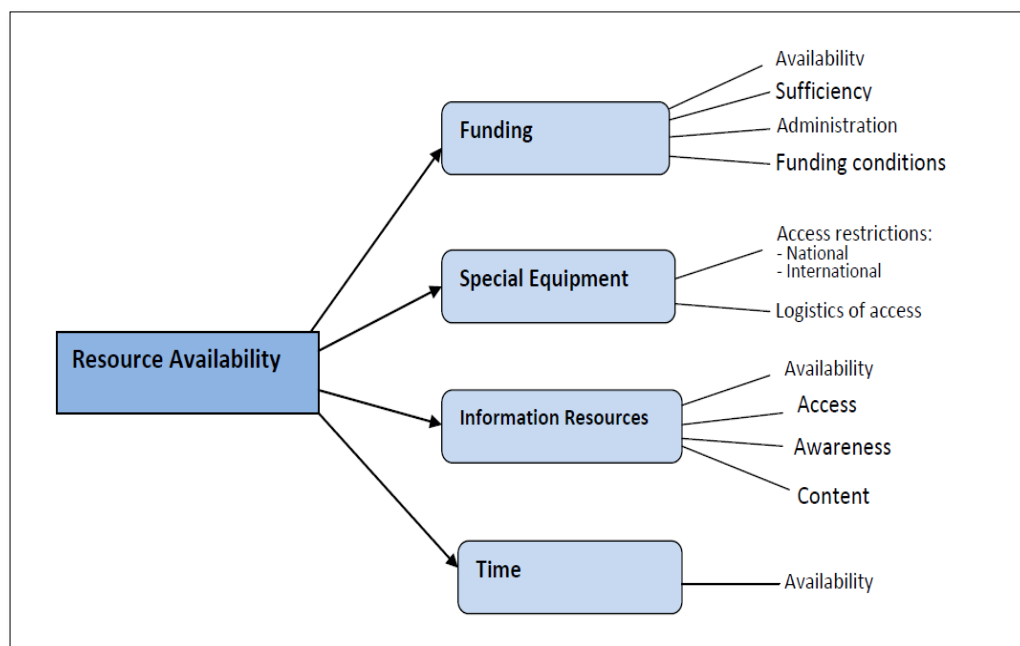
Like Duque et al (2005) and Ynalvez & Shrum (2011), the results of this study point to significant differences in levels of collaboration and productivity across categories of academic qualification, with those with a PhD having higher levels of collaboration. This is consistent with Bozeman & Corley (2004) who realised that the level of collaboration increased with job rank, with research faculty and group leaders having the highest levels as compared to post docs and non-tenured faculty. In comparison with Kenyan university systems, the job rank can be likened to the level of academic qualification, as job ranking is mainly based on academic qualifications, years of service and productivity levels.

Differences in collaboration are observed based on where academic qualifications were attained, with those who studied in developed countries reflecting higher levels of involvement as compared to those who studied in developing countries. This could mean the active research environments they become part of 'socialise' them towards being research active individuals. Crane (1965) and Long (1978) found that training in a major university had significant effects on the scientists' career including access to research facilities and opportunities presented in working with prominent scientists, associated visibility and expanding networks. Similarly, it can be assumed that those who study in developed countries mainly have more exposure to active research environments. They are presented more opportunities for making ties with research active individuals and being incorporated into active research networks, thus more opportunities for doing collaborative research. The combined benefits are manifested in their future research careers. On the other hand, a number of participants pointed to poor research cultures in Kenyan universities. The individuals operate under less stimulating research environments, with less to learn from their peers, less motivation to do research, contributing to lower collaboration levels.

#### **6.4.2 Resource availability**

In this study, it was established that availability of resources was a major determinant of scientists' collaboration levels and behaviour. Participants cited problems related to availability of funding, special equipment, information and communication resources and

time, as presented in figure 6.3 below. This section presents a discussion of these factors and their effects on scientific work.



**Figure 6-3 Resource availability factors affecting collaboration processes**

### ***Funding***

Funding was the most commonly cited resource based problem facing research collaborations, corroborating Gaillard & Tullberg (2001) and Harle (2007). It was noted that there was low investment in research by the government. Statistics presented in the *African Innovation Outlook* (NEPAD, 2010) show that Kenya spent only 0.48% of the GDP on Research and Development (R&D) in the years 2007/2008, way below the 1% endorsed by the African Union Executive Council in 2006 (African Union, 2006). This figure was confirmed by a participant from NCST, who noted that the government spent approximately 0.4 % of GDP on research, corroborating statistics presented in UNESCO (2011) and UNESCO (2012) on R&D spending by countries in sub-Saharan Africa.

Government funding to universities constitutes only approximately 30% of the universities operational budget (see section 3.5). As the universities struggle to meet the budget deficits, they barely have funds to commit to research. During the data collection, it was established that the government allocates an additional Ksh 400M (~£3.1 Million) through the NACOSTI towards promoting Science, Technology and Innovation (STI) (section 3.5).

However this, described as a ‘drop in the ocean’ by one of the participants, is barely enough and only reaches a select number of researchers. This therefore reflects very low funding levels, compared to the amounts allocated to research in the developed world. For example, in the UK, research is funded through seven major research councils, who receive funding from the government's science budget, administered through the Department for Business, Innovation and Skills (BIS). This budget was £3.2 billion in 2010-11 (RCUK 2014b), which is ~1000 times of the current research budget in Kenya. In addition, their strong links with industry provide for a wider resource base. The business enterprise constitutes approximately 60% of R&D funding in the UK, as compared to Kenya’s 16% (UNESCO, 2012).

The underfunded nature of research in Kenya was partly attributed to the low priority given to research funding, both at the national and institutional level. Perhaps this partly explains the emphasis on teaching over research, as indicated by most of the participants, consistent with Harle (2009) and Gaillard & Tullberg (2001). There was an indication that teaching is seen as a more reliable means of raising funds. With teaching, the researcher is assured of some income at the end of the day so long as he delivers the service, while the institution is assured of income from tuition fees paid, so long as they have the numbers (in form of students). On the other hand, participants pointed to research as involving long processes, no certainty of getting funded and if funded, income is not predictable. The benefits may not be in direct financial terms, and may take a longer time to be felt. The need to raise funds has led to universities increasing their student numbers, noted in Kashorda & Waema (2014), and is evident in the influx of parallel degree programs in major public universities. The numbers of teaching staff is not in many cases proportional to the high volume of student admissions, leading to the commonly cited problem of high teaching loads, also identified by Harle (2009).

Consistent with past studies (Shrum & Champion, 2000; Harle, 2007; Mouton, 2008) this study confirmed the high dependence on donor funding to support research, with the majority of the respondents (65%) indicating their source of funding as international organisations. A number of participants indicated they are most likely to seek collaborations with organisations that can provide funding, probably accounting for the relatively high number of ties with international organisations (see Figure 5.6). This is



consistent with Birnholtz (2007) and Luo (2008) who found that resource dependence was important to the groups they studied in decisions of whether to collaborate and with whom. Much reliance on donor support may reduce the independence of researchers in what research they carry out, how they carry it out and dissemination processes. Shrum & Beggs (1997) note that ‘donors, and international organizations continue to maintain a diversity of goals and interests in developmental issues’ (p.1), a view shared by Mouton (2008). Their interests sometimes may not coincide with the researchers interests, and may reflect much control over some processes such as output dissemination. For more impact of research on developmental issues, it’s important that researchers and the country at large have more ownership of the research process and output, through investing more in research.

Insufficient funds, identified by Sonnenwald (2007) as one of the emergent challenges at the ‘sustainment stage’, also emerged as a problem in some collaborations in this study, consistent with Harle (2007). This was partly blamed on poor budgeting in the proposal, and the length it takes for approval of proposal within which fluctuations in money markets make equipment more expensive than was stated in the budget. Some participants noted a lack of understanding by donors on the context of research, as in Shrum (2005). This puts a strain on some project activities, resulting in delays in completion time as the researchers look for alternative funding. Some participants reported that faced with the problem of insufficient funds to complete the proposed work, they resorted to cutting down on the tasks. In some cases, this may seriously affect the quality of the end product, or lead to incomplete reports, which at times beat the logic of having put money and time into something that would be undeliverable, or be delivered when it has lost value with time. In addition, as found in Cummings & Kiesler (2003) and Luo (2008), a consequence of shortage of funds would be reducing travel expenses or other support for some scientists, which would mainly affect junior scientists.

When funding was available, respondents also cited the problem of administration of funds. A number of participants faulted the many bureaucratic processes at the universities in release of funds, which were seen as slowing down some processes and a cause for misunderstanding by collaborators who did not understand how the university systems operate. Consistent with Harle (2007), mismanagement of funds was also cited, which led to incomplete projects and delays in project delivery deadlines. In some cases, funds meant

for research are directed to other university projects. It is surprising that the reason given for directing the funds to other areas was researchers did not apply for funding. Lack of information on funding opportunities emerged as one of the major reasons for non-involvement in collaborative research, which perhaps reflects a lack of awareness of such funding. This can partly be attributed to poor information dissemination systems at the universities, also noted in Harle (2007), as discussed in section 6.3.1 (Access to information). It could also be a reflection of the low priority given to research, thus research funds are easily directed to what is seen as ‘more wanting’.

### ***Special equipment***

Consistent with Melin (2000), access to special equipment scored highly as an important motivation for collaboration (see section 6.4.1). One participant gave an example of a Polymerase Chain Reaction (PCR) machine, that is very expensive and only owned by a few institutions. He noted that one of the ways of gaining access to its usage was collaborating with a person from the organisation owning it, or simply requesting for access. This kind of collaboration is referred to as service collaboration in Laudel (2002). This is complicated by university structures that put restrictions on use of their equipment, with some participants indicating that they preferred seeking collaborations with organisations with less rigid structures, such as research institutes. This perhaps contributes to the relatively high number of ties with such institutes as observed in Figure 5.7. It was also noted that access to equipment in other countries is hampered by international laws that put restrictions on the kind of materials acceptable in the country. This also affects decisions on choices of collaborators.

The government has allocated an ‘equipment fund’ in an effort towards solving this problem, whereby it purchases an expensive equipment, and locates it in one of the institutions for use by those who need its services from the surrounding institutions. This aligns with Finholt & Olson (1997) proposal of concentrating expensive equipment in specific locations to maximise utilisation of the investment. However, remote access mechanisms proposed by Finholt and Olson are hampered by nature of the equipment and poor computer networks and associated tools for access. Researchers are therefore required to access the equipment physically. The logistics of sharing the equipment with people who

are hundreds of miles apart, coupled with constraints such as time, travel funds and poor communication infrastructure pose extra challenges.

### *Information resources*

Though Harle (2010) argues that availability of scholarly literature is no longer such a problem in the East and South African universities, a number of respondents reported problems with access to digital resources. This is an indication that this is still quite a problem and an area of great concern. Harle's findings could have been affected by the sample used, a sample of only four universities in East and South African regions. In Kenya, he sampled only the University of Nairobi. Being the oldest, most established and leading university in the region, it has relatively better facilities than the other universities. Interestingly though, 80% of the respondents from the University of Nairobi indicated sites and material that require payment for use as problematic, an indication that they face the same problems as other universities in accessing digital resources. This could be an issue of lack of awareness of available digital resources, an issue raised by Harle (2010), or limitations in access as a result of poor ICT systems and internet connectivity problems as seen in section 5.5.5, consistent with Muinde (2009) and Kashorda & Waema (2014). Universities repositories mainly lack in content that is useful to the researchers. A study of the university repositories revealed that only one university at the time of data collection had made concerted efforts to compile a compendium of research activities, and was in the process of rolling out a research management system to organise all their present and past research.

### *Time*

Coming second to problems of funding and access to equipment, a number of respondents indicated time as a major barrier not only to collaborative research but research in general, consistent with Harle (2009) and Ynalvez & Shrum (2011). Participants noted a lack of research culture in Kenyan universities, with more emphasis on teaching. With low budgetary allocations, universities find they need to survive and one of the ways they do this is through huge student intakes, as noted in Kashorda & Waema (2014), which are not proportional to the teaching staff. This results in high teaching loads, the result of the common complaint of lack of time to do research, consistent with Harle (2009), though contrary to Gaillard & Tullberg (2001), who found less than 4% of the studied population

saw lack of time as a constraint to research work. The high teaching loads, coupled with the many other administrative and professional duties leaves little time for research. This perhaps can be seen as accounting for the fewer professional ties reported by academics in Shrum & Campion (2000), as opposed to ties reported by those in other sectors – research institutes and NGOs. Participants expressed a desire towards reduction of teaching loads for those in research. However, it also emerged that teaching was seen as holding more reliable financial benefits valued by many in academics as opposed to research. Though it may partly solve the problem of lack of time to do research, it may not be the magic solution to getting people to do research. A change in perception and deeper understanding of the need to do research despite financial benefits would be needed to instill a research culture into Kenyan universities.

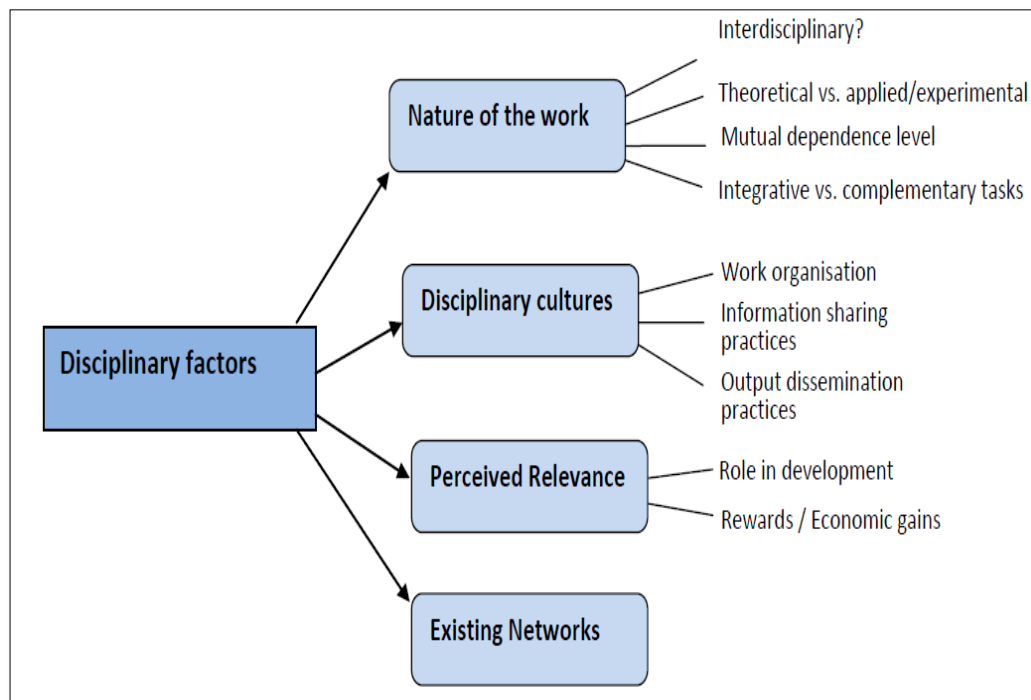
#### **6.4.3 Disciplinary factors**

The results of this study indicate that collaboration and productivity levels differ significantly between disciplinary areas, consistent with Lee & Bozeman (2005), Melin (2000) and Birnholtz (2007). Agriculture has the highest levels of collaboration and forms a more tightly connected and diversified network as compared to the other disciplines (see Figures 5.2 - 5.5).

This category highlights how factors related to nature of the work, the different disciplinary backgrounds and perceived relevance affects the collaboration processes.

##### ***Nature of the work***

Nature of the work determines the level of dependence for resources, work and skills, and frequency of interaction between partners in performing the tasks (Hara et al, 2003; Olson & Olson, 2000; Whitley, 2000; Chompalov et al., 2002). In this study, those who indicated the nature of their work as predominantly experimental or applied, reflect a higher level of mutual dependence for knowledge and special equipment and have relatively more collaborations than those who indicated as predominantly theoretical. For example, none of those indicating the nature of their area of specialisation as theoretical had more than two collaborative research projects, while 35% of those who indicated their area of specialisation as applied had three or more research projects. This corroborates views expressed in past studies including Katz & Martin (1997), Lee & Bozeman (2005) and Becher & Trowler (2001).



**Figure 6-4 Disciplinary factors affecting collaboration processes**

Whitley (2000) sees differences in nature of intellectual fields as mainly resulting from their task uncertainty and mutual dependence (see section 2.4- Disciplinary factors). This, according to Birnholtz (2007), affects the rate of collaboration between disciplinary fields. The nature of the work as described by a number of agriculturalists indicated awareness of problems that needed to be solved. This is evident in the disciplinary networks that exist to support work relating to particular issues, reflecting low levels of task uncertainty. A number indicated the need for seeking those who can complement their own capabilities, reflecting the mutual dependence in their field to solve certain issues. In contrast, a participant observed research in computing as not being well structured and lacking in disciplinary networks, perhaps a reflection of less defined research problems and areas thus high task uncertainty. This could be contributing to the relatively lower levels of collaborative work within computing.

Surprisingly though, Chi square tests of association between disciplinary area and nature of the tasks yielded a statistically non-significant result ( $\chi^2 = 9.65$ ,  $p = .646$ ). This could probably be an indication that the general nature of the tasks cannot be judged at the disciplinary level. This supports Birnholtz (2007) argument on the significance of looking

at the micro level of work attributes of individuals rather than the collective orientation of disciplines, for a better understanding of collaborations. A similar argument was advanced by Becher & Trowler (2001) and Fry (2003), who look at the specialism area as more defining in studying the organisation of science rather than the broader disciplinary levels.

### *Disciplinary backgrounds and cultures*

Diverse disciplinary backgrounds scored low on being a problem within collaborations in the quantitative survey. However, it has been noted in past studies (Walsh & Maloney, 2007; Sonnenwald, 2007; Finholt & Birnholtz, 2006; Borgman, 2007) that differences in work organisation and cultures of different disciplines may affect collaboration processes. Agriculture, being one of the oldest and most established disciplines in the universities sampled, has over the years built a culture of research mostly done collectively. The network diagram (Figure 5.2) shows a closely knit society, with more than 80% of the participants involved in collaborative work. Years of doing research in agriculture have seen the departments and individuals establish links with other university departments, research institutes and private organisations engaging in similar research, thus the likelihood of more collaborations taking place. In contrast, as noted above, computing, in the words of one participant is relatively new with less defined research areas and not well established research networks. In addition, the low levels of manpower trained to do research in computing, as exemplified by the number of individuals with a PhD in this field, partly contributes to lower levels of collaboration.

Participants in this study were in agreement that increase in group diversity, as reflected in various disciplinary backgrounds, and identified as a common source of misunderstanding in Walsh & Maloney (2007) calls for a common understanding of issues affecting the collaboration. This view is supported in Finholt & Birnholtz (2006), who established a number of differences emanating from cultural backgrounds of earthquake engineers and computer scientists, regarding specification of user requirements in their development of a cyber-infrastructure to support the engineer's work. In their study, while engineers believed in a detailed specification of requirements at the initial stages of a project, computer scientists believed in starting with high level requirements to be refined as the project progressed. This brought about conflict and mistrust between the two, mainly resulting from their different work styles. Similarly, Shrum et al. (2001) found differences arising

due to different perceptions regarding use of email, due to the culture of email use in the different groups' within their local environment. Other studies have found differences in information sharing practices across disciplines. While some are very secretive in nature on sharing information outside of their collaborations, others are quite open. For example, Walsh & Bayma (1996b) found that experimental biologists were quite secretive with their data/information as opposed to mathematicians. This kind of secrecy was observed especially with some individuals in public health, some of whom had issues with disclosing information on their collaborations at the data collection stage. Issues of secrecy were also pointed out within university industry collaborations. It was noted that those from industry were quite secretive and cautious about releasing information regarding their operations, citing information security and fears of their information being shared with their competitors. This lack of trust can strain a collaborative relationship affecting overall processes including output dissemination.

#### ***Perceived relevance of research in the field***

This study found significant differences in level of collaboration between disciplines. Some participants attributed this to funding sources that favored some disciplines more than others, probably a reflection of interest in the kind of research done. There was an indication that priority is given to research addressing local needs such as food security, consistent with the views of Duque et al. (2005), Harle (2009) and Adams et al. (2010). This may influence the funding patterns and consequently collaboration levels, corroborating Price & Beaver (1966) who associate higher levels of collaboration with financial support and level of dependence on each other. Perhaps this can be seen as an indication of the knowledge production process in this region moving towards Mode 2, which is focused on addressing practical problems facing the society (Gibbons et al, 1994). However, some participants did not look at it in this sense. With much of the funding originating from international organisations, one participant in the interview claimed that there was a general perception that those from developing countries are supposed to be 'consumers', not 'producers' of technology, thus less interest by international funding bodies in funding technological projects, such as those in engineering. This can be seen as a reflection of the effects of too much dependence on donor support, who Shrum & Beggs (1997) and Mouton (2008) note determine what research is done and how it is done.

However, problems in capability to produce emerge as reflected by the poorly equipped laboratories, also noted in Gaillard & Tullberg (2001). For instance, a participant noted that machines in their engineering workshops had long broken down and even students had to travel a distance of over 300 kilometers in order to access machines in another university. If for instance production of a particular technology requires much reliance on support in terms of equipment from the developed world, then it follows that those who own the equipment are better placed, both technologically and manpower wise to produce and claim ownership on the technology. The claim of being a ‘consumer’ would not then hold because of lack of capability to be ‘producer’. This should be seen as a wakeup call to the government – that it needs to invest in equipping scientists from whichever field with basic equipment for them to be able to move from being ‘consumers’ to ‘producers’.

### ***Disciplinary networks***

The existence of disciplinary networks that address research in various fields creates an avenue where researchers can identify and address various problems facing their area of research. They also act as platforms through which funds towards research can be sought and directed (Harle, 2007). Such networks and organisations seem to be more established and stronger in agriculture, having been a focus of interest and support since pre-colonial times, as seen in Gaillard et al. (1997). In comparison to the other disciplines, a relatively high number of participants in agriculture, associated with higher levels of collaboration, indicated various organisations and networks linked to their area as their source of funding. Examples of those that were commonly cited as supporting or funding agricultural research are the Food and Agriculture Organisation (FAO); the International Fund for Animal welfare (IFAW); the Regional Universities Forum for Capacity Building in Agriculture (RUFORUM); the Alliance for a Green Revolution in Africa (AGRA); The Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA); and The Consultative Group on International Agricultural Research (CGIAR). Others support research in particular specialist areas such as International Centre of Insect Physiology and Ecology (ICIPE) and the International Potato Center (CIP).

### **6.4.4 Institutional factors**

Universities have an obligation to create an enabling research environment for their members. Participants suggested ways of doing this as including provision of forms of



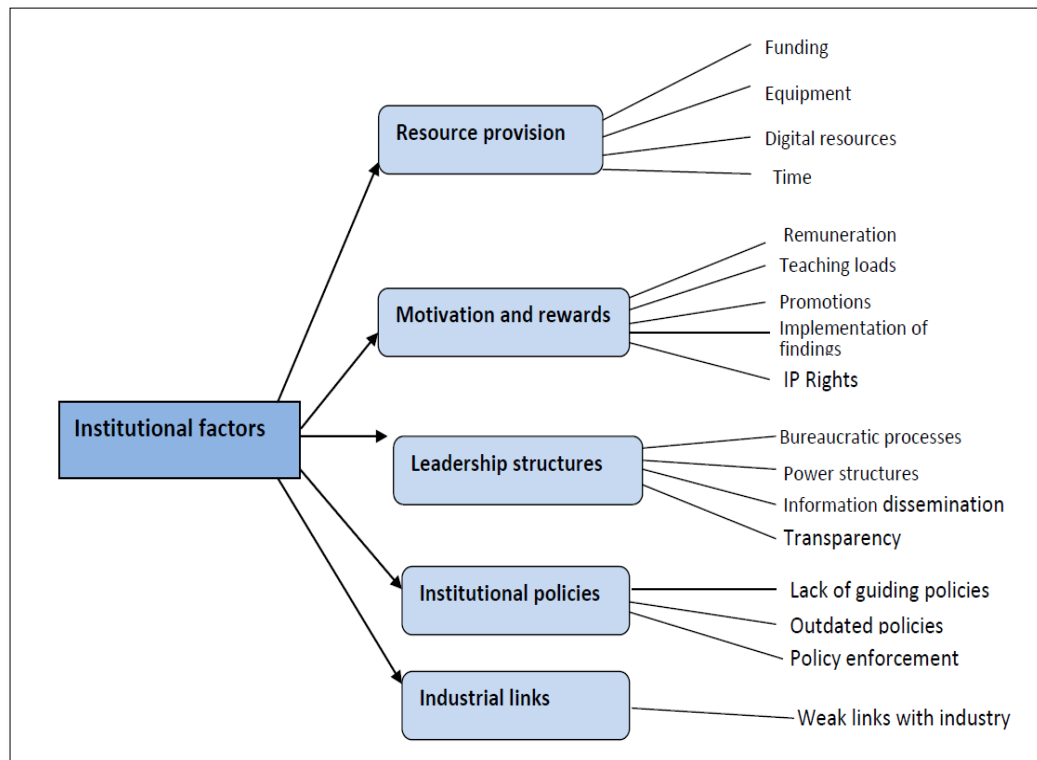
resources discussed in section 6.4.2, improvement of communication infrastructure, both in processes and facilities, and provision for motivation and rewards. Differences in institutional structures such as the prestige accorded to an institution have been found to have an effect on research resources and productivity levels of individual scientists and institutions (Crane, 1965; Long, 1978). However, this study found no significant differences in levels of collaboration or productivity between institutions. Perhaps this could be a reflection that the universities are faced with similar kind of contextual situations, thus none emerges as superior to the other in research performance. However, it is interesting to note that significant differences emerge in levels of collaboration across institutions in past projects. This can be seen as supporting Gibbons et al. (1994) theory of shift towards the Mode 2 type of knowledge production process, in which research is said to be becoming less institutionalised. Though it has been argued that not all institutions in Africa and even in a particular country are equal in their research capacity (Harle, 2009; Mouton, 2008), the differences are probably reducing due to more calls for cross institutional research by funding bodies. To encourage cross institutional collaborative research, the government, through NCST, has made it mandatory that a research proposal should include individuals across various institutions, which was not the case in the past years.

This section discusses institutional factors affecting collaboration processes, including resource provision; management and leadership structures; motivation and rewards; capacity building; and policy and regulatory frameworks.

### ***Resource provision***

Access to resources emerged a major problem affecting research collaborations in this study. Insufficient budgetary allocations from the government as seen in sections 3.5 and 6.4.2 limits the university's ability to fund research. Faced with the problem of having to service the deficit, universities are faced with the problem of having to set priorities for their most important needs. Unfortunately, research happens not to be high on their list of priorities, as seen in the percentage of their budgets that go to research. Researchers are left to rely heavily on donors to fund their research, consistent with Shrum & Campion (2000), Gaillard & Tullberg (2001) and Harle (2009), probably accounting for the relatively high number of ties with international organisations, as seen in Figure 5.7. Institutions are

seeking partnerships with international institutions, organisations and industrial partners as a way of promoting intellectual exchange as well as providing opportunities for those in developing countries to access knowledge and resources in developed countries.



**Figure 6-5 Institutional factors affecting collaboration processes**

An example is Moi University’s collaborative partnership with the Flemish Interuniversity Council, Belgium (VLIR). This partnership involves academics and experts from Universities in Belgium and several members of staff in particular engineering departments at the university, thus displaying increased collaboration.

In addition to prioritising funding, universities would need to invest in acquiring necessary equipment and facilities, put in place mechanisms to ensure they are properly maintained to be of use to researchers. A number of machines that had long broken down were observed in one of the engineering workshops. Lack of funds to repair and maintain them had rendered them useless and eventually outdated, consistent with Gaillard & Tullberg (2001). Having to rely on laboratories in other institutions, several miles away could adversely affect the motivation to do research, collaboration choices made and accomplishment of

project goals, given the time needed for travel and conditions imposed on use by the servicing universities.

### ***Motivation and rewards***

Poor remuneration packages, consistent with Harle (2007) and Gaillard & Tullberg (2001), and motivation and reward mechanisms were identified as affecting research work. Motivation is viewed in different ways by various individuals. While a number indicated preferring financial gains, others look at recognition and promotion as their source of motivation. Some pointed to institutional cultures that gave more priority to teaching as opposed to research, thus high teaching loads that affected motivation to do research (see section 6.4.2). Participants complained of lack of recognition of efforts made in research and innovations. One was specific that the kind of recognition she was interested in was promotion, which was not forthcoming ‘even after making the university that much money’ (PH\_1). Perhaps the university systems need to revise their reward systems to recognise such individuals both in form of promotion and benefits arising from their innovations. Consistent with Ynalvez & Shrum (2011), who noted that Filipino scientists were more interested in material gains from research (as a form of rewards), some participants expressed dissatisfaction at the financial gains they accrued from their innovations as individuals. The university was seen as the major beneficiary, with one noting that he’d rather collaborate with private organisations, associated with much more financial gains.

Lack of implementation of research findings in commissioned research, in the words of one participant, robbed them of the morale to do more research if the previous reports or findings had not been acted on. Similarly, Opata (2011) notes a disconnect between research and policy in Kenya. Roger Harris, in an article written for Research to Action organisation, on July 29th 2013 notes that in order to improve impact of research ‘researchers must have the intent to influence policy and practice for their results to do so, and the intent should be written into the research design’ (Harris, 2013). Harris notes the different view of research output and impact between researchers and practitioners, whereby researchers are more worried about publications and citation counts, while practitioners are interested in actionable advice. Perhaps the university systems need to place more emphasis on practical impact in their reward mechanisms as opposed to basing rewards on publication counts, a view shared by Muinde (2009). This would encourage

researchers to design proposals and research that will be of interest to community, increasing its chances for implementation and impact.

### ***Leadership structures***

Leadership and management structures influence processes such as access to resources, decision making and communication processes. Many levels of authority were identified by Shrum et al. (2007) as complicating decision making processes. University leadership structures were indicated as being characterised by stiff bureaucratic processes with decisions and approvals having to pass through many hands. This affects collaboration processes and causes unnecessary delays to accomplishment of tasks. Such are the processes involved in getting collaborators from outside of the universities utilise university resources, and lengthy procedures in processing and release of project funds, which sometimes were a source of conflict and misunderstanding. Participants reported that those in management at times did not seem to understand the urgency of some of the work or requests made by the researcher. This reflects a conflict in interest between management and researcher interests, also observed by Muinde (2009) and Melin (2000).

Lack of information on collaborative research and funding opportunities scored relatively highly as reasons for non-involvement in collaborative research (see Figure 5.1). Poor communication systems were cited as a barrier to free flow of information, with participants expressing the concern that at times information on available opportunity did not trickle down to the average researcher, consistent with Harle (2007). The processes of disseminating the information followed the hierarchical structures with the information being shared only between those who were higher up in the hierarchy, perhaps a reflection of the organisation referred to as Beaver & Rosen (1979) of the professional elites who were favored in funding decisions. This implies the need for more transparent information dissemination practices, which can be enhanced by use of ICT.

### ***Institutional policies and strategies***

Though there were no significant differences in collaboration and productivity between institutions, it was evident that some universities have better policies and structures in place to support and encourage research. For example, only one among the four universities studied has well-structured proposal writing workshops, which participants felt was important towards winning grants to fund research. One of the four universities has made

concerted efforts in making it mandatory for all members of staff to upload their CVs online, including research profiles and publications, a valuable source of information when seeking collaborators. Only one university had a research management information system that was in the process of being rolled out at the time of data collection, providing information on forms of research that was going on in the university. Though research ethics emerged an issue affecting conduct of research, only one university has a plagiarism policy, first introduced in 2013.

Lack of proper guiding policies, also noted in Mouton (2008) and Harle (2009), on issues such as IP rights in some cases resulted in conflicts in collaborations involving the university and industrial partners, as seen in section 5.4.3 (IP right issues). This was the case especially where terms were not agreed on clearly at the initial stage of forming the collaboration, an issue noted in Sonnenwald (2007). Disagreements have also arisen between university management and individual researchers on IP rights and ownership over inventions/innovations by individuals within the university system, which were termed as exploitive as they were meant to benefit the university.

Universities are largely responsible for developing research skills and capabilities for their members of staff. This is dependent on the existing policies and regulations on staff training and support to further studies. While some universities are very keen on their members of staff attaining PhD qualifications eg giving paid study leave for members to study abroad, one of the universities sampled for this study insists on junior members of staff gaining qualifications from within the country. This comes with challenges in getting appropriate supervision in some disciplinary areas. Some participants expressed concern in lack of support in proposal writing process and gaining specialised skills such as in data analysis. This calls for a need to put in place elaborate measures to support capacity development by targeting a wide range of skills that researchers need to support their collaborative work.

Thus, it's important that the universities devise policies and processes that support and encourage collaborative research, whether in form of provision of resources, access to information, conduct of collaborations, training, administrative and technical support issues. Harle (2009) also notes the need for policies to be well linked. The policies would

need to be revised with time to reflect changes and new developments in the process of conducting research.

### ***Facilitating links with industries***

A number of participants noted the weak links between universities and industry. In agreement with Smith & Katz (2000), some of the participants observed that partnering with industrial partners would lead to benefits of funding and sharing equipment, which were widely cited as barriers to collaboration. In addition, this facilitated creation of links through which their students would benefit through industrial attachments and jobs.

In an effort to promote industrial links, the NCST is partnering with British council on the Africa Knowledge Transfer Partnership (AKTP), to help improve diffusion of skills between businesses and institutions of higher learning (NCST, 2012). However, for such programs to be successful, universities need to market the range of skills available and create confidence in their ability to solve issues relevant to the industry. The need to write quality proposals and design research that addresses practical issues in the society, a characteristic of the Mode 2 type of knowledge production advanced by Gibbons et al. (1994) was seen as important in improving integration with the industry. A participant faulted much of the curriculum offered as not being ‘in tandem with the contemporary practices of the world thus bringing about some disconnect between the industry and the academia’ (COM\_2). Redesigning the curriculum to reflect current issues would create more confidence in what universities can do, thus contribute to strengthening of industrial links.

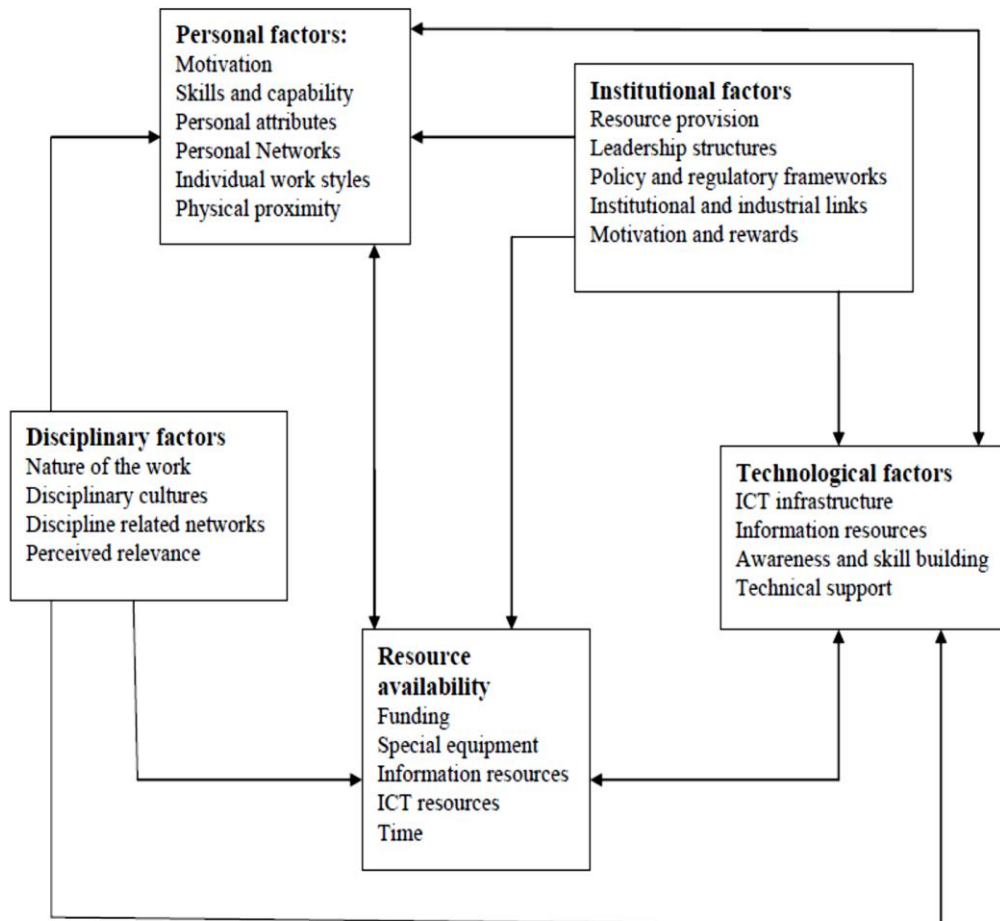
### **6.4.5 Technological factors**

The communication support infrastructure in place would affect major collaboration processes including establishing of connections, communication and coordination, decision making and output production processes. Use of ICT has been found to have positive effects in facilitation of these processes (as seen in section 2.7.1). Majority of the respondents were in agreement that use of ICT has made work easier by allowing flexibility in communication and task handling, especially for remote colleagues. However, many cited problems in use of ICT to support the processes, including poor internet connectivity, lack of awareness of existing technologies, problem of availability and access to digital

resources, acquiring software, technical support and training. The role of ICT and factors influencing adoption and use is discussed in details in Chapter Seven.

### 6.5 A MODEL OF FACTORS INFLUENCING COLLABORATION PROCESSES

A number of factors have been identified as influencing the organisation and conduct of academic research collaborations in Kenya. The factors, as discussed in section 6.2.3, are grouped into five categories: personal, resource availability, disciplinary, institutional and technological factors. Figure 6.6 presents a model representing a synthesis of factors, mainly derived from literature, but richly substantiated by findings from this study to come up with an explanatory model of factors influencing research collaborations in Kenya.



**Figure 6-6 A model of relationships between categories of factors affecting collaboration processes in Kenya**

Though the model is a result of the investigation in Kenya, its components can serve as a framework through which research communities and regions exhibiting similar

characteristics can be investigated to produce context specific information. The discussion below presents a brief description of how the factors within each category in the model interrelate with another, as indicated by the direction of the arrows.

***Relationship between personal factors and other categories of factors***

The *motivation* to do research is influenced by scarcity of funding sources and the efforts put into seeking funding (resource availability), bureaucracy in university processes, such as in disbursement of project funds and sharing of resources, heavy teaching loads and assumed financial benefits. Building *skills and capability* is affected by lack of institutional support (section 6.4.4 – Institutional policies and strategies). Size and participation in *personal networks* is influenced by the kind of work/disciplinary area and existence of active networks of researchers in the area, partly determined by level of establishment of the discipline (section 6.4.3-Disciplinary factors). Institutional links, facilitating access to information and meeting platforms promote the process of establishing connections and expanding networks

***Relationship between disciplinary factors and other categories of factors***

The *nature of the work* in some disciplinary areas requires a wide range of skills and collaboration between different teams or laboratories to get work done or for the purpose of sharing resources. This may result in bigger and more diverse disciplinary and personal networks, which may influence the establishment of collaboration ties, and communication and work processes (section 6.4.3). Differing *disciplinary cultures* affect work styles e.g. information sharing practices (under personal factors). *Perceived relevance* of the kind of work or disciplinary area affects funding support (resource availability) which is in turn affected by national and institutional support systems. Disciplines with more established *disciplinary networks* seem to derive a substantial amount of funding support as reflected in the diverse sources of funding indicated by the participants (section 6.4.3)

***Relationship between resource availability and other categories of factors***

Resource availability is affected by the nature of research, as reflected by the interest vested in some disciplinary fields. Resource availability is also affected by institutional and national support structures such as the priority given to *funding* research and developing ICT infrastructure (section 6.4.2). Poor *information resources* were said to limit access to information, an important part of the knowledge production process, and may affect the



motivation and capability to do research. Availability of resources contributes to growth of both personal and disciplinary networks as actors seek support in both skills and capacity in terms of equipment. *ICT resources* facilitate access to information resources and communication practices, as well as expansion of personal networks. In return, access to information resources is affected by ICT infrastructure (Technological factors), as well as institutional policies and capacity to facilitate access.

#### ***Relationship between technological factors and other categories of factors***

Availability and access to ICT resources is affected by national and institutional support structures that determine level of priority given to improving *ICT infrastructure* as well as support services such as *building skills* and *technical support*. Nature of the work (under disciplinary factors) determines the level of interdependency and need for ICT support as well as support for disciplinary network related activities. Personal factors affecting use of ICT include appreciation for ICT capabilities, that determine motivation to gain ICT skills, and individual working styles that partly determine use. In turn, technological factors affect access to a range of information resources and perceived relevance of ICT in supporting various collaboration activities.

#### ***Relationship between institutional factors and other categories of factors***

Support accorded by institutions in *resource provision*, be it funding, building ICT infrastructure, facilitating access to information resources affect the capability to do research, as this partly provides the basis under which collaborative research can thrive. Institutional *leadership* determine existence of and implementation of policies meant to improve research environments, such as acquisition of necessary resources and building capacity and skills, be it sponsoring doctoral studies or providing skills towards support of day to day research activities. *Motivation and rewards*, such as reduction of teaching loads for those in research is likely to raise the morale to engage in collaborative research (see section 6.4.4). *Institutional links* and /or support for establishing links can encourage growth of personal networks.

## **6.6 CHAPTER CONCLUSION**

This chapter has presented a discussion on the organisation, processes and conduct of collaborative research in Kenya, and the influencing factors, culminating in an explanatory model of factors influencing research collaborations in Kenya. A surprising finding in this

study, as seen in Chapter Five, is that the academic research community in Kenya exhibits relatively high levels of collaboration. This is contrary to past studies that have assumed low levels of scientific networking in developing countries (Gaillard & Tullberg, 2001; Harle, 2007; Adams et al., 2010), including Kenya. In Chapter Five, a number of variables identified as influencing research collaborations were tested and analysed for their effects on collaborative research in Kenya. This chapter synthesises these findings, relating them to past studies, to present a discussion on major factors influencing collaborative work. The factors are grouped into five major categories: personal, resource availability, disciplinary, institutional and technological factors.

The discussion in this chapter shows a major influence of external environment factors on collaborative research in Kenya. This is consistent with other studies that have identified a number of problems of doing research in developing areas, such as access to funding (Harle, 2009; Shrum & Beggs, 1997; Mouton, 2008; Gaillard & Tullberg, 2001), special equipment (Luo, 2008; Gaillard & Tullberg, 2001), information resources (Harle, 2009; Harle, 2010; Muinde, 2009) and time (Harle, 2009; Ynalvez & Shrum, 2011). These present a major hindrance, not only to collaborative research but also research in general. Institutional structures determine the kind of support and strategies levelled towards improving research environments, in terms of provision of resources, capacity development, motivation and rewards and smoothness of operations. However, unlike Crane (1965) and Long (1978) who found the research strength of a university was associated with prestige accorded to the institution, this study found no significant differences in collaboration, productivity or availability of resources, across institutions, an indication that the institutions generally operate under similar contextual situations and constrains.

Significant differences were observed in levels and nature of collaborations across disciplines, consistent with Lee & Bozeman (2005), Melin (2000) and Birnholtz (2007), partly attributed to nature of the work and perceived relevance that determines the level of support accorded to a certain field. Corroborating Mouton (2008) and Duque et al. (2005), there were indications that research geared towards addressing issues that presented significant problems to the country, such as food security was favoured for funding. An interdisciplinary, cross institutional research approach was favoured towards solving such

problems. This aligns with Gibbons et al. (1994) theory on the evolution of the Mode 2 type of knowledge production process, described as surpassing disciplinary and institutional boundaries, and mainly focussed on the context of application. However, though Gibbons et al. do not differentiate the rate of growth towards Mode 2 from a disciplinary perspective, the ‘context of application’ in this study seems to favour some disciplinary areas over others.

Mouton (2008) and Harle (2007) note that though there are a few exceptions, most countries in Africa display similar issues affecting their research systems. The resulting model therefore, can be used as a reference or guide in conducting similar country specific studies in the region and to the wider developing world context.

## **CHAPTER 7: ICT AND RESEARCH COLLABORATIONS**

### **7.1 INTRODUCTION**

Gibbons et al. (1994) note that with the changing nature of the knowledge production processes, ICTs play a critical role in supporting the distributed collaborations, which are an increasingly common feature of today's research environments. However, how they are used largely depends on the context of their use. This context includes people, their usage practices, cultures and supporting infrastructure. Given the importance ascribed to and benefits associated with use of ICT for collaborative work (section 2.7.1), this study sought to establish their role with reference to academic research in Kenya. This relates to the second aim of the study, as set out in section 1.3 (*understand adoption and use of ICT to support collaborative research in Kenya, and analyse the associated factors*). This chapter therefore presents a discussion on their availability and use (section 7.2) and the role they play in the various collaboration processes (section 7.3). This then gives way to a discussion on the factors explaining adoption and use practices (section 7.4) that uses the UTAUT framework as an analytical lens, and a modelling of the factors (section 7.5), based on UTAUT.

### **7.2 AVAILABILITY AND USE.**

As discussed in section 2.6.2, ICT plays a variety of roles in the collaboration process. This includes the three common roles identified by Finholt (2002) as communication purposes, information search and accomplishment of specific tasks. Though recognising that some tools and technologies may be more appropriate for accomplishing specific tasks in various disciplinary areas, the focus of this study was on general tools used for communication and access to information across disciplines.

#### ***Availability***

Results from the quantitative survey indicate that majority of respondents have access to basic ICT resources, including a computer or laptop, mobile phone and internet connection at work place (see Table 5.7). However, it's important to note that simple access may not mean ready access at any one time one needs to use the resource. For example, with much of the data collection requiring contact with the participants mainly in their offices, extensive sharing of computers in some of the offices was noted. Having worked as an

academic member of staff in one of the public universities, I have firsthand experience in the situation of sharing computing resources. This sharing may not translate to ready access. The majority of respondents also complained that though they had internet connection in their offices, it was characterised by constant down times. That too does not also translate to ready access, corroborating Ynalvez & Shrum (2011) findings on the Filipino scientific community.

The results also reveal that a number of respondents have invested in 'self-infrastructure', a term used by one of the participants, as seen in the high percentage of those with computer/laptop at home. However, fewer individuals indicated having a means of connecting to the internet at home or internet access on a mobile phone (see Table 5.9). Perhaps investment in self-infrastructure can be seen as a response to unreliable computing facilities at the university, or a bid to increase flexibility in work processes and access to information. Some though noted that this came with additional cost implications, especially as concerns internet access which was mainly in form of privately owned broadband modems. A 200MB data bundle costs approximately £2 on the biggest mobile/internet service provider in Kenya. Sometimes one may need use of internet activities involving hundreds of megabytes of data and information such as downloading files and making video calls. These activities can be quite costly, especially in a country where salaries and remuneration packages for researchers are relatively low, thus may limit use.

### *Use*

Like most previous studies (Walsh & Bayma, 1996b; Vasileiadou, 2009; Barjak, 2004, Matzat, 2004), the most commonly used form of technology for communication and sharing within the academic research community in Kenya is email. Second to email is the mobile phone, which has become the most common communication tool in Kenya, irrespective of the sectors, communities or age groups. This use can be attributed to its wide availability and ready accessibility and may seem a perfect technology for instant access. However, a mobile phone has limitations in the type of tasks it can support and the user interface, and was seen more as a device for giving simpler messages and alerts over issues that needed attention.

Approximately, only half of the respondents had smart phones, noted as important 'self-infrastructure' tools for flexible access to the internet, especially where cabled

infrastructure was a problem. This can be seen as a partial solution to the problem of ‘ready access’. According to the General Manager Consumer Business Unit at Safaricom, as reported in the Capital FM business news of 16<sup>th</sup> April 2014, Kenya is said to be the leading market for smart phones in sub-Saharan Africa, with 67% of mobile phones sold being data enabled (Capital News, 2014). The percentage of those who own a Smartphone among this group of an ‘elite community’ in Kenya is therefore surprising. Perhaps this can be linked to perceived usefulness of a mobile phone by this community, seen more as a tool for giving simpler messages. The simplified use of mobile phone may not call for use of a Smartphone. On the other hand, PewResearch<sup>39</sup> survey report of February 2014 reported that 76% of Kenyans once online engage in social networks. Given that over 98% of internet users in Kenya access the internet on mobile phone (CCK, 2012; CCK, 2013), the high engagement in social networking may have led to the high demand for Smartphones in the general Kenyan population. This major use of social networking on the Smartphone by majority of Kenya internet users was referred to as time wasting by some researchers, which could affect their attitude towards acquiring and using Smartphones.

Video conferencing applications such as Skype and web based storage applications such as Dropbox are commonly used for communication and sharing documents in developed countries (Vasileiadou, 2009). However, percentage of use in the studied population is quite low as indicated by results of the quantitative survey (Table 5.8). Their low usage was attributed to factors such as poor internet connectivity and lack of awareness of the technologies (discussed in section 7.4). Email use may be sufficient for some forms of communication such as simple exchange of information and documents. However, Kraut et al. (1988) observes that other forms of communication means would be better suited to support intensive kind of interaction and exchange especially that which was referred to as most appropriately supported by face to face interactions. This is not to say that technology can wholly replace face to face meetings. Vasileiadou (2009), Cummings & Kiesler (2005) and Walsh & Bayma (1996b) found that face to face meetings were still a valued means of communication in support of collaborative research activities. Similarly, participants

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<sup>39</sup> ‘Pew Research Center is a nonpartisan fact tank that informs the public about the issues, attitudes and trends shaping America and the world. It conducts public opinion polling, demographic research, media content analysis and other empirical social science research’ ([www.pewresearch.org](http://www.pewresearch.org))

emphasised the importance of face to face meetings, as seen in an engineer who argued that some tasks such as drawing and explaining complex diagrams were impossible to perform online. Kiesler & Cummings (2002) note that the face to face meetings are especially important for work that requires much interdependence and is characterised by much uncertainty. But in the absence of face to face interactions, there's need to employ technologies that emulates face to face meetings.

Positive attitudes in adopting technology are seen in the high usage of email. The observed low usage of other forms of communication could be an indication that there are barriers limiting their use. This allows room for optimism, that if the barriers are identified, and strategies put in place to deal with them, their rate of adoption and use would be higher with positive benefits for researcher's work. A discussion of factors determining adoption and use of ICT is presented in section (7.4).

Use of tools for information search is affected by some of the factors limiting use of tools for communication. Like the communication tools, those used to search for information such as World Wide Web (www) require good internet connection. Information search is also affected by limited access to digital resources, in form of the richness of /variety of materials in the digital libraries. Though Harle (2010) as discussed in section 6.4.2 reports that availability of digital resources is no longer such a problem in African universities, the findings in this study indicate problems of both availability and access. Poor ICT systems pose problems of ready access to digital resources. The participants too highlighted problems of access to particular software they require for particular tasks and the associated costs in their acquisition. One participant was of the view that though the university provides for the very basic software, the diverse kind of research carried out in the university reflects diverse needs is specific software requirements. The university would find it difficult to fulfill the needs of each one of them, thus cost implications for the particular researchers, who sometimes revert to the simplest option available.

### ***Variations in use***

Significant differences in ICT use are observed across disciplinary areas and nature of the area of specialisation, consistent with Olson & Olson (2000), Walsh et al. (2000), Fry & Talja, (2007) and Matzat (2004). Agriculturalists have the highest likelihood of using email for any chosen task and surprisingly, computer scientists the lowest. Possible sources of

differences are identified as nature of the work (level of interdependence) type of collaboration (local vs. remote), level of collaboration and level of participation in disciplinary networks.

Agriculturalists emphasised on the interdependent nature of their work and reflect a diverse range of collaborators across institutions and organisations, and a more connected network (see Figure 5.2). On the other hand, the other disciplines reflect lower collaboration levels, less connected networks, and association with fewer disciplinary networks. Agriculturalists would therefore tend to use technology more to support the much collaborative activities as compared to other disciplines. This corroborates Birnholtz (2007), Fry & Talja, (2007) and Olson & Olson (2000), who see the differences in ICT use as resulting from characteristics of the work itself. Though the correlation between the nature of the tasks and disciplinary area was statistically non-significant, a higher percentage of use is observed within fields which more respondents indicated as being of experimental or applied in nature, as compared to theoretical fields. Walsh & Maloney (2007) found that interdependent tasks involving more ambiguous and non-routine work posed more problems of coordination, requiring more frequent communication. These kind of tasks, mainly associated with experimental and applied fields, could partly have accounted for the higher use of ICT observed.

Remote collaborations tend to use technology more than local (Walsh et al., 2000). Those involved in remote collaborations indicated the crucial role technology played for them. The data in Table 5.10 reflects noticeable differences in ICT use between remote and local operations. This is an indication that fields with a greater constitution of remote collaborations have a greater tendency to use ICT for communication than those whose collaborations tend to be local.

Significant differences in use are realised between those who studied in a developing vs. developed country, and between gender categories with more use recorded in men than females, consistent with Duque et al. (2005) and Ynalvez & Shrum (2011). Research environments in developed countries are supported by relatively reliable ICT infrastructure and a culture of use of ICT systems to support scholarly communication. Individuals studying within these environments somehow get assimilated into the cultures of communicating through technology, which they may continue with even on going back to



their own countries. This group of individuals reflected higher collaboration levels, and as discussed in section 6.4.1, may also have extended networks of international collaborators. They may therefore employ technology more to communicate with their remote collaborators. The differences in use across gender categories could be associated with socio-cultural beliefs and environments that associate men with the tougher fields and tasks, as pointed out by Muinde (2009). The use of technology and its applications, relatively new to this part of the world, therefore emerges as an area more explored by the ‘more bold’ users.

### **7.3 ROLE OF ICT IN COLLABORATION PROCESSES**

#### **7.3.1. ICT in establishing relationships**

##### *Use of Social networking sites and online discussion forums*

As discussed in section 6.3.1, physical proximity and socialisation/meeting forums encourage contact and forging of collaborative relationships. However, with scientists distributed in time and space, physical meetings may not always be possible, and may limit the number of accessible individuals. ICTs on the other hand provide a range of opportunities for scientists to make contacts and build relationships, even in the absence of physical meetings.

Social networking sites can be a source of connections (Gruzd et al., 2012) and have been found to promote social bonding in a common space (Nardi, 2005). They contain search facilities that can be used to look up for particular individuals of interest as well as their connections, thus can be a valuable source of identifying and seeking connections. Informal communication in a social networking site has also been found to promote social bonding, as discussed in section 2.7.2. Social networking sites can therefore play an important role in establishing and building relationships. However, results of the quantitative survey indicate that a majority of respondents consider social networking sites not important in research work. Some respondents indicated that they did not see them as appropriate for scholarly work, with one noting that they were ‘time wasting’ and another ‘you don’t get serious people on a social networking site like Facebook’. This can be seen as an issue of perceived usefulness discussed in Davis (1989) (see section 2.8). This can be attributed to the fact that social networking sites are not tailored specifically to academic

communication, with a wide range of audience some with little interest in academics. Gruzd et al. (2012) advises on use of academic social networking sites such as researchgate.net and academia.edu. However, his study found they were less commonly used than the popular social networking sites such as Facebook and LinkedIn, attributing it to the level of popularity. Making scholars aware of such sites as well as their benefits could possibly have a positive impact on their use, but this would also require an appreciation of the benefits they offer for scientific work.

Blogs, wikis and online discussion forums are also a source of ties, a valuable communication media and avenue for creating visibility. Online discussion forums destined for a particular community bring together individuals with similar interests, help create a sense of group identity and encourage sharing of ideas (Luo, 2008). Vasileiadou (2009) observes that this sense of group identity can be strengthened by use of 'communication media which affords explicit access to all members of a group but not outsiders' (p. 19). This is a notable advantage over face to face meeting, as one can get an enormous response to a question within no time online, in contrast to the time it would take to seek an equal number of people physically to answer the question. Through such discussions, one can also get references from those involved, thus creating a chance to expand networks. In addition, Luo (2008) and Vasileiadou (2009) note that such forums help minimise status differences that arise in physical interactions, and benefit inexperienced researchers or those who may not contribute to the discussion but have something to learn from the various views, as seen in Walsh & Bayma (1996b).

Low usage was recorded for such forums, with an average use of 4.2% over the various project activities. A participant noted that though he had received invitations to join online discussion forums, he had not considered it important for his research work, which could be a reflection of attitude towards perceived benefits. Some did not perceive them as useful for the kind of work they did, expressing preference for face to face meetings for tasks that required detailed discussion and explanations. This supports Luo (2008), who found that online forums were most suited for sharing explicit and factual knowledge as opposed to deep discussions and interactions. This perhaps can be seen as a reflection of lack of knowledge on the diverse range of tools that can support such activities. Technology may not exactly replace the benefits of face to face meetings in establishing meaningful relations

and exchange, but it offers numerous benefits to those who seek them, especially to individuals separated by time and space.

### *University and national information repositories*

University repositories can act as a good source of information on ongoing research, publications and researcher profiles. This is important in identifying possible areas of research and individuals involved, thus a possible source of collaborative ties. However, this study found most university websites contain scanty scholarly information, consistent with Harle (2007) and Muinde (2009). Only one university among those studied had compiled a compendium of research activities at the time of data collection. A closer look at the research activities compiled revealed that the information available varied among departments, with some seemingly quite outdated and others having links leading to empty pages. Muinde (2009) attributes the scanty, uncoordinated nature of information on some university websites to the problem of rushing to acquire technology (in this case the university websites) without thinking how the technology was to be put to use (the content). Corroborating this view, Borgman (2007) notes more attention has been on building technical infrastructure, as opposed to ‘content to support data and information intensive scholarship’ (p.227).

While agreeing with these views, this study notes that it could also be a result of low integration of ICT into university processes, also noted in Kashorda & Waema (2014). A participant described a prevalent ‘paper culture’, with a number of university departments still in the process of automating their processes. Much of the research is not formally published, remaining what Gitau et al. (2010) refer to as ‘grey literature’, as little effort is made to make it visible to the wider research community. As noted in section 6.4.4 (institutional factors), one of the universities studied has made concerted efforts to have members upload their CVs online, a good source of information on research areas and interests of the individuals, important in search for connections. However, a closer look at the CVs revealed some were not updated since the year 2009, when the university administration made it a mandatory requirement to have their CVs online. A similar observation was made by Ynalvez & Shrum (2011), in the Filipino scientists they studied. Borgman (2007) attributes this to lack of motivation and time, noting that researchers were usually in a rush to secure funding for the next research project to bother with such tasks, a

view shared by Ynalvez & Shrum (2011). Researchers need to understand the importance of making their research activities visible.

There was a general concern over lack of research information systems, with only one university having had one that was just being rolled out at the time of data collection. Lack of such systems was also noted at the national level. This is contrary to Muinde (2009), who argues that there is a lack of demand for such systems, relating it to poor research culture and information seeking behaviours. On the contrary, majority of participants in this study show an enthusiasm and desire towards having sufficient research information sources. A need for a centralised database of detailed and updated research information, including the researchers involved and their areas of interest and contact details, was raised. Through this, researchers could have a reference point when they were searching for people working in a certain area or similar interests. An example of such an initiative is the European Commission's Community Research and Development Information Service (CORDIS), defined as a 'public repository and portal to disseminate information on all EU funded research projects and their results in the broadest sense' (CORDIS, 2014). Through their partner service among others, CORDIS offers 'an interactive platform to promote your organisation and expertise, find business or research partners, create groups and join networks, with search and filtering facilities to find the collaborators best matching your needs' (CORDIS, 2014). A desire for a service at the national or regional level similar to CORDIS, through which various research project details are availed (individual and project profiles can be created, project and publication data availed), and provides for networking and interactive service was expressed. A participant noted the existence of some initiatives, citing BecA (see footnote No. 20), which he described as *low key* and discipline specific, expressing the desire for a more inclusive and functional service.

AuthorAID, an international program based at INASP<sup>40</sup> provides a service for researchers in developing countries to register as mentors or mentees, in which a researcher gives a biography and required service (mentor or mentee). AuthorAID also acts as a source of information on calls for proposals, available opportunities for funding and sponsorships and

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<sup>40</sup> INASP 'in an international development charity working with a global network of partners to improve access, production and use of research information and knowledge, so that countries are equipped to solve their development challenges' (www.inasp.info)

upcoming workshops. Their resources section provides support materials for reference on issues such as academic writing, important for upcoming researchers. It also acts as a discussion forum on which researchers can ask a question, share advice and information (AuthorAID, 2014). Unlike CORDIS, AuthorAID targets a general research audience in developing countries across continents. Though providing a networking service through its mentor/mentee service, it lacks in many other functionalities like those pointed out above as provided by CORDIS.

Access to existing bodies of knowledge in digital libraries is considered important to the knowledge production process. Access to a variety of academic literature in digital libraries is important for this purpose, and ICTs play an important role in facilitating access (Sooryamoorthy & Shrum, 2007). This emerged a major challenge for academic scientists in Kenya in the quantitative survey (see section 5.5.5). Access to the digital resources requires reliable library management systems and internet connectivity. Library management systems have only been recently introduced in the Kenyan public universities. For example, one of the major public universities included in the sample only implemented a library management system, including an online institutional repository towards the end of 2012. Access to the digital resources is faced with various issues. For example, Kashorda & Waema (2014) found problems in use of mobile devices to access electronic resources at Kenyan universities, calling for design of information resources that supported such use. Corroborating this view, Borgman (2007) notes that digital content in libraries should be made accessible to researchers whether locally or remotely, using a variety of devices.

Investing in a national library with much more capacity and wide variety of easily accessible digital content, could act as a reference point for individuals and institutions on content not available in their libraries. Technology comes in handy in provision of such access. A national library exists in Kenya. However, it provides a limited number of e resources, mainly providing links to organisations that provide open access to some of their e resources, such as the UNESCO, HINARI, INASP and IDRC. INASP has especially been at the forefront of improving ‘access to, production and use of knowledge’ across Africa, Asia and Latin America. (INASP, 2014). It has made concerted effort to promote awareness of and access to open access resources available to institutions of higher learning in Kenya.

Unlike national libraries especially in the developed world that provide a central access point for research done within the country, the Kenya National Library does not provide such service. Research done at a particular institution, including theses and dissertations are only accessible through the individual institution's library. A SWOT analysis by the Kenya National library services (KNLS) for their 2013 to 2017 strategic plan identified low automation levels as a result of limited ICT budgetary allocations and inadequate technical expertise as some of major problems facing the national library services (KNLS, 2013). Perhaps the government can borrow a leaf from the national library in the UK, the British Library. The British Library has a vast collection of data and information resources, both print and digital from many countries, in various languages and formats. The legal deposit scheme requires a publisher to give a copy of every UK print publication to the British Library and five other major libraries if requested, and more recently, 'legal deposit also covers material published digitally and online, so that the Legal Deposit Libraries can provide a national archive of the UK's non-print published material, such as websites, blogs, e-journals and CD-ROMs' (British Library, 2014). This provides access to a wide range of materials, including 'printed books, journals, magazines and newspapers, microfilm, publications on hand-held media such as CD-ROMs, websites and material available via download' (British Library, 2014). A researcher can easily get material not available through their local university libraries, improving access. Upgrading the services of the Kenyan National Library to acceptable standards requires lots of goodwill from all stakeholders.

Improving access to digital resources requires strategic plans to improve infrastructural facilities to facilitate access, populate information resources with relevant content, create awareness of and impart skills in use of the digital resources so researchers can derive associated benefits.

### **7.3.2 ICT in work processes**

In this study, it is evident that ICT is regarded highly as an important tool in supporting collaborative processes given the high usage of email. This section presents a discussion of how ICT has been integrated into the major work processes, towards an understanding of the role they play in supporting the studied research community activities.

### *Allocation and coordination of tasks*

Like other processes, the most commonly used form of ICT for coordination purposes is email. Though results of the quantitative survey indicate higher percentage of use for coordinating remote activities, it is evident that email is also highly used for local coordination purposes, probably indicating a growing culture of use in a wide range of circumstances. Consistent with Walsh & Maloney (2007), frequent use of ICT was found to have a significant effect in reducing problems of management and control, which includes coordination of members' activities (see section 5.5.3). However, like Cummings & Kiesler (2005) and Vasileiadou (2009), some participants expressed preference for face to face communication for some project activities. This is especially so at the initial stages of laying out the project road map, a process that was pointed out as requiring intensive discussions, consistent with Vasileiadou (2009). However, physical meetings may not be possible at all times. ICTs offer a wide range of functions and support for the various activities, with some offering better support for some tasks than others (Kraut et al., 1987; Vasileiadou, 2009). As pointed out in section 7.2, such discussions could be better supported by technologies that emulate face to face meetings. However, it emerged from this study that other technologies supporting such kind of communication, such as VOIP applications with video conferencing facilities are rarely used. Participants cited lack of awareness, poor internet connectivity or lack of purpose/need to use the technologies. A discussion of the factors affecting use is presented in section 7.4.

The coordination mechanisms employed and supporting tools differ from project to project, and is affected by the interdependent nature of the tasks (Olson & Olson, 2000; Birnholtz, 2007; Fry & Talja, 2007). Olson & Olson (2000) argue that work involving more interdependencies is more difficult to coordinate especially remotely, as compared to that with less dependency. Consistently, those who indicated their area of specialisation as being predominantly applied, which is usually associated with more interdependencies, reported more problems of task assignment and coordination as compared to those who indicated their area as theoretical, associated with less dependencies. Similarly, Fry & Talja (2007) found use to differ across specialist areas, more defined by nature of the tasks. In their study, use of private intranets was common to support intensive communication within fields and specialist areas with high mutual dependence such as HEP, while open

scholarly mailing lists, for communication to the wider scientific community were common among social scientists.

The kind of tasks within a field will therefore influence the choice of technological support. However, as pointed out by Vasileiadou (2009), Olson & Olson (2000) and Walsh & Bayma (1996b), ICT facilitates collaboration processes, but does not change their structure or organisation. Proper working cultures, processes and procedures need to be in place if ICT is to be used to support them successfully.

### ***Status and Decision making processes***

A number of factors were found in literature as influencing decision making processes, as discussed in section 6.3.2. Hierarchical decision making structures and the many bureaucratic processes were cited as a problem by a number of participants. Muinde (2009) observes that such structures create power distances and breakdown in communication. Participants complained of poor communication systems blaming the university for lack of procedures and mechanisms that would ensure everyone got timely information.

ICT can play an important role in conveying information and making transparent the decision making processes. ICTs also facilitate making decision making participatory, a desire expressed by some participants (see section 6.3.2). Vasileiadou (2009) notes that the 'more public the medium, the more open and participatory a decision-making process' (p. 122). A group or institutional mailing list, for instance, encompassing mailing lists of particular departments and/or sections, and a university wide one, would ensure that information got to all relevant parties. Constant and transparent updates through messages posted on the mailing list and other avenues of information such as university websites would keep all informed of the processes through which such decisions are made. Such avenues of communication should offer the flexibility of two way communication, where one can query and get answers through the chosen medium.

As an illustration of the situation in one Kenyan university, at institution Y, only technical support persons have access to the particular departments' mailing lists. A look through the mailing list reveals it has only names of academic members of staff (whereas including upcoming researchers such as PhD students would open them to important information). To post information on a certain mailing list, one has to go through the person entitled with



managing the list, give the information to be posted and details of who should receive the message. If and when the message is posted depends on the person in charge, which could affect flexibility and timeliness of communication in using the mailing list. This person also acts as a filter of the messages, by deciding which message to post and which not too. From one point of view, this may sound good as only messages that are presumed important are passed on. However, this depends on who decides what is important, and does not encourage the spirit of free expression of ideas, a desirable characteristic of participatory decision making and communication environment. It's important that anyone can communicate through the list directly, thus the chance of engaging in or following a conversation without restrictions of if, when or how a message is sent. Using a public medium such as a mailing list, whether for communication within a particular group or wider university community, one can solicit input for decisions engage more people in the process, thus making the decision making process more participatory. However, in instances where decisions are made on a one to one basis or only particular individuals are involved, other means of communication such as personal emails, chat or VOIP calls would be useful. In addition to these technologies, (Finholt & Olson, 1997) note that group decision support systems offer a set of tools that aid in structured decision making, especially where a large number of people are involved.

One of the benefits of ICT use cited in literature is its inclusion of 'peripheral researchers' and reduction of status differences. This can be in form of informal participation through online discussion forums, in which the reduced status differences offered by ICT can encourage a discussion on common ground (Vasileiadou, 2009; Finholt, 2003; Walsh & Bayma, 1996b). The social status differences were indicated as a concern for some members in this study, as exemplified by what a participant referred to as 'misconceived competition going on among faculty ..... and some misguided sense of pride with regard to certain faculty' (COM\_3). ICT allows people to contribute to a discussion or conversation on common ground, masking the status differences and associated attitudes that would limit free participation. Vasileiadou (2009), for instance, found that in addition to making the decision making process more participatory, the general mailing list also offered the advantage of minimising the negative influence of status differences in decision making. However, in agreement with Matzat (2004), it should be noted that the status differences may still be carried on to an online discussion if the individuals can recognise the identities

of others in the network. Bukvova et al. (2010), for instance, found that blog posts from senior researchers received much more attention as compared to blog posts from junior researchers. This is an indication that contributions and decisions of the more influential individuals could be given more recognition than others, if their identities are revealed on e space, thus the need to mask such identities in decisions requiring free participation by all.

ICT use for decision making processes is influenced by existing structures and formal communication procedures. A need arises therefore to reorganise decision making processes to accommodate more participation and transparency. As mentioned earlier, ICT should not be expected to transform the decision making processes. The university management, scientific leaders and coordinators, and researchers themselves will, with facilitation of ICT

### ***Socialising processes***

Walsh & Bayma (1996b) note that the increased communication afforded by ICT encourages formation of group identity. A number of participants expressed preference for organisation of more forums where they could physically meet, such as conferences, workshops, common rooms within the universities. However, organising for meetings take a long time, and limitations of travel grants, work schedules and other responsibilities come in the way of participation in such meetings, thus the need for technology which supports socialisation processes.

Informal communication plays an important part in the socialisation processes. The mobile phone is a common communication device in the group studied, that affords individuals flexibility of use, and can be a useful tool for encouraging informal communication as pointed out by Nardi (2005). Nardi advises on use of IMS for informal communication thus encouraging bonding processes, noting that logging into IMS creates a sense of presence similar to working in a shared space (see section 2.7.2). Vasileiadou (2009) also notes the importance of general lists in socialisation processes, such as their use for emotional support, 'rewarding and praising each other's work' (p.127), as indicated in her study. The benefits of online socialisation mechanisms afforded by social networking sites, instant messaging services and VOIP may not be recognisable in the studied population, as these technologies were indicated as being of low importance for the majority (see section 5.5.3).

Though in agreement with Kiesler & Cummings (2002), that physical meetings offered more 'substantial' form of socialisation, there are situations where face to face interactions are hard to organise. Vasileiadou (2009), who argues that best results are achieved when use of ICT is boosted with face to face meetings in the socialisation processes, recommends a combination of the two for better results.

### ***Conflict resolution processes***

In teams working together, conflicts are bound to arise, as discussed in section 6.3.2. Vasileiadou (2009) notes use of a certain media would determine how public a conflict would become, thus how resolved. Choices in use of ICT for the various processes as discussed above can alleviate sources of problems leading to conflict e.g. ICT can counter problems arising out of reduced communication due to distance, facilitate flow of information and participatory decision making processes, and foster the creation of a sense of common identity important for team work. In this study, ICTs were hailed as a means of collaborators keeping each other updated and easing the process of communication, which is a way of reducing misunderstandings and conflicts. The effects of ICT on some processes are seen for instance in the significant reduction in coordination problems in this study, corroborating past studies such as Walsh & Maloney (2007). Maintaining flow of information and constant updates in project matters, fosters a common understanding and minimises problems related to communication and sharing of information.

### ***Output production processes***

Past studies have associated use of ICT with increased productivity (Lee & Bozeman, 2005; Cohen, 1996; Sooryamoorthy & Shrum, 2007; Walsh et al., 2000; Barjak, 2006). ICT facilitates exchange of information and drafts during output production processes, supports need for increased frequency of communication usually associated with output production (Vasileiadou, 2009; Riemer et al., 2008) as well as facilitating access to information on possible publication forums and other output forums. Though differences in publication productivity based on frequency of using the internet were statistically not significant in this study, the results indicate a gradual increase in publications with frequency of using the internet. However it is not clear if the increase is as a result of more use of the internet or more collaboration.

Various types of ICT can be used to support different output production processes. A mailing list, for example will support exchanges within the groups in coming up with the output, and a shared form of cloud storage e.g. Dropbox can facilitate exchange of drafts, documents and reports. Video conferencing applications such as Skype and Webinars can be used to hold meetings to share the output. A number of participants complained of lack of awareness of some of the technologies mentioned here, such as Skype and Webinars. This indicates the need for university management to put effort in creating awareness and introducing the researchers to various technologies, so they widen their opportunities for communicating with ICT.

#### **7.4. FACTORS CONTRIBUTING TO ICT ADOPTION AND USE**

Sections 7.2 and 7.3 above have presented a discussion on availability and use of ICTs within research collaborations for the studied population, as well as their role in the collaboration processes. A number of factors are identified as affecting adoption and use. This section applies the Unified Theory of Acceptance and Use of Technology (UTAUT) model, developed by Venkatesh et al. (2003) as a lens through which factors identified as contributing to adoption and use of ICT for collaboration purposes within the studied population are discussed. Several models exist to explain user acceptance of technology and innovations. As seen in Section 2.8, UTAUT is a result of an analysis and integration of eight common technology acceptance and usage models, including the widely used Roger's (1995) Diffusion of Innovation (DOI) Theory and Davis' (1989) Technology Acceptance Model (TAM). Noting the similarities in the constructs used across the various models, Venkatesh et al. (2003) made a comparison and analysis of the constructs represented by eight commonly used models to come up with an integrated model, the UTAUT. The model proposes four main factors influencing adoption and use of information technology as performance expectancy; effort expectancy; social influence and facilitating conditions. This model is chosen for the discussion in this section because of its representation of a wider range of factors determining adoption and use of technology, not fully represented in the individual models.

However, it should be noted that this study did not employ the exact measures used by Venkatesh et al. (2003) in coming up with UTAUT. This was considered necessary so as not to limit the investigation to specific issues, but give room for emergence of issues that

affected collaborative research within this particular context. It is therefore the general concept of the constructs represented by UTAUT that is discussed within the context of adoption of ICT for research collaborations in Kenya. The following subsections therefore represent a discussion of the factors in relation to the constructs represented in UTAUT.

#### **7.4.1 Performance expectancy**

Performance expectancy is defined as ‘the degree to which an individual believes that using the system will help him or her to attain gains in job performance’ (Venkatesh et al., 2003, p. 447). This definition includes items related to effectiveness, time management, quality of output and productivity. This can be looked at as perceived usefulness of the technology in Davis’ TAM model or relative advantage in Rogers’ DOI model, referring to expected gains or value in usage of a technology. A technology that is perceived as aiding better performance of tasks while offering cost benefits (cost can also be in form of time) is expected to have a higher rate of adoption. Like in Venkatesh et al. (2003), performance expectancy emerged a strong predictor of intention to use technology for the studied population. Factors related to performance expectancy are discussed below.

##### ***Perceived benefits (expected gains in efficiency, effectiveness and ease of accomplishing tasks)***

In this study, use of email is significantly correlated with both increase in collaboration and productivity. Using communication technologies has been proven to have a significant effect in reducing communication and coordination problems in collaborative work. The rate at which the technology is adopted will depend on its perceived usefulness for the task at hand (Davis, 1989; Rogers, 2003; Lewis et al., 2003), its popularity (Gruzd et al., 2011), accessibility (Ynalvez & Shrum, 2011), convenience of use and expected reduction in costs (both time and money).

Like in many past studies (Walsh & Bayma, 1996b; Barjak, 2004; Vasileiadou, 2009), email is the most commonly used form of communication. Some respondents pointed to the ease and convenience of using email as the reason for its choice, and due to the fact that most people are familiar with its use. Participants described the ease of communication and savings in terms of time and money afforded by ICT, made by the flexibility of sending documents online in place of having to travel to deliver them. A correlation of the factor scores produced in the factor analysis of common problems in collaborations, as seen in

section 5.4.3, and frequency of use of the internet indicates that frequent use of the internet significantly reduces problems of management and control consistent with Walsh & Maloney (2007) and Cummings & Kiesler (2005). Realisation of such benefits may have positive effects on perceived usefulness, and may have contributed to the wide use of the internet (especially email) across the range of activities as shown in Table 5.8.

The perceived benefits could to some extent influence the attitude and enthusiasm to explore and embrace ICTs for collaborative work. While some participants found use of ICT indispensable for the kind of work they did, and a few have found use of a variety of internet technologies such as VOIP and web forums useful to their collaborations, some felt that the kind of communication they engage in had not called for use of ‘sophisticated technologies’. Others felt that ICTs were inappropriate for the kind of work they were involved in, as pointed out by an engineer who felt that ‘Some of the things are really difficult because there are things you have to explain on paper and drawing and so on. Really you need to be there and discuss’. This probably points to three issues: a lack of appreciation of the power of ICTs in supporting a diverse range of activities, or a lack of knowledge of diverse technologies that could support the activities referred to as best performed by face to face meetings, or a need based on the type of work or task at hand.

The power of face to face meetings for some tasks is indisputable, but in situations where collaborators are dispersed in time and space, organising such meetings may not always be possible. In such cases, it would be useful to explore use of tools embedded in online applications that allow participants in a session to perform most of the tasks done in face to face meetings, such as writing, drawing, and displaying content. Such is the whiteboard services in the Blackboard Collaborate platform. However, their use would be determined by other factors such as the support infrastructure, discussed in section 7.4.3. Some seemed to fear the uncertainty brought about by use of newer ‘sophisticated technologies’, thus the feeling that email was sufficient for their communication. This kind of fear aligns with Rogers (2003) and Hofstede’s (as cited in Muinde, 2009) view of uncertainty avoidance, where people tend to avoid what is not familiar for fear of negative outcome. However, a number of participants showed an appreciation for the benefits offered by ICTs, reflecting a willingness to adopt, though citing lack of awareness of various other technologies, as well as poor support conditions.

Perceived usefulness and hence rate of use has been found to be influenced by the nature of the work and stage in the project, which possibly determine the level of interaction and need for ICT support (Vasileiadou, 2009; Walsh et al., 2000; Walsh & Maloney, 2007). Past studies have found work that involves high mutual dependence as relying more on use of ICT to support their communication (Walsh & Maloney, 2007; Olson & Olson, 2000; Fry & Talja, 2007). Significant differences in ICT use were realised across disciplinary areas and nature of the area of specialisation, as seen in section 7.2 (Variations in use). Agriculturalists stressed on the interdependent and applied nature of their work, and reflect the highest percentage of use of ICT, corroborating the studies mentioned above. On the other hand, some computer scientists pointed to the isolated manner in which they worked, and reflected least use. Communication needs as dictated by the nature of work therefore determine the level of dependence on ICT for support, and differs between projects and disciplines, influencing the rate of adoption and use.

#### *Type of collaboration and networks*

Some participants felt that the usefulness attached to a communication technology, which affects rate of adoption and use will depend on the type of collaboration, and size and form of networks. Being involved in remote international collaborations creates opportunities for interactions and exchange that require technological support as it calls for one to keep pace with the modes of communication used by the remote collaborators as observed by a participant. Though there is wide use of ICT (especially email) to support both local and international collaborations, a higher percentage of respondents indicated use for remote collaborations (Table 5.10), consistent with Walsh & Bayma (1996b) and Cohen (1996).

Differences are seen in use between the various disciplinary areas (see Table 5.9). The size and level of interconnectivity in the disciplinary networks can be seen to determine level of activity, thus need for ICT support. Agriculturalists have the highest rate of use, reflect bigger and more connected networks, an indication that technology would be more useful in supporting communication across such networks. On the other hand, computer scientists reported less disciplinary networks, and had the lowest rate of use. This corroborates Ynalvez & Shrum (2011), who found that the size and type of professional networks impacted positively on diverse use of the internet. Similarly, Rogers(2003) notes that

existing communication networks and their level of connectedness influences the rate of adoption of an innovation within the system.

### ***Demographic and socio cultural factors***

Differences in use were significant across categories of level of academic qualification, region where highest degree was attained and gender. This could be an indication of the usefulness attached to ICTs by the given groups. More usage is recorded by those with advanced academic credentials (PhD). This could be attributed to the higher levels of collaboration recorded in this category, thus a display of increasing reliance on ICT to support their collaborative work.

The varying rate in adoption and use could also be as a result of a combination of factors, including exposure to a culture of ICT usage. Computing was referred to as a ‘relatively new discipline’ in the words of one participant. Computing courses have only been recently introduced at primary and high school levels, and only to selected schools in Kenya (Muriithi, 2005). At the university level, computing courses only became common from the year 2000 (the first computer science course having been introduced as a field of study at the University of Nairobi in 1993).

A majority of students do not have access to computing facilities (Kashorda & Waema, 2009). The ‘networked learning indicators’ used by Kashorda & Waema (2014) in their 2013/2014 e readiness survey of Kenyan universities scored low, an indication that universities were ‘still not ready to use ICT to transform learning and research’ (p. 36). A culture of not using computing facilities in search of information, or to support their learning from the earlier education life, and a culture of not using ICT for the wider university processes, could affect the morale and exploration of newer forms of ICT that could be beneficial to collaborative work. Participants pointed out that universities were still entrenched in a ‘paper culture’, and a number of processes were yet to be digitised. For example, digital libraries systems are crucial for access to information for the studied group, but this has only recently been achieved in some Kenyan universities, an indication of the slow rate at which ICTs are getting integrated into some crucial university processes. A culture of use is reflected by those who have studied in developed countries. In developed countries, use of communication technologies is popular. These individuals get used to the culture of using technologies and may more readily adopt the same practices on



going back to their countries. This probably accounts for the higher rates of use in this category. Studying in developed countries may also have led to establishing ties and networks with individuals in these countries with whom keeping in touch would require use of communication technologies adopted by these groups, as noted by Ynalvez & Shrum (2011).

The results of this study reflect higher rates of adoption and use among men as compared to women. This aligns with Venkatesh et al. (2003) finding that performance expectancy was moderated by gender and age, with the effects more significant for young men. Muinde (2009) attributes gender disparities in use of ICT to a cultural set up that encourages boys or men to take up the tougher scientific courses including computing. This is observed in the higher ratio of male to female students in the science based subjects, also reflected in domination of males in academic staffing levels in the sciences, as seen in section 6.4.1 (Demographic factors). This brings in the mentality that trying out the more complex technologies is more of a 'man affair'. This may have a positive effect on their self-efficacy and personal innovativeness. Self-efficacy is defined as an individual's perception or conviction on his ability to accomplish a task using a certain technology (Lewis et al., 2003), while personal innovativeness is the willingness of an individual to try out new technology, usually associated with positive beliefs about technology use (Rogers, 1995; Lewis et al., 2003). However, unlike Muinde (2009) and Venkatesh et al. (2003), age was not significant in determining use of various forms of ICT. This probably reflects the willingness towards use of ICT expressed across all age groups, though it was noticed that the younger generation constituted the majority of those who responded to the online survey, reflecting the enthusiasm with which the younger generation embraces technology. This leads to some optimism, that with improved infrastructural environments, a digital society that will see much more use of technology to support work processes is on the offing.

It is therefore apparent that people will use technology based on how it works for them, especially its effectiveness in performance of tasks and achievement of their communication goals. While majority have found use of email adequate for their collaborations, few others have found better service in a combination of technologies, though this is met with various limitations as discussed in the next sub sections.

Universities and individual researchers are encouraged to invest in various technologies which will add value to their collaborations. However, caution needs to be taken too, with careful evaluation of the environments into which the technologies will operate (Kling et al., 2003; Borgman, 2007). Considering ‘how’ should come before ‘what’ of the technology, a situation Muinde (2009) refers to as ‘putting the cart before the horse’. This will avoid investing in technologies that are incompatible with existing systems and infrastructures, rendering them useless.

#### **7.4.2 Effort expectancy**

Effort expectancy is defined as ‘the degree of ease associated with the use of the system’ (Venkatesh et al., 2003, p.450). This includes complexities in learning and interacting with the system, and the time and effort required to perform a task. This is similar to Davis’ ‘Perceived Ease of Use’ in the TAM model and ‘Complexity’ in Rogers’ DOI theory. Technologies that are perceived as complex and difficult to use will have a slow rate of adoption, except in mandatory settings where the users have no option but to learn to use the system or technology.

Having relevant skills has been positively associated with perceived ease of use of technology. Results from the quantitative survey show those who indicated having above basic skills in use of computers as being more frequent users of the internet. Having more advanced skills could mean less effort in learning to use various technologies, reducing the complexity with which they are viewed, thus higher rates of adoption. Unlike Muinde (2009) who reports many in academia in Kenya as lacking computer literacy, over 80% of the respondents indicated they are above the basic level of skills in using computers. This could be as a result of the efforts of many of the universities in impacting basic computer literacy skills to their members of staff. However, applications tailored for performing specific tasks in particular settings would require special training. A number of participants expressed lack of support for specialised training. This, in the eyes of one participant makes gaining the skills an expensive venture, thus not motivating and can contribute to lower rates of adoption. Additionally, participants indicated less exposure to a variety of technologies, which Venkatesh et al. (2003) notes significantly impacts effort expectancy. Consistent with Cummings & Kiesler (2008), participants noted that the different levels of

exposure and skills within a group usually led to members resorting to the easiest means of communication to avoid complexity of tools used by the other.

Results of this study show that some of the participants believe computing systems are complex, which may affect the intention to use ICTs. Lewis et al. (2003) found that such beliefs, usually typical in individuals with low self-efficacy and personal innovativeness had a negative influence on ease of use. Participants complained of poorly designed information sources such as university websites, that lack in content or present complexities in searching for content, and library information systems (LIS) that present problems in accessing materials remotely, consistent with Kashorda & Waema (2014). These issues present complexities in use. LIS have been introduced rather recently in some universities and can be said to be going through some teething problems. How the problems are resolved is dependent on the commitment of a number of actors, including the policy makers who decide on access policies, and ICT departments that organise for the technical implementation.

The importance of ICTs meeting local needs for them to be useful to the communities they serve are stressed in Gomez (2014) and Heeks (1999). Proper design of systems that meet researcher needs, are compatible with existing research practices and present less complexities in learning and use would encourage uptake and use. A number of respondents, for instance, pointed to the need for research management information systems (RMIS), at the national level that was lacking. Through such a system, researchers could keep informed on ongoing and past research, identify individuals with similar research interests, seek connections and encourage sharing of information. A system offering such services is likely to be received positively, as it would be addressing a prevalent problem within this community. Designers of technologies for use in the research context would need to ensure that complexity is minimised, and that they offer extra gains to the users to motivate their use

### **7.4.3 Facilitating conditions**

Facilitating conditions construct is defined as ‘the degree to which an individual believes that organisational and technical infrastructure exists to support use of the system’ (Venkatesh et al., 2003, p.453). Venkatesh et al. note that this refers to technological and organisational environments that present barriers to use. Items discussed under this

construct include the existing ICT infrastructure, availability of knowledge and skills necessary to use ICTs, compatibility with other systems used and work style, and technical support and the role of the university in facilitating adoption and use. These factors point to the major role of institutional environment in facilitating adoption and use, and noted by Lewis et al. (2003) as having an influence on beliefs in usefulness and ease of use.

### *Availability of ICT resources*

Use of computing technologies is highly dependent on supporting infrastructure. Though a majority of respondents have basic tools for communication, 'digital poverty' as described in May et al.(2014), with reference to access to ICTs, awareness of their usefulness, and possessing relevant skills to make meaningful use of them is prevalent in Kenyan universities. Use of the internet brings a number of challenges. The dimension of problems in use of the internet shows that sites and materials that require payment for use and internet downtime led in problems of using the internet, reflecting issues in availability of and access to digital resources. Consistent with past studies in the region, (Harle, 2009; Duque et al., 2005; Kashorda & Waema, 2009; Kashorda & Waema, 2014), lack of reliable internet connectivity was cited widely in the qualitative survey as a major stumbling block to use of internet mediated technologies for collaborative work. One participant had been appointed to head a newly established department whose offices did not have cabled or wireless internet connectivity, posing major challenges in communication and access to information for him. It is therefore not unusual to find academic members of staff /researchers in public access computing venues, that Gomez (2014) notes have become common in developing countries and are favoured due to good customer service and connection speed. A number of participants indicated that to deal with the unreliable internet connectivity at the university, they resorted to using privately owned mobile broadband modems, which can be quite costly.

Problems in internet access affected use of a diverse range of technologies. One participant remarked that he had given up on using Skype because he had to wait for off-peak hours of internet traffic (i.e. early morning or late in the evening). Even with the off-peak hours, he could not be assured of a smooth conversation as the connectivity is usually poor. Although internet access problems have been identified in past studies, the extent to which they are a problem in Kenyan universities is quite surprising, given the high rating of

Kenya as seen in ITU (2013), as one of the leaders in bridging the digital divide in the region. The national ICT Master Plan of 2014 notes major developments in ICT environment in the country in the last five years, including ‘rollout of the National Optic Fiber Backbone Infrastructure (NOFBI) and four undersea cables, implementation of high-speed networks by telecommunications operators, establishment of policy frameworks and regulation of the ICT sector’ (GoK, 2014, p.3), among others. It would be expected that such improvements have an impact on internet connectivity in HEIs in Kenya, among other sectors.

Kashorda & Waema (2014) note a considerable increase in bandwidth consumption in Kenyan universities, from an average of 0.436Mb/s to 4.22Mb/s per 1000 students. However, they further note that a huge increase in student enrolment thus increased demand for internet services, not matched by increase in the budget towards internet bandwidth has seen problems of internet connectivity in Kenyan universities persist. According to Kashorda & Waema (2014), the majority of universities assign only 0.5 % of their operational budgets towards the cost of internet bandwidth, way below the 10% recommended in the 10<sup>th</sup> Cycle of Performance Contracting for tertiary institutions, under which public universities fall (GoK, 2013a). They note that 50% could afford to double the amount, if this was made a priority. To embrace technology, the need to prioritise improvement of ICT infrastructure was emphasised in this study. However, Ynalvez & Shrum (2011) note that even with improved infrastructure, the effect on the work of scientists will depend on how the individuals make use of the technologies.

#### ***Availability of technical support and compatibility with existing systems***

The importance of availability of technical support in use of ICT, closely associated with mediating the effects of effort expectancy has been noted as affecting usage behaviour (Morris & Venkatesh, 2000). Users tend to gain more confidence in use of technology if they know that help, if needed, will be available. The problem of poor technical support and unreliable services was highlighted, with a participant noting the common problem of internet and system downtimes. For example, the unreliable nature of university email systems was pointed out, in terms of availability of the service and limitations in mailbox storage, corroborating Harle (2007), which perhaps accounted for the large number of respondents who it was noted in the process of carrying out the online survey, used

commercial email addresses. Comparing the situation to international organisations that a participant noted had dedicated ICT teams such that ‘the moment you complain they are there to sort it out’, it was noted that such kind of teams were lacking and it took hours on end to get things sorted. This, coupled with the frequent power outages which, consistent with Kweku (2012) were noted as relatively common, could affect the use of and motivation to use digital systems and online content. Universities therefore have a role to play in providing for qualified, reliable and adequate technical support, guided by policies regarding the qualifications, number and work definition of required technical support team.

Compatibility, both with the technical and social systems, closely related to effort expectancy, has been found to have a positive effect on adoption (Rogers, 2003; Venkatesh et al., 2003). A technology that is compatible with the work styles of scientists would allow for a smoother transition into its adoption would be viewed with less complexity. However, the reverse is also true, that proper organisation of work has to be in place for facilitation with ICT to be more effective (Walsh & Bayma 1996b, Olson & Olson, 2000).

#### ***Lack of awareness of a diverse range of technologies***

A number of participants cited lack of awareness of available ICT options, noted by Rogers (2003) as affecting adoption of any new innovation or in this case, technology. This is quite surprising for a group of people seen part of the most educated and elite in the community. For people to make use of the technologies, they have to be aware of them. The communication channels used to create awareness of an innovation could determine the rate of adoption (Rogers, 1995). Rogers notes that while use of mass media is associated with faster rate of adoption, interpersonal channels would be more useful for complex technologies. Some participants in the study indicated having had to adjust to communication modes used by their collaborators and networks, corroborating Rogers’ views. However, a number of participants called for universities to take a more active role in facilitating awareness of the various technologies, as well as supporting researchers in acquiring the necessary skills through organised training in the use of such technologies, to instill confidence in their use.

### ***Institutional policies***

The factors discussed under this section show that universities have a big role to play in facilitating adoption and use of ICT, not only for supporting research work but also for the entire university processes. University leadership to a large extent determine the ICT environment (Muinde, 2009; Kashorda & Waema, 2014; Lewis et al., 2003), that influences use. Having adequate ICT policies and regulatory frameworks is important, so is their implementation. Out of the four universities involved in the study, only two had ICT policy documents at the time of data collection to guide acquirement, implementation and use of ICT facilities and services. But even so, participants complained of lack of implementation of policy, thus a disconnect between what is on paper and the real situation on the ground, also observed by Mouton (2008). This corroborates Kashorda & Waema (2014) observation that though institutions recognised the importance of incorporating ICT in university processes, this did not translate to visible efforts and results towards achieving this, largely blaming it on ‘failure in strategy execution’ (p.3). For instance, disparities, as noted by some participants, are seen in the proposed standards regarding improved connectivity and reliability of networks and services, and meeting of training needs. Institutions play a major role in creating and facilitating an enabling research environment. Consistent with Mouton (2008) and Harle (2009), who noted that disparities in research support systems across universities, differences are observed in existence of some policies across the universities eg on meeting research skills and training needs, and information availability.. However, the majority of issues such as resource availability and access (including ICT resources) emerged salient across the general Kenyan research community.

#### **7.4.4 Social influence**

Venkatesh et al. define social influence as ‘the degree to which an individual perceives that important others believe he or she should use the new system’ (Venkatesh et al., 2003, p.451). This construct is represented by items referring to influence from important individuals in the surrounding environment. The social system and communication practices of those one mainly engages with may influence the mode of communication adopted (Rogers, 2003). For example, a number of respondents gave the reasons for their extensive use of email as that email is the kind of technology most people are familiar with and use. A participant noted that he resorted to using Skype because it was most convenient form of meeting with his collaborators based in different parts of the world, who preferred

the particular communication medium. The particular person had to adapt to what the others in his circle mainly used, so as to comfortably identify himself with the group and participate in online discussions. Social influence is also demonstrated by those who studied in developed countries. They reflect higher rates of use as compared to those who studied in developing countries, consistent with Ynalvez & Shrum (2011), probably due to the usage cultures associated with where they studied. Social influence does not only come from those you work with, but can also come from family and friends (Gruzd et al., 2012). One may take to constantly using social networking sites such as Facebook, because that's the best way to keep updated on friends and family. However, their use may not only be limited to the social circle. Participants in Gruzd et al.'s study reported that building both social and professional connections was one of the most significant benefits they derived from their use.

Venkatesh et al. (2003) argue that social influence constructs are mainly significant when use is mandatory, where one has to comply in response to social pressure. In such situations, the effort related to learning a new technology may have negative effects on perceived ease of use in the initial stages of adopting the technology, but this eases with more interaction with the technology (Davis et al. as cited in Venkatesh et al., 2003). However, as seen in this study, choice and use of technology for collaborative research is not a mandatory requirement, and is dependent on individual researchers and teams. This corroborates Lewis et al (2003), who observes that the autonomous nature of knowledge workers meant they had flexibility in choice and use of technology. Use is therefore mainly voluntary, and it may take a longer time to adopt certain technologies, especially where there is no support from the institution.

Integration of ICT within the wider university systems and processes would be expected to have a positive effect on their use for research work. This kind of effect was demonstrated by Putnam & Kolko (2010), who found that the level of integration of ICT into the national systems such as education and health affected perceived usefulness and thus type of use of the technologies between the US and Central Asia. Participants complained that most processes at the university were still paper based, corroborating Kashorda & Waema (2014) finding on low integration of ICT into education and research. Automating and digitising



most processes would encourage wide usage of ICT within university environment, including supporting research.

Venkatesh & Davis (2000) note that adoption of certain technologies could also be a response to status gains. Some technologies are associated with higher status, and are adopted as a status symbol. However, there was no evidence in the study to support this claim.

#### **7.4.5 Disciplinary factors**

In addition to the constructs represented in UTAUT discussed above, this study found significant differences in use of ICT across disciplinary areas. Agriculture had the highest percentage of use, corroborating past studies that have found use to vary between disciplinary fields and specialist areas, as seen in section 7.2 (Variations in use). A higher percentage of use was recorded by those indicating their research areas as experimental and applied than theoretical in nature. As seen in section 2.8 (Disciplinary factors related to use of ICTs), work involving high mutual dependence has been found to rely more on use of ICT to support the frequent communication practices. Corroborating past studies, differences in use, as discussed in section 7.2, can be seen as stemming from variations in nature of the work, level of collaboration and activity in disciplinary networks between fields.

As discussed in section 2.8, fields with low task uncertainty (as defined by Whitley, 2000) thus well-defined research and problem areas, high mutual dependence and closely knit collaboration networks tend to employ more of ICT that supports communication practices within the group or particular network (Fry, 2006). On the other hand, fields associated with high task uncertainty, less defined collaboration networks and less mutual dependence tend to rely more on technologies that can enable them communicate and get feedback from a wider audience, thus tend to apply open forms of communication (Fry & Talja, 2007; Matzat, 2004; Walsh et al., 2000). For instance, Fry & Talja (2007) noted that while private intranets, closed mailing lists and group homepages were very useful in supporting closely knit collaborations in natural and health sciences, open mailing lists and personal homepages were more common in social sciences. The particular kind of ICT adopted by a particular group, network or individuals may therefore vary, based on the nature of the work involved. However the differences in this study are looked at from the wider

disciplinary level. Future studies could investigate the particular form of ICT used for particular kind of work at the specialism level. However, it also emerges that other forms of technology (other than email and mobile phone) are hardly used to support scientific work. Exposure and access to a variety of technologies would provide researchers with a choice over the type of technology to use for various activities, enriching this kind of investigation.

The level of establishment of a discipline fueled by prioritisation and support for research in a particular field contributes to existence of active disciplinary networks involved in various areas of research. Rates of adoption will be higher due to need for support of increased interactions in such networks. This is observed in agriculture. With higher levels of collaboration and more closely knit networks, they record higher rates of ICT usage. In contrast, computing records lower levels of collaboration, with participants citing lack of established networks in their field of research and records least use of ICT within research collaborations.

As seen in this study, different disciplinary fields therefore display different levels of adoption of ICT. Studies in organisation of science and knowledge production processes that use the UTAUT framework to analyse acceptance or adoption of technology, could consider the disciplinary or specialist area as a determinant of acceptance and use of ICT for knowledge production purposes.

## **7.5 A MODEL OF FACTORS INFLUENCING ADOPTION AND USE OF ICT WITHIN RESEARCH COLLABORATIONS**

A number of factors have been identified as affecting the adoption and use of ICT to support the collaboration processes. Figure 7.1 presents a modelling of these factors, categorised by the constructs represented by UTAUT. The findings reveal differing rates of adoption and use between disciplinary areas, as discussed in section 7.4.5, reflected in the model. A brief discussion of the relationships between the factors across these major categories is presented.

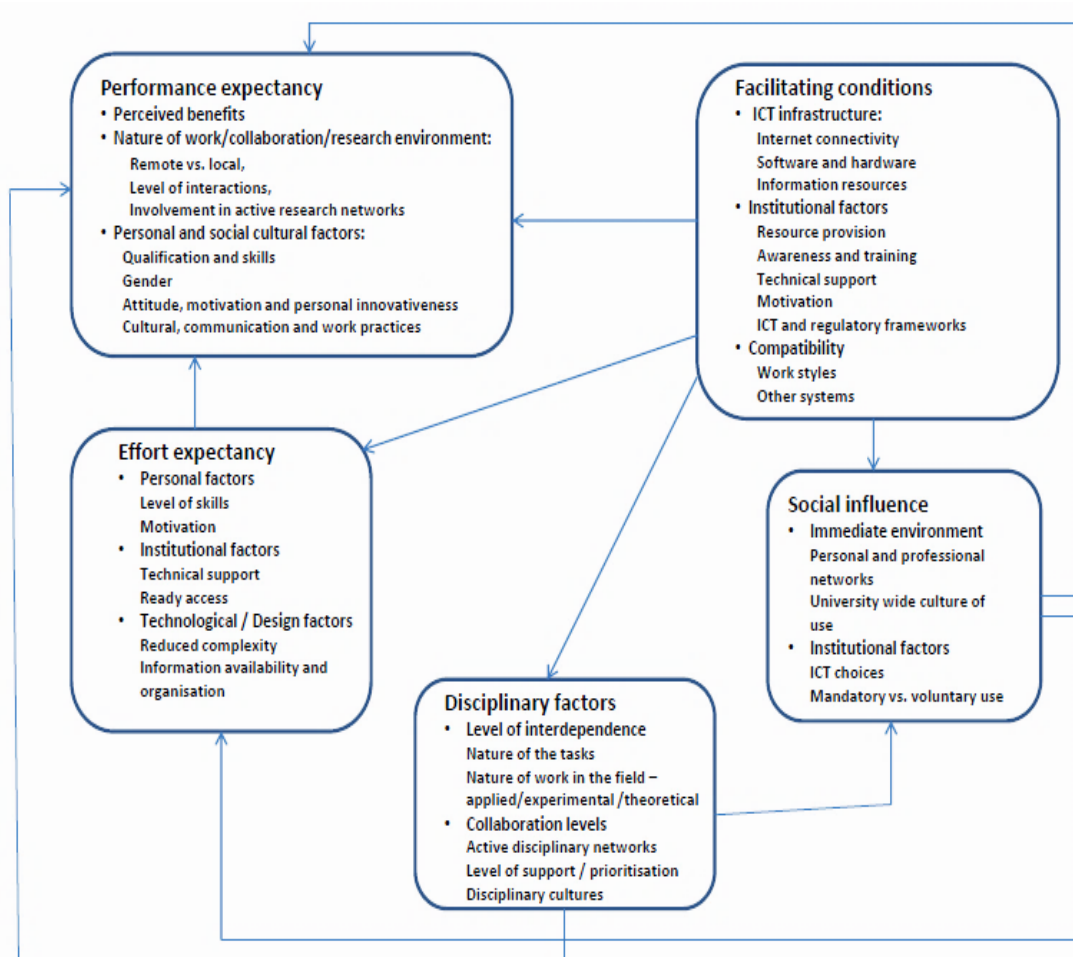
### ***Relationship between performance expectancy and other categories of factors***

As discussed in section 7.4.1, factors that have an effect on performance expectancy include the *nature of the work and collaboration*. Remote collaborations involving higher

levels of interdependence tend to rely more on ICT support. *Personal characteristics* such as level of skill and training have been found to have a positive effect on self-efficacy and perceived usefulness, as seen in Lewis et al (2003). *Cultural and communication practices* in the work environment that do not encourage use of technology, compounded with a resistance to change affect the attitude towards use or perceived relevance. In turn, performance expectancy is affected by the institutional ICT environments that determine availability and access to facilitate realisation of expected benefits (Facilitating conditions). Complexity (assumed or real) associated with use of a certain technologies (Effort expectancy) may lower the motivation and attitude towards their use affecting the perceived usefulness. As seen in section 7.4.4, the social influence of modes of communication in the immediate environment would determine the importance associated with use of certain technologies towards adapting to these environmental conditions, affecting the perceived usefulness.

#### ***Relationship between facilitating conditions and other categories of factors***

Facilitating conditions include existence of reliable *ICT infrastructure* and *institutional mechanisms* towards improving ICT environments. This includes acquisition of and making accessible ICT resources, and employing policies and strategies that promote and facilitate adoption and use. *Compatibility* with work styles and other systems has a positive effect on motivation and may lessen the effort required to use the technology. Factors under this construct have an effect on all the other constructs, corroborating Venkatesh et al. (2003) and Lewis et al. (2003) findings on their effects on both beliefs and actual usage of technology. Difficulties in accessing and using various forms of ICTs affect both performance and effort expectancy. Facilitating use paves way for the effects of social influence, as more individuals may tend to adopt use of technology based on the existing conditions and culture of use within the immediate work environment. Facilitating conditions also determine what is available to maximise support for the varying nature of work activities as defined by the disciplinary field.



**Figure 7-1 A model of factors affecting adoption and use of ICT within research collaborations in Kenya**

***Relationship between effort expectancy and other categories of factors***

Effort expectancy is affected by the *personal factors*, including level of skills that determine the level of difficulty that users may experience in using a technology, and motivation to adopt new technology as defined by self-efficacy and personal innovativeness, usually associated with positive beliefs about technology use (Lewis et al., 2003). *Complexities in design* however may present difficulties irrespective of level of skills or motivation. Institutional support in providing for facilitating conditions, such as training and skills development and provision of technical support would reduce the negative effects related to effort expectancy, while having a positive effect on performance expectancy. It is assumed that by making use mandatory, the facilitation involved and

social influence from within the immediate use environment would have a positive impact on both performance and effort expectancy.

***Relationship between social influence and other categories of factors***

Social influence is defined by usage practices of those in one's *immediate environment*. This includes the university environment as well as one's social and professional networks. *Institutional ICT choices* in terms of the technologies they choose to make available and support in form of training affect individual choices in their adoption and use of technology. This is because people tend to use what majority others in the work or immediate environment use. *Mandatory requirements for use* have been found to raise the rate of adoption and use (see section 7.4.4-Social influence). The training and support that goes with mandated use ease the problems of effort expectancy, and may also have positive effects on performance expectancy.

***Relationship between disciplinary factors and other categories of factors***

The disciplinary fields or nature of the area of specialisation usually defines the *nature of the work* and level of *mutual dependence*, which affect the need for use of technology. This affects the perceived usefulness (performance expectancy) of the various technologies in supporting work practices. Some particular tasks may require use of a specific type or set of technologies, while a wider range of ICTs may be used for general communication purposes. Higher levels of collaboration are associated with increased use of technology. Disciplinary fields that portray existence of active disciplinary networks and are said to receive more support have higher levels of collaboration (see sections 7.2 and 7.4.5). *Disciplinary cultures and practices* may also define the type of technologies adopted to perform particular tasks within a discipline or specialist area, thus the social influence of usage practices within particular groups or networks of individuals. This in turn is affected by facilitating conditions within the work and use environment.

**7.6 CHAPTER CONCLUSION**

Various forms of ICT present numerous benefits in support for collaborative work. This study identified positive effects of ICT use on both collaboration and productivity. However, use is mainly limited to email and mobile phone. Ready access to a number of ICT resources was found problematic. Researchers noted a dire need for sufficient

information resources, through which they could identify ongoing or past research, to avoid duplication, and build on existing research, as well as identify potential collaborators.

It is surprising that a number of researchers in academic institutions, who are considered a highly educated elite community in Kenya, were unaware of other technologies commonly used to support remote communication in the developed world, such as Skype. This is an indication that what may be an obvious means of communication in the developed world may not be obvious to this group. Though Kenya is often referenced as leading in ICT infrastructural developments in the region (ITU, 2013), internet connectivity was the most commonly cited ICT infrastructural problem. A number of factors emerged as influencing adoption and use of ICT within this community. The factors are discussed within the UTAUT framework developed by Venkatesh et al. (2003), which proposes four major constructs as influencing the intention and usage of information technology: performance expectancy, effort expectancy, social influence and facilitating conditions.

This study found a major influence of facilitating conditions on all the other constructs as seen in Figure 7.1. The construct refers to environmental context that determines availability and facilitation of use, mainly associated with institutional capabilities and strategies. This corroborates Lewis et al. (2003), who found that institutional influences had the most impact on beliefs and intention to use technology. This also aligns with Kashorda & Waema (2014) and Muinde (2009)'s views on the role of universities in creating an enabling ICT environment. Though Rogers (2003) argues that adoption rate is higher if the adoption decision is made at a personal level, participants expressed the need for institutional intervention in creating awareness and facilitating access and use. In addition, individual perceptions with reference to expected benefits and relevance in accomplishing the tasks at hand was found to influence the attitude towards use of technology. Consistently, Davis (1989) and Venkatesh et al.(2003) found perceived usefulness of the technology had a strong influence on intention to use technology.

In addition to the four constructs represented by UTAUT, disciplinary factors is added to the model, based on major differences realised in adoption and use of ICT between disciplinary areas. This corroborates past studies that have found differences in use between disciplinary and specialist areas, including Walsh & Bayma (1996b), Walsh et al. (2000), Matzat (2004) and Fry & Talja (2007). Studies using UTAUT to analyse adoption and use

of ICT for knowledge production processes could consider disciplinary or specialist area as a determinant of adoption and use.

Chapter Eight provides a set of recommendations on improvement of collaborative research in Kenya.

## **CHAPTER 8: RECOMMENDATIONS TOWARDS PROMOTING RESEARCH COLLABORATIONS IN KENYA**

### **8.1 INTRODUCTION**

As discussed in chapter one, collaborative research has become an important element of today's knowledge production processes. Lack of knowledge on the status of collaborative research in Kenya was the major motivation for this study. The study was aimed at understanding the organisation and conduct of academic research collaborations, and influencing factors. In the preceding chapters, various factors influencing the organisation and processes involved, including the use of ICT to support collaborative work have been identified and discussed. Factors relating to organisation and conduct of collaborative research are grouped into five categories: personal, resource availability, disciplinary, institutional and technological factors. Based on the importance of ICT in supporting collaborative work, a discussion on the role of ICT in research collaborations and factors influencing their adoption and use was presented in Chapter Seven.

Based on the research findings, this chapter extends the discussion by presenting a set of recommendations for improvement of collaborative research in Kenya. As seen in Chapters five, six and seven, many of the factors determining the nature of collaborative research relate to influence of the external environment, whose effects would apply to both collaborative research and research in general. Consequently, some of the recommendations made in this chapter would apply to improvement of both collaborative research and research in general. The recommendations mainly target three stakeholders: firstly, the policymaker, who plays a major role in determining the nature of the research environment. The policy maker can be the government ministries or agencies that are entitled to deal with research issues, or the university level management; secondly, the researcher, who is a major determinant of what research is conducted and how it is conducted; and thirdly, the designers of information and communication technologies, who would play a major role in meeting the information and communication needs of the research community. However, all the stakeholders would need to work together in determining the success of research collaborations.



The recommendations are mainly drawn from participants' responses and suggestions for improvement. Others refer to success factors identified in literature and assessed for their applicability in the Kenyan context, and to a smaller extent from the experience of the researcher in working in the higher education sector in Kenya. The recommendations act as general guidelines towards improvement of research collaborations, but should not be taken as a complete blueprint for successful research. They are therefore open to review and extension. The extent of their application to individual institutions and researchers may vary, as situations relating to individual research environments differ. Each section/subsection begins with a highlight of major factors identified as presenting barriers to collaborative research in the study, followed by suggestions for improvement.

## **8.2 RECOMMENDATIONS TO POLICY MAKERS**

### ***Capacity building***

Professional qualifications emerged as a significant determinant of both collaboration and productivity. For example, 86% of those with a PhD responded *yes* to involvement in collaboration in the last ten years, as compared to 38% of those without. Those with a PhD have a mean number of 1.98 current projects and 10.98 publications over the past ten years, while those without PhD have a mean number of 1.39 current projects and 3.14 publications over the same period (see Table 5.13). This is an indication that attainment of skills and training is important in building capacity for research and promoting collaborative work. This reflects a need for institutions to focus more on capacity building, in terms of sponsoring more students to do PhDs. A general shortage of supervisors and mentors, more serious in some disciplines was noted, corroborating Opata (2011) findings on low supervisory capacity in many Kenyan university departments. Many of those already qualified were overburdened with many responsibilities, and others were pursuing personal research interests such as contract work (Harle, 2009; Opata, 2011; Gaillard & Tullberg, 2001), probably out of the form of rewards attached, to afford time to mentor PhD students. This makes a PhD study take several years, which is quite de-motivating for those wishing to pursue the degree.

Better reward mechanisms such as factoring PhD supervision into their normal workload, better compensation for extra time spent, promotions and other forms of recognition based on number of PhDs supervised and length taken could be considered. This would encourage

qualified senior researchers to take on PhD students and encourage them to complete within some stipulated time. Co-supervision of PhD students with researchers in other institutions in the country, region or internationally would improve access to the PhD mentorship not available in some poorly resourced universities (Harle, 2007), and probably improve the quality of PhDs produced as a result of the shared expertise.

Universities also need to lay down regulations regarding requirements for supervision and PhD training, including penalties for overextended projects to encourage completion rate. While PhDs in Kenya have been known to extend to 10 years and beyond, other countries have put restrictions to encourage completion rate. For example, Opata (2011), on analysis of the list of graduands from two major public Kenyan universities in 2010, notes that the PhD completion rate ranged between five to fifteen years, with only 14% of the candidates completing in five years. On the other hand, a number of universities in the UK such as the University of Brighton restrict the period of study for a full time PhD degree to 60 months. Any extension beyond this period would only be permitted under exceptional circumstances.

Levels of academic qualification differ significantly between disciplines. Agriculture reflects a high percentage of individuals with PhD qualifications (85%), as compared to engineering (48%), public health (44%) and computing (23%). The low percentage of PhD holders in computing is consistent with Kashorda & Waema (2014), who found that only 13.5% of the 535 ICT faculty members in the 30 universities studied had a PhD. One of the major universities studied had only one person with PhD qualifications in the computing department, while another had three at the time of data collection. The percentage of qualified individuals in a field affects availability of supervisors and mentors for PhD level research, noted as a problem above. In this study, agriculture, which has more individuals with higher levels of academic qualifications reflect bigger more connected collaboration networks, a reflection of effects of qualifications on the research related capabilities. More focus on funding training in areas/disciplines with less trained research personnel would enable growth of research and collaboration networks in those areas. This can be done through special calls for proposals and availing scholarships targeting such areas.

A number of respondents noted a need for continued professional staff development support, especially, in proposal writing and grant awarding processes as well as specialised

training in other areas relevant to conducting research, consistent with Harle (2007), Harle (2011) and Gaillard & Tullberg (2001). Provision of such support differed across institutions. For instance, only the University of Nairobi, among those studied had a clearly set out program on training in writing proposals at the time of data collection. Most PhD programmes do not include structured course training on research methods (Opata, 2011). Such a course before commencement of a PhD is necessary to arm the students with the skills to conduct a PhD study, including continuing support in specific training needs e.g. data analysis packages. The results of this study indicate less commitment in supporting early career researchers who had just completed their PhDs into starting off and building a research career (see section 5.4.3 – Time for research). This is seen in the sentiments of a participant, that:

You have been trained to become a researcher only to end up becoming the head of the department or the chairman. I don't think that was the plan, to be bogged down by administrative duties.... being a head of department in these public universities is just a nightmare. And you get co-opted into all this committee for this, committee for that, ISO committee...things you don't need, so there's hardly time for research (COM\_3)

Harle (2011), in a detailed report on how this can be achieved, notes that universities need to recognise this as a need and devise strategies that address the problem. This could be in form of offering both time and financial support, and include facilitation for networking, support in grant application processes and publishing, gaining project management skills and encouraging mentorship by senior academics (Harle, 2011).

### *Availing resources*

Availability of funding, special equipment and time were identified as the main resource barriers to collaborative research.

### *Funding*

The results of this study show little investment in funding research, both at the institutional and national level, as seen in sections 3.5 and 6.4.2. Universities are faced with huge budget deficits from insufficient government funding, which constitutes only 30% of the university's operational budget (details in section 3.5). This means much of the internally generated funds end up servicing the deficit, thus little is allocated to research. The

government and university management would need to make a deliberate effort to prioritise funding research.

Increased collaborations and partnerships with industry were suggested as one of the ways of getting the industry contribute to research funding. A suggestion was made by a participant towards having a central body coordinate research and funding issues (such as the Research councils in the UK). Though NCST/NACOSTI is responsible for coordinating and allocating research funds, a participant from NCST noted that it is limited in this mandate because of the decentralised nature of research operations and varying sources of funding for academic institutions in Kenya:

In Kenya we have that model that the co-ordination is not so centralised. You see the institutions get their funding and they are doing their own thing depending on their mandate.... it would appear like the National Council is coordinating research in all these institutions, it is not... the universities today have their own charters - in as much as we have a mandate to co-ordinate, these guys will tell you us we are following our charter. (F\_1)

A central body would act as a platform through which areas of research that interest both academics and industry can be identified and flagged for funding, with an expected effect of increasing the impact of research done. This would also act as a central reference for attracting support and partnerships with industry, identified as a valuable source of funding. It would create an avenue through which donors could seek collaborations and channel their funds, rather than channelling through individuals or specific institutions. It would also promote efficient coordination and monitoring of research funds.

#### *Acquisition of and access to equipment*

Stiff bureaucratic processes were highlighted as barriers to sharing of equipment and access to already acquired funds, as seen in section 6.3.2 and 6.4.4. Some participants expressed a preference for seeking collaborators outside the university environment where there were less stringent regulations and procedures in accessing equipment for members of a collaboration not part of the particular institution. This is reflected in many collaborations outside academia, which though to a larger extent seem to be determined by funding patterns, could also be determined by availability and flexibility of access to equipment. This calls for university management to reconsider some of the administrative processes involved in sharing and accessing resources to make the process more flexible and

friendlier to the researcher, likely to result in increased motivation to do collaborative research.

In accordance with past studies, the level of resource dependence differed across disciplines, more determined by the nature of the work, affecting collaboration levels and processes (see section 6.4.3). It is important that disciplinary areas that depend highly on existence of particular resources are identified and more attention given to acquiring of the resources. The NCST has set aside an 'equipment fund' to facilitate acquiring of expensive equipment that can be shared among the institutions in an attempt towards solving such problems. However, participants cited problems in logistics of access, especially for institutions that were located far from the facility. If institutions could see each other as collaborators rather than competitors, they could augment government efforts by joining hands to acquire more of the shared equipment. This would ease the problem of availability and access to special equipment as well as probably lead to more research links between the sharing university departments. Participants cited problems in international transfer of materials (see section 5.4.3 - conditions and restrictions imposed on international collaborations) and use of some facilities overseas. Perhaps policies supporting such restrictions need to be revised to promote the collaboration processes of individuals both nationally and internationally.

#### *Information resources*

Poor information resources emerged as a barrier to accessing information and establishing links. This is reflected in the scanty information on university websites, problems in accessing online resources and lack of research information systems (see section 6.4.2 – Information resources). However, some universities have better information resources than others. For instance, more information on staff and publication profiles is found on the University of Nairobi website due to a mandatory requirement enforced by the university management in 2009, to have all academic members of staff upload their CVs online. JKUAT, on the other hand had compiled a compendium of research activities, a useful central reference point for research going on at the university, which was not available in the other universities, and was the only university with a research information system at the early stages of roll out at the time of data collection. The participants noted a need for institutional support in creation of forums where researchers can meet and lead to creation

and/or expansion of ties. In addition to physical forums, online forums such as those provided by CORDIS (see section 7.3.1) and ResearchGate offer researchers platforms for collaboration and exchange. In dealing with the problem, participants made the suggestion of having a centralised database with information on current and past research and researcher information including affiliation, research interests, etc. which would ease up the process of searching for collaborators as well as reduce possibilities of duplication of research. This would act as a reference point for those interested in a certain research area as well as assist in identification of new research areas (for a full discussion on this, see section 7.3.1). Populating university websites and repositories with updated and useful information on ongoing research would also be a useful source of information.

Materials requiring payment for use emerged a major problem in use of online resources (50.9% of the respondents considered this a major problem, 29.6% a problem and only 19.5 % considered it a minor problem or not a problem). This reflects a need for universities to invest more in digital information resources. Expanding the services and resourcefulness of the national library, as discussed in section 7.3.1 would expand the information resource base. The government, in cooperation with institutional management needs to invest in making the national library a rich source of information for any research conducted over the years. This could include a variety of digital and media resources, including deposits of completed research produced from all universities and research institutes, thus a central point of reference. This would also mean subscribing to a wide variety of journals and information resources, to ensure that researchers have access to a wide variety of reference for literature that they could fall back on if the resources were not available in their own institutions.

### ***Strengthening of links with industry***

As mentioned above, creation and strengthening of partnerships with private organisations and industry would be likely to augment and boost government efforts in funding research. It could create opportunities for training, such as for PhD students to be integrated into research projects involving the industrial laboratories. This could offer them the much needed financial sponsorship as well as training and research experience. A number of participants pointed to the weak links between universities and industry. As seen in section 5.4.3 (Weak links with industry), confidence by the industry in seeking universities to solve

their problems was pointed out as lacking. A lack of trust was seen in the secretive nature of industry, mainly due to the fear that their information would be shared with competitors. Lack of trust between the two was exacerbated by unethical conduct among some academics such as one case narrated by a researcher of university taking money and not delivering on the project (see section 5.4.3 – Weak links with industry). Participants highlighted the need for researchers to conduct research geared at providing practical solutions to problems, that which is market oriented and interests the industry. It was noted that this should also be reflected in the curriculum offered. Universities in Kenya have been accused of offering outdated courses not commensurate with market needs (see section 6.4.4). The assumption is that the same applies for research, with some from industry not trusting the capability of researchers to solve current issues, preferring to seek solutions from outside the academia. This is exemplified by the narration of a how researchers at a Kenyan university successfully managed to solve a problem that was unsolvable by expatriates enlisted by the Kenya Power and Lighting Company:

... It is a recent case. Kenya Power consulted some people from South Africa to solve a certain problem in the power industry. Those people came, they provided their solution, and it failed. The same Kenya Power engaged JKUAT staff. They solved the problem. Can you tell me the expatriates are the best? (ENG\_3)

Redesigning the curriculum to address current needs in the market would lead to more confidence in what the universities produce, including research, promoting involvement with the industry. Participants also highlighted the need for researchers to market themselves, show their capabilities and thus create confidence in industry going to them for solutions.

### ***Reduced bureaucracy***

Participants complained of long bureaucratic processes that characterise Kenyan universities, affecting collaborative processes. These include the lengthy procedures involved in letting collaborators not part of a university access equipment within the university (see Section 5.4.3 – Access to special equipment), and bureaucracies in approval for disbursement of funds (see Section 5.4.3 – Institutional structures, processes and support). Reorganising university decision making structures, reducing the levels of authority and adding flexibility to the conduct of some of the processes to make them friendlier to the researcher would have an impact on accomplishment of tasks. Digitisation

of these processes and centralised databases would lead to minimising redundancy and much paperwork that result in tedious processes of approvals and delays to project activities. The universities need to move from this paper culture and adopt the technologies that will hasten the processes.

### ***Policy and their implementation***

Some institutions have policies in support of various aspects of collaborative research, while others are lacking (see section 6.4.4 – Institutional policies and strategies). For example, the University of Nairobi (UON) has well-structured proposal writing workshops to support professional development of researchers, which was lacking in other universities at the time of data collection. It is important that universities design adequate policies that guide various aspects of collaborative research such as call for proposals and associated grant awarding processes, capacity and skills development, IP right issues, decision making and conflict resolution processes. Equally important is need for evaluation of the policies in meeting growing research needs with time, making necessary revisions and ensuring their implementation. Participants displayed a lack of awareness of some of the existing policies or guidelines as to the conduct of some aspects of collaborative research, as seen in section 6.4.4. Others cited lack of implementation of policies, also noted in Opata (2011), which is likely to affect the morale and motivation to do research.

As an example, clearly laid out IP rights policies are necessary for researchers to understand their rights to research output to avoid conflicts and discontentment which affect the morale to engage in research, as discussed in section 6.4.4. Universities now seem to have IP policy documents, but a number of researchers expressed little knowledge of them and / or their contents. Thus, there's need for the university to create awareness of their existence and content, to avoid situations like one described by a participant where a collaboration had to come to an immature end because of disagreements between the industrial collaborators and a university department on issues of IP rights (see Section 5.4.3 – IP right issues). Others felt that the policies did not favour the researcher, perhaps reflecting a need for their periodical evaluation and revision to create a reasonable balance and reflect changes and new developments in the process of conducting research.

Lack of research ethics, especially as regards plagiarism and recognition of IP rights was noted as a major problem to those working on collaborative projects (see section 6.4.1 –



personal attributes). Plagiarism is a rarely understood term, more so for those who have studied locally, and is hardly found in university websites or course guidelines. In a recent article in the Standard Digital News Kenya, a prominent Kenyan Politician with PhD level qualifications is accused of lifting ‘almost an entire chapter in Robert Greene’s popular *The 48 Laws of Power*’ to put it in a newspaper column (Mwaura, 2014). This shows the serious nature of this vice among the general ‘learned’ community in Kenya. The University of Nairobi, a leading Kenyan university has only recently recognised the importance of sensitisation on plagiarism, introducing a plagiarism policy (2013) that proposes to educate students and members on staff on what plagiarism is, how to avoid it and its implications. In this study, participants expressed fears of doing joint work due to common cases of plagiarism such as people passing off research done jointly or done by others as their own. Making people aware of the consequences of such and implementation of such policy should encourage people to work together and acknowledge others’ contributions in collaborative work.

### ***Motivation and rewards***

Universities should strive to motivate their researchers into conducting more research and seeking collaborations. The majority of researchers complained of lacking time to dedicate to research, as a result of the universities’ focus on teaching as opposed to research (see sections 5.4.3 – Time for research and 6.4.2 - Time). Suggestions were made on relieving those involved in research of some teaching load as a way of motivation to conduct research.

Research work was regarded as not being very financially rewarding, and a number of researchers are engaged in private consultation work or teaching loads of part-time hours to supplement what was referred to as poor remuneration packages, to afford time for research, corroborating Harle (2009) and Gaillard & Tullberg (2001). This points to a need for the government and universities to consider appropriate pay packages, to gain commitment towards research work. While some value financial incentives, others indicated other forms of motivation such as promotions and other forms of recognition were important to them. For example, while one participant was of the view that ‘I don’t expect the university to pay me money to motivate me; my motivation is getting the promotion’ another saw research as not being very financially rewarding, opting for quicker

ways of getting money through part-time teaching. Perhaps the universities should consider other reward mechanisms, not only based on publications as is mainly the case, but on other forms of productivity and impact of research. For example, the universities could also organise research award ceremonies to celebrate those who have achieved most within a certain period, as a way of recognition.

Universities need to ensure researchers are compensated accordingly for work carried out by giving them a fair share of IP ownership. As seen in section 5.4.3 (IP right issues), some felt that universities were the main beneficiaries of research products and indicated they preferred work outside the university that was more rewarding.

### ***Competition***

In this study, reference was made to ‘unhealthy’ competition between the universities, with participants calling for more cooperation between local universities. This was exemplified with their wanting to make MoUs with institutions far away while ignoring local universities, thus the fewer ties observed between the universities studied as seen in Figure 5.6. However, as much as there’s a need for closer ties locally, international ties are important as they enable sharing of equipment, knowledge, skills and best practices that may not be available locally. Research policies at the national level are encouraging cross institutional research, whereby the NCST gives funding preference to research that involves individuals across universities. Creation and facilitation of forums where researchers can meet, share and strengthen relationships would encourage ties across institutions reducing competition at personal level. At the national level, the NCST is making an effort towards this by organising workshops for researchers across the institutions to disseminate research output. However, the workshops were faulted for being too general as they involved an audience from all disciplines in a single venue, thus the call for workshops to be organised along particular themes for more impact.

### **8.3 RECOMMENDATIONS TOWARDS UPTAKE OF ICT**

Unreliable internet connectivity, lack of awareness of various technologies, training and acquisition of relevant skills, inadequate technical support and existing usage cultures affect adoption of ICT not only for support of collaboration processes, but also research work in general. A discussion of issues related to improving ICT infrastructure, mainly targeted at policy makers, follows below.

### ***Internet connectivity***

Though Kenya has been referenced as a leading ICT hub in the region it is surprising that majority of respondents complained of poor internet connectivity. Major national infrastructural developments have been realised in the last five years, such as building of a National Optic Fiber Broadband infrastructure (NOFBI) connecting all major towns (see Figure 3.2). However, much of campus networks have yet to be upgraded to match the speeds offered by NOFBI optic cabling, as evidenced by the number of participants citing problems with internet connectivity (see section 5.5.5 – internet connectivity problems). Consistently, Kashorda & Waema (2014) point to the high rate of dissatisfaction with campus networks, noting the low priority given to their improvement, as seen in section 7.4.3. Kashorda & Waema (2014) further note that most of the studied universities were charging ‘student lab fees’ sufficient enough to meet most ICT needs, but it was not clear if the funds were being used for that purpose (p. Xi). This points to the issue raised in section 6.4.2 (funding), that funds were sometimes directed to what was seen by the management as more wanting.

The university management would need to prioritise improvement of existing campus infrastructure so as to realise benefits of improved national infrastructure. This may be a high call for them given the huge budget deficits they have to service in every annual budget, as seen in section 6.4.2, and will call for further support from the government. In addition, there have been calls for partnering with private organisations who could contribute to funding or development of ICT infrastructure within the universities, a view shared by Kweku (2012). Such is the partnership between JKUAT and Safaricom, the biggest mobile services provider and ISP in Kenya, which has seen Safaricom donate a mini GSM network laboratory equipment worth Ksh 80 million (approximately £615,000) for the JKUAT Engineering and Telecoms laboratory. More of such partnerships with industry are likely to promote research related activities, whether in terms of providing for access to or improving facilities, funding support or even providing for environments where students can gain experience through industrial attachments.

### ***NRENs***

As discussed in Section 2.9 – *ICT infrastructure*, having a dedicated National Research and Education Network (NREN) designed to operate specifically for higher education and

research is likely to improve the internet experience in the sector. Though KENET has been referenced as one of the most advanced NRENs in Africa, its services are mainly limited to provision of bandwidth to institutions of higher learning at subsidised rates, while offering independent technical advisory and network design services to individual campuses (KENET, 2014). After securing a \$22.5 million grant from the government of Kenya in December 2013, KENET aims to connect its member institutions through a high speed private network (see Section 3.6). The Executive Director Kenya Education Network (KENET), while launching a network of 136 campuses on 9th December 2013, highlighted the need for support to universities in last mile broadband connections and improvement of campus networks.

The amount of bandwidth available to an institution is dependent on the amount of funds that an institution commits to purchasing internet bandwidth. Though internet access was a major problem for the majority of respondents across the universities, some differences in access speeds across universities surface based on the bandwidth available to a university. Perhaps implementing a cost sharing model, such as the one employed by Janet in the UK, as discussed in section 2.9 (ICT infrastructure) would ensure that no institution is limited in the amount of bandwidth it can access based on affordability. In addition to improving internet access, universities need to put measures of managing and utilising the bandwidth available, such as monitoring usage, so it's not wasted on non-academic material.

### ***Hardware and software***

Universities also need to invest in other ICT resources including computers and software to improve ready access. Extensive sharing of computers was noted. As seen in section 5.5.1, the majority of researchers have solved this by investing in their own computers. However, as reported by a number of respondents, the same does not apply to software. One may require a range of software over a certain period to do his work, and it may not be affordable. The universities therefore need to invest in a range of most commonly used software, to ease the burden on the researcher, which sometimes results in delays or shortcuts to accomplish the tasks with what is available. The most common software used could be identified and provided at the department level (as some of the different commercial off the shelf kind of software are designed to accomplish the same set of tasks). Individuals can then be encouraged to make use of the acquired software instead of having

to request for many kinds of software in which the only difference may just be the brand name. Alternatively, including software costs in the project proposals would offload some of the cost issues from the individual researchers and university saving the time taken to acquire them.

***Creating awareness and providing for efficient technical support***

As seen in section 7.4.3, a number of respondents cited lack of awareness of what would be seen as ‘common technologies’ for supporting collaborative work in the developed world. A participant noted the need for universities to create awareness as well as facilitating availability and accessibility:

for people to consume these products, then they must be aware of them. Maybe some of us are not aware that these technologies do exist .. But being aware also is an issue of is it free, or how much do I need to pay to use it? (ENG\_3)

The universities, perhaps through the ICT departments in universities, need to identify and acquire (though some are free) technologies that would be most useful in supporting collaboration activities (for a discussion on technologies that support various collaborative work processes, see section 7.3.2). However, acquiring the technologies is not enough. The universities would need to create awareness of their existence and usefulness. Organising for awareness creation workshops and training would arm the researchers with skills and more options thus flexibility of choice of what would best support their work. Many universities are doing a commendable job in providing basic ICT skills training for their staff. However, some tasks require specialised training and skills e.g. data analysis using various software. The university management would need to carry out a needs assessment of common and specialised training requirements and make it part of an ongoing skills development program. Availability of technical support was seen as important by the participants in this study, consistent with Venkatesh et al. (2003). In addition to assisting researchers in the daily hurdles faced in use of ICT, skilled technical staff would ensure more efficiently running systems, thus creating confidence in their use. Universities therefore have a role to play in providing for qualified, reliable and adequate technical support, guided by policies regarding the qualifications, number and work definition of required technical support team.

### ***Developing a culture of use***

Developing a culture of ICT usage by embedding it in the curriculum in early stages of learning as well as at higher education level would promote the creation of a digitised community. Realignment of university processes to accommodate use of ICT, e.g. making it mandatory to use ICT as a medium of instruction, and performing academic duties e.g. assignment handling, will encourage general use and adoption by researchers in their daily research routines (see section 7.4.4).

### ***ICT policies***

Comprehensive ICT policies are important to guide acquisition, development and implementation of ICT programs and services. Differences emerge in existence of ICT policies across the universities. For instance, while the University of Nairobi had a comprehensive ICT policy, another of the studied universities only had an automation policy listing departments and processes that needed to be automated at the time of data collection. While this could be a reflection of lack of vision on the part of the leaders, it could also be a reflection of the low priority given to improvement of ICT services as pointed out by Kashorda & Waema (2009) and Kashorda & Waema (2014). University management need to give more appreciation of the benefits accrued from improving ICT systems, thus come up with strategic plans and guiding policies. The policies and regulatory frameworks need to be comprehensive enough to provide guidelines on acquiring and management of ICT resources and facilities, usage policies and information security policies among others.

## **8.4 RECOMMENDATIONS FOR RESEARCHERS**

### ***Different disciplinary backgrounds and cultures***

As discussed in section 6.4.3, the different disciplinary backgrounds can be an issue due to the differing work practices and training in conducting research. With the growing interest and focus on interdisciplinary research, it is necessary that researchers learn to understand each other and look for ways of creating harmony within the collaboration. Organising workshops in which people can share on issues involved in the conduct of interdisciplinary research would enlighten individuals on the kind of situations that emerge and how to deal with them. As suggested by Maglaughlin & Sonnenwald (2005), in case of conflict, an intermediary who understands the different disciplinary practices and work processes

would perhaps be necessary to bridge the differences and help the individuals or groups come to an understanding. As discussed in section 6.3.2 (conflict resolution), a clearly laid out conflict resolution mechanism would need to be in place. This would give the parties involved a reference point for seeking solutions, especially in cases of serious conflict to avoid premature end to a project. The arbitrators, for example could be a high level board involving members outside the collaboration to give non-partisan guidance on how the problem can be resolved.

### ***Intrinsic motivation and writing quality proposals***

In addition to external motivation described in section 8.2 above, researchers need to be intrinsically motivated to be actively involved in research. Writing quality proposals and actively seeking funding support, actively marketing their skills and partnering with those in industry were proposed as some of the ways of expanding ones research boundaries. It is important for researchers to propose research that addresses issues that policy makers and other stakeholders are struggling with in order to elicit their interest. This is evident in the interest shown towards agricultural research, which reflects higher collaboration levels and exhibits more active disciplinary networks, as discussed in section 6.4.3. Some participants attributed the level of attention and interest to writing proposals that target solving particular issues affecting the society. This corresponds to a characteristic of Mode 2 type of knowledge production as discussed by Gibbons et al., (1994), a focus on the application context. A focus on proposing research that would improve the society in one way or the other, or contribute to development issues in the country would perhaps attract more support for the 'less funded' disciplines. An innovation such as the M-Pesa<sup>41</sup> money transfer has revolutionised mobile money transfer area not only in Kenya but worldwide. In Kenya, it has been a great success given the population using mobile phones and the ease it brought to this population, as a cost effective, flexible way of sending money in relation to the traditional banking practices, meeting most of the criteria for fast adoption of an innovation described by Rogers (2003). Writing proposals targeting such kind of

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<sup>41</sup> M-Pesa, a mobile- phone based money transfer application and service developed in Kenya, is described by Vodafone as 'the world's most successful money transfer service. It enables millions of people who have access to a mobile phone, but do not have or have only limited access to a bank account, to send and receive money, top-up airtime and make bill payments'. First launched in Kenya in March 2007, it has been deployed to nine other countries, the latest being Romania in March 2014. ([http://www.vodafone.com/content/index/about/about-us/money\\_transfer.html](http://www.vodafone.com/content/index/about/about-us/money_transfer.html))

application context, regardless of disciplinary area would surely attract interest and funding.

Some participants felt local research was largely being ignored in favour of research and technologies from outside, cautioning the government of ignoring the potential of local universities in providing solutions to local problems. Some university departments look at collaboration as partnering with big multinational research companies and laboratories such as Microsoft, Google, Nokia, IBM etc. Without disputing the usefulness of such collaborations, the smaller collaboration between local researchers trying to solve local solutions need not be ignored.

### ***Dissemination practices and involvement of stakeholders***

In addition to approaching stakeholders with proposals that match their need for expertise, researchers could organise seminars and workshops to showcase their expertise and disseminate results. The NCST is doing a commendable job by organising dissemination workshops targeting the wider research community. However, a participant noted that such workshops needed to be organised around research themes for it to have more impact on bringing researchers with similar interests together, as opposed to the current organisation that brought together all disciplines (see section 5.4.3 – creation of forums where researchers can meet and share). Researchers should consider using dissemination outlets that are of relevance to the practitioner, policy maker or any other potential consumer of the research. Oliver et al. (2014) note that dissemination methods used by majority of researchers such as peer reviewed journals and academic conferences usually target other researchers, rather than policy makers. Noting that policy makers do not usually read academic literature in search for solutions, their research output needs to be packaged in the right form for the particular audience and appropriate means of dissemination considered for the research to have an impact.

As seen in section 6.4.4, some participants complained of lack of implementation of research findings. Oliver et al (2014) notes the importance of instilling trust in the quality of research and cultivating a good relationship between the researcher and policy maker, for research to influence policy. Involvement of stakeholders throughout the research project is likely to promote feelings of ownership thus higher chance of implementation of findings. However, this is complicated by the fact that much of the research done in Kenyan



universities is sponsored by donors, as seen in section 6.4.2, whose interests may not be in line with the researchers' or other beneficiaries of the research (Shrum & Beggs, 1997; Harle, 2007). Donors need to have a commitment towards supporting and facilitating research they sponsor have an impact. Researchers could include in their initial proposals plans for dissemination and creating impact, to elicit support towards this from the donors.

### ***Specialisation in research***

Participants pointed to lack of specialisation in particular research areas. This could hamper possible connections with industry, as those in industry at times did not know who had the particular skills and capabilities to work with in solving their problems. Specialising would give one an avenue through which to market their skills and capabilities, as well as leading to easier identification of individuals and groups with whom one could work. Research groups specialising in particular areas of research were pointed to as lacking in most Kenyan university departments (see section 5.4.3 – Need to create research teams and specialise). Forming such groups would bring together individuals with skills and capability in the particular areas, and provide an environment in which research problems are identified, ideas grow and are nourished within a group of people with common interests. This is likely to lead to the benefits of easier identification for partnerships, as well as a channel through which research funds can be sought.

### ***Trust, commitment and ethical issues***

Participants highlighted the need for transparency, trust and commitment towards achieving project goals. It is important that researchers earn trust and confidence among their colleagues and other stakeholders. Researchers need to ensure that they deliver on the agreed project mandate, and to the required standards. Transparency and accountability were pointed to as lacking especially concerning use of project funds. Perhaps the principal investigators, who are usually in charge of funds management should be made (either by project funder, university management ..) to keep an accurate record of all transactions and make it accessible to all with an interest in the project, to increase transparency in use of project funds. For bigger projects, Vasileiadou (2009) advises on employing the services of a project manager, to run all issues of management including keeping such records.

Ethical conduct of researchers emerged an important concern among the academic research community. Academic dishonesty was pointed out as common, with regards to people not

recognising contributions of others in work that was done jointly, perhaps for selfish reasons such as gaining sole credit for the work. As seen in Section 7.2 (policy and their implementation) policies addressing academic dishonesty were lacking, with only the University of Nairobi having a plagiarism policy by December 2014. Researchers should realise the need to adopt good ethical practices in the conduct of their work, so as to earn trust and respect within their colleagues and the wider research community. This includes acknowledging others' contribution to the research as well as materials referenced. Some, especially those who have studied in universities in the developing countries where issues of plagiarism may not be clear and policies to address them lack may not be familiar with accepted and correct referencing practices. Universities could organise workshops and seminars that train researchers on correct referencing and create awareness on the need to avoid plagiarism and observe research ethics.

### ***Incorporate a variety of ICT into work practices***

Use of a variety of technologies has been found to benefit research work in many ways. However, this study shows that email and phone are the most commonly used form of ICT to support communication and information sharing among researchers in Kenya. Other types of technologies such as VOIP, web forums, chat and fax are less common. Their low usage was attributed to factors such as poor internet connectivity, lack of awareness of some of the technologies, and their usefulness in supporting some kind of tasks.

To meet the challenge of internet connectivity, a participant advised researchers to invest more in 'self-infrastructure', such as Smartphone to allow them instant and flexible internet access. Out of the 93.2% who indicated they had a mobile phone, only 57.4% were internet enabled. Researchers are encouraged to use a variety of technologies, as some are better at supporting some tasks than others and offer more to the quality of communication (see section 7.2 – Availability and use). A Skype meeting, for instance, would be better in the absence of face to face meetings in the initial stages of formation of a collaboration, where building of strong relationships and trust is much influenced by physical interactions between the partners than a simple exchange through emails, with someone you have not met. However, it is also noted that use of some technologies, especially those that require much bandwidth such as video conferencing, is limited by the infrastructural facilities available.

To deal with the issue of awareness, university ICT managers and departments need to keep informed and updated on newer technologies that could support communication and research processes, and organise for awareness creation and training workshops. The researchers could also take the initiative of being explorative in finding out how they can maximise the use of ICT to support their work. For instance, a number indicated they hardly make use of online discussion forums and networking sites tailored for research and scientific work. Through these sites, they can engage in interesting discussions, get feedback on their work, share documents and identify researchers with similar interests, thus a source of collaborative ties among other benefits. (A discussion of some of the roles ICT plays in collaborative work is presented in Section 7.3). Researchers therefore need to appreciate the benefits that ICTs offer to their work, and adopt a positive attitude towards integrating them into their work. A personal sacrifice towards acquiring skills and necessary ‘self-infrastructure’ may be required, but the benefits may be worth much more.

#### **8.5. RECOMMENDATIONS FOR DESIGNERS OF TECHNOLOGIES**

As seen in section 7.3.1(university and national information resources), participants expressed concern over poor information resources and lack of research information systems. It was noted that some university information resources, such as websites were lacking in relevant content, some hardly updated and links linking to empty pages, consistent with Muinde (2009) and Harle (2007). As seen in section 8.2, participants expressed a desire for a centralised database of research and researcher information.

The NCST should be able to tell the scientific community, who is doing what and where they are, so that people can know where to go hunting for collaborators. Similarly, the universities should also be able to do the same, say we have this discipline, these people are working in this area, a way of getting the information around, of who is doing what and where they are and what they are working on, so that people can look them up (PH\_3)

As described in section 7.3.1, at the national level, an internet based platform, easily accessible to members of the research community, where scientists can access details of ongoing or past projects including the people involved, and include functionalities to support communication and sharing of information would be a boost to collaborative work in Kenya. This platform could incorporate search facilities that allow researchers to search for those with similar interests. The platform could also act as a central messaging centre to pass on important information such as availability of research grants, conferences and

workshops. It could contain a discussion board, where a researcher can start a discussion, ask a question and get feedback. Making such a platform relevant with important research related material and services would probably promote use of such web forums, even among those who indicated low usage or non-usage of them. However, the designers of such information and communication resources would need to ensure complexity in access to information and use is minimised, to encourage uptake for even those with ‘technology phobia’. Expanding the services of the national library, as seen in section 8.2 (availing resources) and section 7.3.1(university and national information resources) would require a correspondingly efficient library management information system, to facilitate easy and flexible access to the library resources for the researcher, as well as management of library processes.

Only JKUAT had a research management information system (RMIS) at the time of data collection. An RMIS should provide tools through which researchers can easily store and manage their project information and activities. Such is the CONVERIS Research Information System, an off-the-shelf RMIS that has been adopted by a number of institutions worldwide for research management purposes. Once logged into the personal profile through the university’s research portal, one can enter and access a variety of research related information including profile details, information related to a particular project (e.g. lead investigator, co investigators, financiers, external partners etc), funding opportunities, ethical reviews etc. Through CONVERIS one can manage information regarding publications, journals, research activities, and create things to do list that would act as a reminder of coming deadlines and tasks that need attention. CONVERIS’ compatibility with other applications allows one to automatically import publications or other data files from external sources such as reference managers and online repositories. CONVERIS also contains a messaging service that allows messages to be sent to other CONVERIS users, and delivers notifications on changing status of CONVERIS content. Through the research portal within CONVERIS, one can easily share as well as access information shared by others over the web with flexible filtering services. The application also allows one to generate a CV based on the information stored and the required content (CONVERIS, 2014). An important element of this RMIS is that it can be customised to individual needs.

Such an application could gain wide usage within the research community due to the flexibility and ease it brings to research management. Considering that it contains many features that are relevant for research management, it could be adopted and customised to university and researcher needs and save on time that would be used in developing a similar system from the scratch.

Designers also need to ensure compatibility of systems designed and built with other existing systems and hardware. For instance, Kashorda & Waema (2014) noted problems in access to materials in digital libraries using mobile devices, which were a common data access tool among students. Compatibility is not only in hardware and software, but also in the user processes. Technologies designed or adopted should easily integrate with work processes of individuals

## **8.6 CHAPTER SUMMARY**

This chapter has presented a discussion on a number of recommendations towards improving and promoting the status of collaborative research in Kenya. This includes guidelines for support and processes that would work towards establishing and management of successful collaborations. A number of the recommendations are drawn from participants' responses and suggestions on best practices, indicating they are grounded in reality, thus their applicability in improving their research life. The guidelines provided can be of consideration by policy makers, both at the national and institutional levels, the researchers themselves and designers of information technologies. Though noting that research environments differ between countries and regions, many in developing countries exhibit similar characteristics (Harle, 2009; Mouton, 2008). The recommendations can therefore act as a reference point for evaluation of, and guide to improving and promoting collaborative research not only in Kenya but in the wider African and developing world context.

Table 8.1 below provides a summary of the barriers to collaborative research and subsequent recommendations as discussed in this chapter. The letters in square brackets in the recommendations column reflect their target audience. [U] = university level management, [N] = National level management (with reference to the government ministries and agencies entitled to deal with research issues), [R] = Researcher level and [D] refers to designers of information technologies.

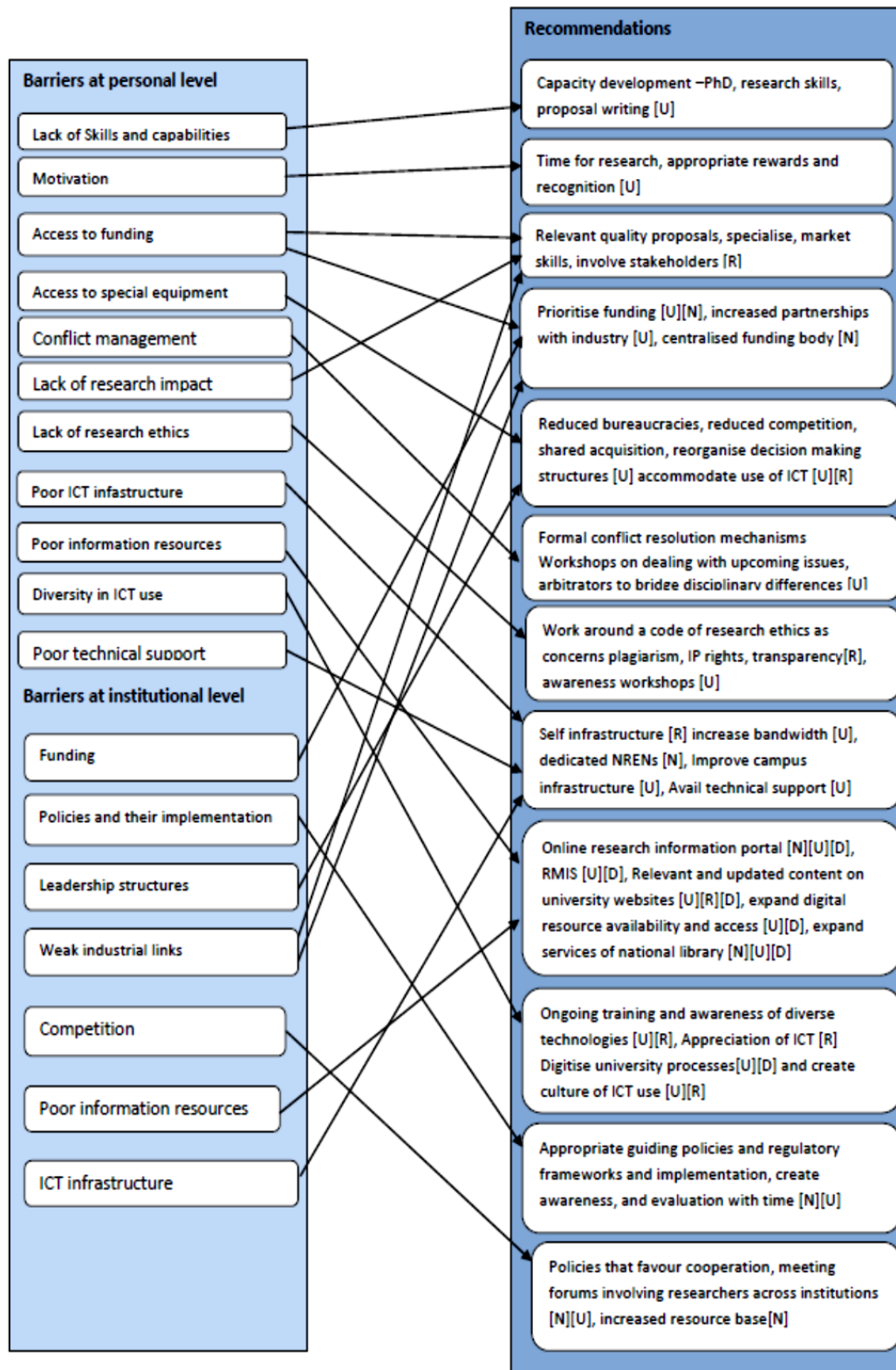


Figure 8-1 Summary of barriers to collaborative research and recommendations

## **CHAPTER 9: STUDY CONCLUSIONS**

### **9.1 INTRODUCTION**

Collaboration in research has become a key component of the knowledge production process. This has been made easier by advances in ICT, referred to by Gibbons et al. (1994) as crucial in supporting the activities of the distributed actors in collaborative research. Literature points to low levels of research and networking in Africa, including Kenya. However, studies and methods on which such claims are based have been faulted. Many studies on research collaborations are focussed on the developed world. There is a limited understanding of the processes and conduct of collaborative research in the developing world, and specifically, Kenya. This study therefore sought to understand the organisation and nature of academic research collaborations in Kenya, and the role that ICT plays in supporting collaborative activities within this community.

In meeting the research objectives (see Figure 9.1), it was necessary to carry out an intensive study of a select group of academic researchers in four disciplines across four major public institutions in Kenya. As pointed out in section 1.2, no study has researched the academic research community in Kenya that closely before, thus the basis for this study's contribution to knowledge. A mixed methods research design was employed so as to understand the broader aspects of organisation as well as derive a deeper understanding of particular issues affecting collaborative research. Self-reported measures of collaboration were used to improve accuracy of the data on collaboration levels and academic networking, as per definition of collaboration presented in Chapter One. This approach was taken as a measure towards overcoming the shortcomings of bibliometric measures in representing level of research and networking, as noted in past studies (Beaver & Rosen, 1979; Katz & Martin, 1997; Lee & Bozeman, 2005). These methods have especially been faulted for under-representing research done in Africa, whose thematic emphasis on local problems may result in invisibility of their publications in international databases of published material (Shrum, 1997; Duque et al., 2005; Mouton, 2008).

A study of literature identified a number of factors that affect the processes of collaborative research. As pointed out above, much of the literature is on collaborations in the developed world. However, research environments differ, and this affects the knowledge production

processes between regions. The factors identified in literature were therefore investigated and analysed for their effects on the organisation, processes and conduct of collaborative research within the Kenyan context. This includes factors affecting the use of ICT to support collaboration processes. Section 9.3 highlights the major findings, in relation to answering the research questions and thus meeting the objectives and major aims of the study.

## **9.2 LIMITATIONS OF THE STUDY**

The study adopted a rather broad approach to exploring the nature of collaborative research in Kenya. As pointed out before, there is a dearth of literature on scientific research collaborations in the region. It was therefore found necessary to provide for a basic understanding of their nature, before moving on to specific issues. This approach limits the exploration of some issues in depth. For example, though the relationship between collaboration and productivity is measured in the study, as a way of validating the importance of collaborative research, specific details of why people prefer to publish or not publish are not explored further. However, this provides a basis for deeper future investigations into the issue.

The study also deliberately employed a rather broad choice of scientific disciplines. Past studies have found that organisation of research is to a large extent defined by the nature of the work, more defined by specialist or problem area rather than the broader disciplinary areas. Such studies therefore advocate for the use of specialist areas in studies of 'knowledge producing communities' (Fry, 2003, p.248). However, the organisation of academic research in Kenya makes it difficult to identify specialist areas, as seen in section 4.5 (selection of the disciplines). In this study, it was necessary to identify general trends and views across a range of disciplines whose effects could be generalised to collaborative work. Corroborating past studies that have found a number of challenges in conducting research in developing areas (Harle, 2007; Duque et al., 2005; Ynalvez & Shrum, 2011; Mouton, 2008), external environment factors were found to weigh heavily on collaborative research in general. These factors therefore may apply across the majority of disciplines. However, given that research is more defined by the nature of the work, choice of specialist area would be expected to provide a deeper understanding of particular issues facing groups



working on specific research areas, and give a better understanding of the social organisation of scientists involved in a problem area, as in Crane (1972) .

The broader disciplinary approach reduces generalisability of some of the features of collaborative research to some specific specialist areas. This may also apply to some disciplinary areas outside the scope of this study such as the humanities that may display a different form of organisation. However, identification of the general collaboration patterns in the wider disciplinary area provides a pointer to areas that form a basis for further investigations into specialist areas.

The study established a relatively large number of ties of academic scientists with scientists in other sectors. It would have been interesting to capture the views of this wider scientific community. However, this may not have been unachievable within the set deadlines and resources. Future studies could consider broadening the sample to include scientists from other sectors.

Some issues were experienced during the data collection. The study was designed to be an online survey, but low response rate necessitated personal delivery of the questionnaires. Sometimes it took a lot of time and effort to get hold of the participants and feedback, making it take longer than was originally predicted. Perhaps this is a reflection of the non-suitability of online surveys to a study of this intensive nature, in which response rate was important in defining validity of the results. This especially applies to populations where a culture of using technology is not the norm, or participants have reservations on conducting surveys online as was the case with a number in this study.

### **9.3 SUMMARY OF FINDINGS**

Figure 9.1 presents a mapping of the research questions to the objectives and aims the study was designed to meet, as outlined in Chapter One. The first objective of the study was *to review relevant literature to identify factors affecting structure and process of research collaborations including the adoption of ICTs*. As pointed out in section 9.1 above, in addressing this objective, a study of literature identified a number of factors that affect the processes of collaborative research, that were further investigated for their effects on the process of collaborative research in Kenya. This objective was therefore successfully met.

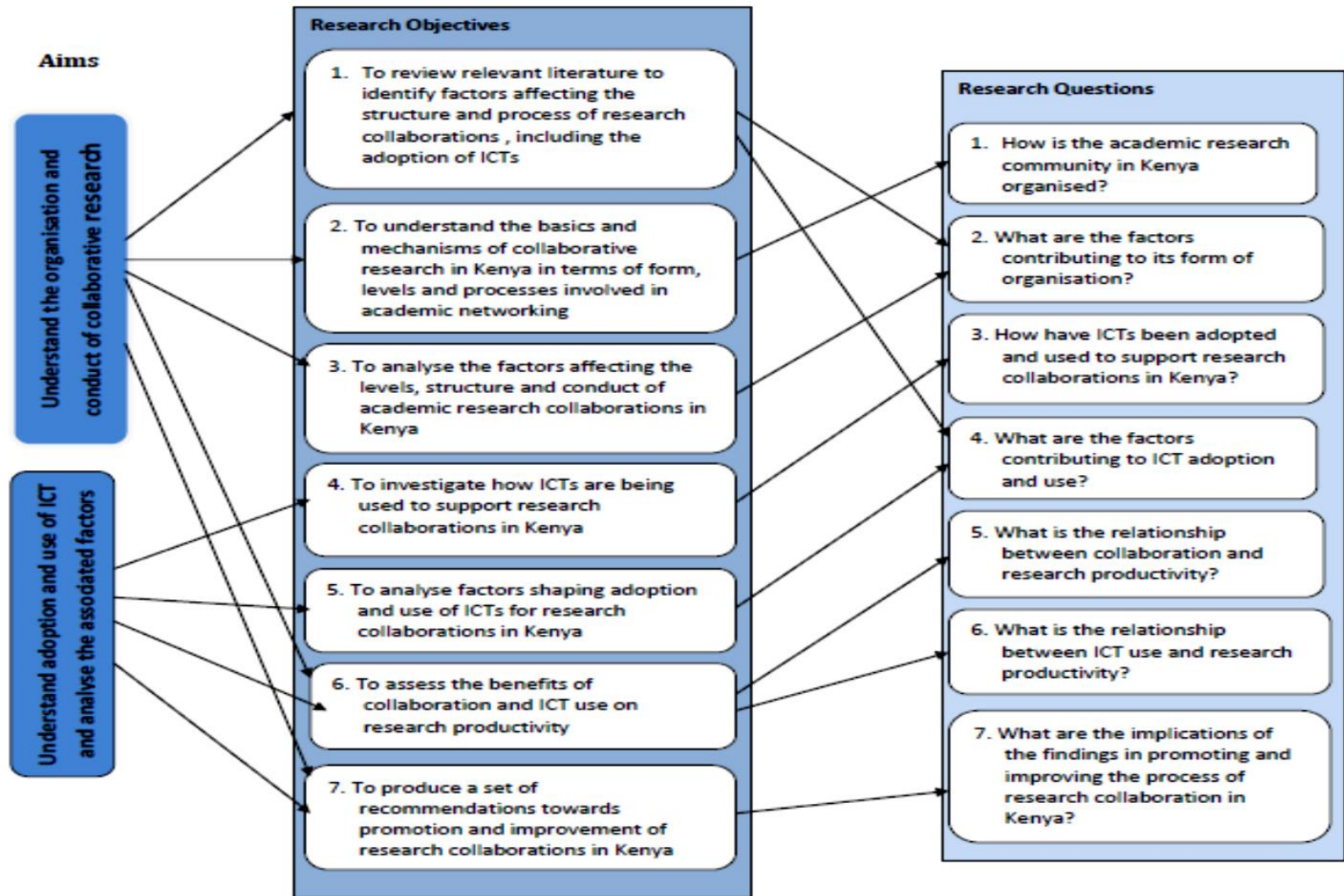


Figure 9-1 A mapping of research questions to objectives

In relation to answering the first question and thus meeting the second objective of the study (*to understand the basics and mechanisms of collaborative research in Kenya, in terms of form, levels and processes involved in academic networking*), data from the self-reported measures of collaboration was used to establish the level and form of links existing within members of this community. A key finding in this study is the relatively high level of research collaborations in Kenya. This is contrary to past studies that have reported low levels of research and networking in the region (Gaillard & Tullberg, 2001; Harle, 2007; Adams et al., 2010). However, the levels are dependent on disciplinary areas, with individuals in agriculture exhibiting higher levels and a more connected network as compared to those in engineering, public health and computing. This corroborates some of the past studies (Lee & Bozeman, 2005; Melin, 2000; Birnholtz, 2007), which found differences in collaboration levels across disciplinary areas. The high level of connectedness of individuals in agricultural research, both within and outside academic research probably indicates some form of social organisation of a research area described by Crane (1969, 1972) as ‘invisible colleges’ exists. However, the network structures in the other disciplines reflect less connected networks, in which the kind of social organisation described by Crane may be difficult to identify. Contrary to Crane (1969) and Crane (1972) who found that the members in a problem area were brought together by interest in a specific problem area, resource needs, especially funding emerged a central determinant of Kenyan scientists’ collaboration seeking behaviour. This probably accounts for the relatively large number of ties with organisations outside the academia, from whom most funding emanates, and less ties between the academic institutions themselves. Details of the levels and form of organisation are found in sections 5.3 and 6.2. of the thesis. The second objective was therefore successfully met.

In response to question two that relates to the first (stated above) and third objective (*to analyse the factors affecting the levels, structure and conduct of academic research collaborations in Kenya*), a number of factors were identified as affecting the levels and form of collaborative research, as reported in sections 6.3 and 6.4 of the thesis. A number of the factors have been identified in other studies in literature. However, research environments differ, and the extent and nature of their effects on collaborative research would depend on the particular research environment. Their analysis within the Kenyan context led to deeper understanding of their effect on this particular community, thus

recommendations tailored to the specific situations identified in Kenya. Factors identified specific to the academic research communities in Kenya include: the extent of challenges in availability and access to various resources; existence of and implementation of policies in support of collaborative research; transparency and ethical issues, such as in evaluation of proposals and use of project funds; and national and institutional support for information access and networking processes.

Variables derived from a synthesis of models, frameworks and studies in literature, including Sonnenwald (2007), Kraut et al. (1987), Sargent & Waters (2004), Amabile et al. (2001) and Maglaughlin & Sonnenwald (2005) were investigated with reference to Kenya. Their analysis, richly substantiated by findings from the study led identification of five major groups of factors that affect academic research collaborations in Kenya: personal, resource availability, disciplinary, institutional, and technological factors. Though some of the issues discussed are specific to the Kenyan context, the resultant categories and subsequent explanatory model (Figure 6.6) can serve as a framework through which research communities and regions exhibiting similar characteristics can be investigated. In addition to providing new knowledge for Kenya, the analysis of these factors in section 6.4, and modelling of their interrelationships in section 6.5, presents a new contribution to the literature on collaborative research in developing countries within the broader field of science and technology studies. Objective three was therefore successfully met.

Factors related to the individual choices and collaboration behaviour such as personal motivation to do research, level of skills and experience, level of commitment, individual work styles, ethical issues and size of personal networks all have a bearing on how researchers conduct themselves and success of collaborative relationships. However, factors external to a collaboration and those relating to disciplinary differences emerged more influential in determining the levels, structure and conduct of collaborative research.

Resource dependence emerged as the strongest determining factor in decisions to collaborate for the majority in this community. Problems in funding were most commonly cited, corroborating Harle (2007), Shrum & Campion (2000) and Gaillard & Tullberg (2001). These problems were largely attributed to little commitment to fund research at both the national and institutional levels. Scarcity of special equipment was also identified as a common problem, which is exacerbated by restrictions imposed on their access.

Participants reported that they would usually collaborate with those who could provide funding and access to equipment. As noted before, this is seen as partly explaining the high number of connections with international organisations as seen in Figure 5.7.

As seen in Section 6.4.3, the nature of a discipline and ‘importance’ of research associated with it emerged as having an effect on the support accorded to it thus affecting the levels and organisation of research. As noted in past studies (Harle, 2007; Duque et al., 2005; Mouton, 2008; Gaillard et al, 1997), more interest is shown in funding agricultural research, probably accounting for the higher collaboration and productivity levels in the discipline. A combination of need to solve important problems, willingness of various sectors to support agricultural research and level of establishment in Kenyan institutions is seen as accounting for the many professional networks associated with promoting agricultural research and higher collaboration rates. On the other hand, participants saw reluctance towards supporting ‘technological research’. This was seen as resulting from the much reliance on technology from the west, and less focus on local capacities and capabilities. The lower levels of collaboration in computing were mainly attributed to less establishment of the discipline within Kenyan universities, lack of disciplinary networks and shortage of trained personnel.

Unlike universities in developed countries, some of which are associated with more prestige and better research environments (Crane, 1965; Long, 1978), the results of this study indicate features salient to all institutions as regards the nature of research environments. Research is referred to as one of the major mandates of the university in Kenya, and institutions have an obligation to provide for to the best of their ability, and support an enabling research environment. However, a number of problems emerged with institutional level capabilities and management. Participants cited low priorities to funding research, bureaucratic systems that complicated or slowed down collaboration processes, lack of certain policies to guide the conduct of collaborative research, poor linkage with industry and poor motivation and reward systems.

Low funding levels were seen as partly resulting from insufficient budgetary allocations by the government towards universities, leaving them with huge deficits to cater for thus less to allocate to research. Availability of time for research emerged a major problem, mainly blamed on the universities major focus on teaching, consistent with Harle (2009) and

Ynalvez & Shrum (2011). The need to meet their financial requirements has led to a proliferation of parallel degree courses, not equally matched by availability of manpower, thus researchers find themselves faced with heavy teaching loads. The universities reluctance to offer some relief to those pursuing research or with administrative duties, and less financial gains associated with research was found to heavily weigh on an individual's motivation to do research. A high regard for material gains and discontent with university kind of rewards led to some individuals venturing more into contractual work with private organisations as opposed to work associated with the university. Competition between local universities, with each wanting to outshine the other was found to affect collaboration choices, which can be looked at as partly accounting for the lower number of collaborative ties between local universities, as seen in Figure 5.7.

In response to questions three that relates to the fourth objective (*to investigate how ICTs are being used to support research collaborations in Kenya*), the study involved measures of availability and use of ICT to support collaboration processes. It was found that the majority of researchers mainly rely on email to support communication processes, sharing of documents and information. Researchers hardly use other forms of communication tools such as VOIP and web forums, which are commonly used in the developed world.

On further investigation of factors contributing to adoption and use of ICT (relating to objective five – *to analyse factors shaping the adoption and use of ICTs for research collaborations in Kenya*), lack of awareness of existing technologies, poor ICT infrastructure and perceived usefulness in supporting their work affected adoption into research work practices. This corroborates past studies that have found ICT infrastructural constraints (Duque et al., 2005; Shrum, 2005; Kashorda et al., 2007; Kashorda & Waema, 2009; Kashorda & Waema, 2014) in institutions in Kenya. It also corroborates Rogers (2003), Davis (1989) and Venkatesh et al (2003) on the effects of perceived usefulness of a technology on its rate of adoption and use. Differences emerge in use between disciplinary areas as seen in section 7.2 (Variations in use), and indication that the perceived usefulness and actual use is influenced by the nature of the work and level of interdependence (Walsh & Bayma, 1996b; Walsh & Maloney, 2007; Olson & Olson, 2000; Fry & Talja, 2007).

Availability and access to digital resources emerged a major problem, contrary to Harle (2010). Poor structure and content of information in institutional repositories and lack of

research management information systems all affected information access processes vital for knowledge production process. In addition, lack of a central point of reference for information on completed and ongoing research was pointed to as posing problems in search for collaborators and identification of new research areas, resulting in duplication of research. Many university processes were yet to be digitised, with participants noting the universities were still entrenched in a 'paper culture', corroborating Kashorda & Waema (2014). This is partly explained by a lack of appreciation by university management on the benefits of ICTs, as seen in the less commitment and prioritisation in improving campus infrastructure as discussed in section 7.4.3. A discussion of the role ICT could play in the major collaboration processes, notably for the pre-collaboration and in-collaboration processes is presented in section 7.3.

In response to question five and six that relates to objective six (*to assess the benefits of collaboration and ICT use on research productivity*), and as part of establishing the benefits of collaborative research, this study found a positive though weak relationship between collaboration and productivity for academic research scientists in Kenya. This corroborates Duque et al. (2005) findings on Kenyan academic scientists, though their definition of collaboration, as seen in section 2.3.1, differs from that used in this study.

Unlike collaboration levels, this study found that productivity levels were more affected by factors of personal nature (academic qualification, region of study, age, gender) and disciplinary area as opposed to resource related factors (see section 5.6.1). For example, as seen in section 5.4.3, though resource availability was a major hindrance to collaborative research, an increase in availability of resources was not related to increased levels of publication productivity. Use of the internet had significant effects on collaboration, though frequency of use had no significant effects on productivity (section 5.6.1). This leads to the conclusion that to publish or not to publish is more a result of personal choices rather than external environment factors. However, the particular issues relating to personal choices of publication were not explored in this study, thus an area of exploration for future studies.

Question seven, relates to the seventh objective (*to produce a set of recommendations towards promotion and improvement of research collaborations in Kenya*). Towards meeting this objective, Chapter Eight presents a set of recommendations that target three main groups of stakeholders; the policy makers, both at the institutional and national levels,

the researcher, and designers of information technologies. The recommendations are richly informed by participants' responses and suggestions for improvement, the study of best practices adopted from literature, and to a minor extent, personal experiences of the researcher from having worked in an academic institution in Kenya as well as studying in a developed country.

#### **9.4 CONTRIBUTION TO KNOWLEDGE**

##### ***Empirical contribution***

As noted before, a study of literature identified a dearth of studies on research collaborations in the developing world. Much of existing literature is on research collaborations in the developed world. However, differences exist in research environments that shape the processes involved in collaborative research. The importance of understanding the context within which research is carried out, and how this context shapes collaborative research was pointed out in Chapter One. This formed the basis for this study.

By meeting the research objectives set out at the beginning of the study, the study has contributed to the wider body of knowledge on the knowledge production processes. This is of interest to scholars in science and technology studies and information science. The study provides an understanding of the level and form of collaboration networks within academic research in Kenya that has remained vague thus far. The findings from this research have also provided new contextual knowledge on factors affecting the levels, form and conduct of academic research collaborations in Kenya. The study unearthed context specific situations, thus providing new knowledge for Kenya. The factors are summarised in a model in Figure 6.6. Mouton (2008) and Harle (2007) note that research environments in Africa face relatively similar contextual situations. Therefore, though the model is a result of the investigation in Kenya, it could act as a guide to factors that could be investigated in particular countries to produce context specific information.

Various studies have addressed the diffusion of internet and mobile technologies in developing areas, including Kenya. However, none has investigated the use of a range of ICTs within the particular context of supporting collaborative research in Kenya. This study therefore sheds light on the extent of use of a number of ICTs in supporting collaboration processes, and factors determining their adoption and use. This knowledge could be of



interest to scholars in CSCW with an interest in developing countries studies. A strong link exists between research and development. These findings would be of interest to scholars in the newer research area, information and communication technology for development (ICTD), that Burrell & Toyoma (2009) describe as ‘an emerging field of research that examines the link between information and communication technology and socioeconomic development’ (p.1).

### ***Conceptual and theoretical contribution***

The factors for investigation in this study were mainly drawn from a synthesis of models, theories, frameworks and concepts in literature. However, noting that majority of the studies were on research collaborations in the developed world, the factors were investigated for their effect within the Kenyan context. This study reaffirmed the validity of those that were found to have significant effects on research collaborations in Kenya, realigning the findings of the study with some of the existing theories, frameworks and concepts in literature. Their contextualisation within the Kenyan case also adds to knowledge on the validity and applicability of the dimensions they present for developing countries studies. For example, the study found a strong link between external environment factors and the conduct of collaborative research in Kenya. This implies that models and frameworks that encapsulate factors related to both personal and work related influences as well as environmental influence to collaborative work would be more relevant to investigating research collaborations in developing countries.

The findings of this study portray a number of features in the organisation of collaborative research that aligns to Gibbons et al. (1994) theory on the Mode 2 type of knowledge production. Search for complementary skills and resources rank high in motivation for collaboration, as opposed to institutional affiliation, an indication of the fading disciplinary and institutional boundaries. This is encouraged by government funding policies, which support more of cross institutional research projects. There was evidence of more interest in funding research that is focussed more on application context, another characteristic of the Mode 2 type of knowledge production process. However, though Gibbons et al. do not differentiate the growth towards Mode 2 using a disciplinary perspective, the ‘context of application’ in this study seems to favour some disciplinary areas over others. This is seen in the relatively higher level of support levelled towards agricultural research, accounting

for the higher levels of collaboration in the discipline. By providing an understanding of these features of collaborative research, some more notable in some disciplines, this study contributes to an understanding of applicability of Gibbons et al.'s theory with reference to developing countries research.

In this study, differences emerge in collaboration levels based on nature of areas of specialisation. For example, those indicating their area of specialisation as applied had higher collaboration levels than those who indicated theoretical. This is a reflection of the importance of considering the applied, experimental and theoretical dimensions of knowledge production structures, mostly defined by the specialist area, towards understanding collaboration patterns and academic research cultures. The specialist area provides greater analytical insight and is likely to yield more relevant information to interested parties such as policy makers. However, it also emerged in this study that socio-cultural factors, such as resource availability and institutional support structures have an equally important influence on collaborative practices and structures. Therefore, both the specialist area and socio cultural factors in the research environment play an important role in determining the collaborative outcomes.

In the analysis of factors determining the adoption and use of ICT for research collaborations in Kenya, the UTAUT theory developed by Venkatesh et al. (2003) was found fit as a framework within which to discuss the findings. Having resulted from the integration of eight common technology acceptance models, it encompasses a wide variety of factors that affect adoption and use of IT. Contextualisation of the constructs it represents to the research environment in Kenya brings a new perception on its use for technology adoption studies. In addition, this study established the relevance of disciplinary area in determining adoption and use of ICT for research work, which could be a consideration for future studies on adoption and use of ICT for knowledge production processes.

### ***Contribution to policy and practice***

Literature shows a worldwide rising interest in collaborative research. However, this study identified a dearth of literature on the status of research collaborations in developing areas, and factors influencing them. This research was therefore timely as it addresses a gap of knowledge on issues that are currently of interest to scholars as well as policy and practice.

This study culminated in a set of recommendations on issues that were found pertinent to the Kenyan research community, providing a theoretical understanding of how collaborative research can be enhanced in Kenya. Factors, both process and contextual, that inhibit the growth of and effectiveness of research collaborations were highlighted and suggestions and recommendations as to how the various issues can be approached made (in Chapter Eight of the thesis). This constitutes new knowledge for Kenya as no study has provided such a comprehensive analysis and set of recommendations towards promoting and improving collaborative research in Kenya before. Though noting that research environments differ between countries and regions, many in developing countries are said to exhibit similar characteristics. The set of recommendations can therefore be considered for adaptation by other developing countries displaying similar contextual situations.

#### ***Contribution to methods used to investigate research collaborations***

This study also contributes to an understanding of methods best suited to study research collaborations in developing areas. This especially applies to scholars in information science with an interest in identifying communication patterns or social organisation in a group of scientists within a disciplinary or specialist areas. Much of past research has used bibliometric measures of co-authorship in international databases to project levels of collaboration and productivity. These measures have been accused of under representing research done in Africa, thus the projections of low levels of academic research, networking and productivity for developing countries scientists. The relatively high levels of collaboration established in this study, by use of self-reported measures of collaboration and productivity confirm the previously noted inadequacy associated with bibliometric methods for studies in the region. This study therefore supports studies advocating for self-reported measures over bibliometric measures, or a combination of the two in studies of collaboration and productivity in developing regions.

The levels and structure of collaboration differ between disciplines. The knowledge of collaboration structures within and between disciplinary areas serve as a basis for identification of areas that can be sampled for more intensive analysis of the social organisation of scientists working on a certain problem or specialist area. Crane (1972) notes that one may not identify some kind of social organisation in a problem area if ‘the area under consideration has not experienced rapid growth that is associated with

development of a social organization' (p. 48). Agriculture field displays features (such as the relatively high collaboration levels, and existence of various organisations and disciplinary networks supporting specific areas of agricultural research) that indicate that there could be some form of social organisation within problem areas in the discipline. However, this is not clear in the other disciplines. For example, computing displays a relatively small population of research active individuals, meaning research in computing may not have matured enough for a form of social organisation to be identifiable. This knowledge therefore forms a contribution towards the choice of sample that may be appropriate for deeper investigations into the work organisation of scientists within the selected disciplines.

### **9.5 IMPLICATIONS OF THE STUDY**

It is clear from this study that success of collaborative research is based on a combination of factors. Resolving issues affecting collaborative research needs joint efforts of all stakeholders. Much support is needed, both nationally and institutionally in terms of provision of resources and creation and facilitation of conducive research environments. This research has identified important issues with regard to promotion of collaborative research, significant to a target audience of researchers, policy makers and ICT specialists.

The findings and subsequent recommendations provide information for the researcher on personal, institutional, disciplinary and technological issues that affect collaborative research. Such is the need to develop skills and capacity, understand issues affecting interdisciplinary research, build personal networks and maximise the use of ICT to support their work. This arms them with important knowledge thus better preparedness in dealing with the issues and applying best practice for success of their collaboration.

The study also highlighted a number of factors significant for the policy maker both at the institutional and national level. These include the need to prioritise research thus provide for resources, improvement of infrastructure and promotion and facilitation of use of ICT for collaborative activities. A need to reduce bureaucratic processes, design and implement relevant policies, promote industrial links and motivate researchers was also noted. Designing technologies that facilitate ease of access and use of computing resources, as well as meeting the researcher's information and communication needs, taking into consideration existing socio technical infrastructures will encourage adoption and use. The

study highlighted problems concerning lack of, design and content of information resources as well as lack of research information systems that would act as a central reference for research conducted at the institution. This is significant for designers of technologies that support collaborative research.

## **9.6 FUTURE RESEARCH**

As pointed out in the limitations to the study in section 9.2, further investigations could be carried out into the publication behaviour of scientists. Such a study could compare the results of a bibliometric analysis and self-reported publication results to substantiate the claims in literature on reduced visibility of scientific output in Africa due to their publication outlets. This could also involve an intensive study into their publishing habits and motivations, to give more understanding to the issue.

Participants in this study pointed to weak links with industry, important for solving problems that have a significant impact on the society, which also provides a means to funding support. Further studies could investigate university industrial links, with a view to understanding better the parameters that define them and offering more comprehensive recommendations on how they can be strengthened.

There was an indication that the majority of research funding comes from outside the country, with a number of collaborations linked to international organisations. Further studies could investigate further the extent, nature and conduct of such international collaborations, answering questions such as the level of their extent, challenges in their conduct, ways in which they differ from local collaborations, and their relevance in solving national, regional problems.

Further studies could use the interpretivist approach to dig deeper into the work organisation, communication behaviour and other collaboration aspects of specialist or problem area. This could enable a comparison based on nature of the work as defined by the specialist area as opposed to use of broader disciplinary area. This could also help define communication behaviour and use of ICT based on nature of the work, thus development of, facilitation of or encouragement of use of tools that are most applicable in supporting work of a particular nature.

Participants complained of lack of implementation of research findings, which affects the morale to carry out collaborative research. Further research could investigate the extent to which research output informs policy, determining factors and how this could be better achieved.

Future research can also involve testing of the model developed in section 6.5 and its facets in different settings across a wider variety of disciplinary and specialist areas and regions. This would prove its validity and generalisability in various contexts, and if possible, improve on it or further extend it.

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## **PUBLICATIONS AND PRESENTATIONS RELATING TO THIS THESIS**

Muriithi, P., Horner, D., & Pemberton, L.(2014). Understanding factors influencing the effect of scientific collaboration on productivity in a developing country: Kenya. *Proceedings of the American Society for Information Science and Technology*, 1-6 November 2013, Montreal, Canada. 50:1-10

Muriithi P., Horner D., & Pemberton L(2013). Patterns of communication among the academic research community in Kenya. *Presentation at Society for Social Studies of Science (4S) conference*, 9- 12 October 2013, San Diego, USA.

Muriithi P.M (2013). ICT supported collaboration among the academic research community in Kenya. *Doctoral Consortium paper presented at the RCIS conference*, 28-31 May 2013, Paris.

Muriithi P.M (2013) Understanding factors contributing to adoption and use of ICTs within research collaborations in Kenya. *Paper presented at the ICTD 2013 Pre – conference Symposium*, 2 – 6 December 2013, Cape Town, South Africa.

## APPENDICES

### **Appendix 1: Introduction to the online survey and reminder email**

Dear Mr/Mrs/Ms/Dr/Prof xxx,

My name is Petronilla Muriithi, a PhD student at the University of Brighton in the United Kingdom, on a Commonwealth Scholarship, and an academic member of staff in the Department of Computing, Jomo Kenyatta University of Agriculture and Technology (JKUAT).

Researchers, University Administration, Policy Makers and Funding Bodies need to make informed decisions concerning research collaborations, and designing technologies that support research collaborations calls for an understanding of how such collaborations work.

Therefore I am carrying out a survey aimed at understanding how the scientific academic research community in Kenya is organised, how the various tasks and activities in research collaborations are handled, how technology is used to support these tasks, and challenges faced, while at the same time seeking to understand the needs of research collaborations in Kenya.

The necessary permits to carry out the research have been granted by the National Council for Science and Technology (NCST) and the DVC RPE, University of Nairobi (copies are attached), and supported by the Director, SCI.

The survey could take about twenty five minutes.

Your participation is very important to the study, and will be greatly appreciated. All answers will be strictly confidential. Please click on the link below to access the survey:

<http://www.surveymonkey.com/s/KenyanResearchCollaboration1>

Kind Regards,

Petronilla Muriithi

***Reminder of online survey***

Dear Mr/Mrs/Ms/Dr/Prof xxx,

My name is Petronilla Muriithi, of the Department of Computing, JKUAT, and a PhD student at the University of Brighton in the UK.

I am humbly reminding you of a request to participate in a survey on Collaboration among the Academic Research Community in Kenya, being conducted as part of my PhD studies. Attached are the necessary permits granted to carry out the research.

Your participation is ***Very Important*** to my studies, and will be greatly appreciated. All answers will be treated confidentially.

Please click on the link below to access the survey:

<http://www.surveymonkey.com/s/KenyanResearchCollaboration1>

Kind Regards,

Petronilla Muriithi

**Appendix 2: Interview introduction and guide**

***The introduction***

My name is Petronilla Muriithi, a research student in the School Of Computing, Engineering and Mathematics, University of Brighton.

Researchers, university administration, policy makers and funding bodies need to make informed decisions concerning research collaborations, and designing technologies that support research collaborations calls for an understanding of how they work.

Therefore, my investigation is aimed at understanding research collaborations among the academic research community, in terms of their organisation, technologies used and challenges faced within the collaborations.

The interview could last for about half an hour, and will be semi structured, adopting an open ended conversational style. You are free to ask any questions within the course of the

interview, and you have a right to decline to answer any particular questions, and the right to end the interview upon request.

The information given will be treated confidentially.

Do you have any question before we get started?

Would you mind if i record the interview?

### ***Interview guide***

#### *Academic Background:*

- Could you briefly describe your research area?
- Would you describe it as predominantly Theoretical? Applied? Experimental?
- In general, is research in your area carried out on an individual or joint basis?

#### *Looking at the Nature of most collaborations you are involved in:*

- What groups of people do you mainly collaborate with – academics / industry
- Where are the members situated – within your university, other universities in the UK,
- International?
- Would you refer to your collaboration as Interdisciplinary?

#### *Thinking of a current or recent collaborative project*

- How the collaboration formed / what was the motivation behind its formation?
- How is the project funded?
- Please tell me about the nature of the tasks within this project. How are they handled / organised? – Project planning, coordination of members' activities, leadership and management?
- What challenges have you faced in the organisation and management of the activities of your collaborations? How do you deal with the challenges?

### *Use of Technology*

- What are the major modes of communication within your collaboration? e.g email, web forums, seminars, meetings?
- Tell me more about how you use ICTs to support the activities of your collaboration – e.g contacting members, planning project activities, giving updates on progress, communicating results?
- Are there any particular problems you experience in their use / do you see the technologies available to you as sufficient in supporting the activities of your collaboration?

### *Needs of research collaborations*

- Do you feel that there are issues or areas that need to be looked into or prioritised in order to promote research collaborations at:
  - The Institutional level?
  - National level?

Is there anything else that you would like to cover, contribute or clarify?

Is it okay to contact you again if I need to ask any further questions, or need to clarify any points?

*Thank you very much for your contribution and time.*

## Appendix 3: Instrument for quantitative data collection – the questionnaire

**Research collaboration in Kenya**

**1. Introduction**

My name is Petronilla Muriithi, a PhD student at the University of Brighton in the United Kingdom, on a Commonwealth Scholarship, and an academic member of staff in the Department of Computing, Jomo Kenyatta University of Agriculture and Technology (JKUAT).

Researchers, University Administration, Policy Makers and Funding Bodies need to make informed decisions concerning research collaborations, and designing technologies that support research collaborations calls for an understanding of how such collaborations work.

Therefore I am carrying out a survey aimed at understanding how the scientific academic research community in Kenya is organised, how the various tasks and activities in research collaborations are handled, how technology is used to support these tasks, and challenges faced, while at the same time seeking to understand the needs of research collaborations in Kenya.

The survey could about twenty five minutes.  
Your participation is very important to the study, and will be greatly appreciated.  
All answers will be strictly confidential.

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**Research collaboration in Kenya**

**2. SECTION A: GENERAL INFORMATION**

*This section is to collect some basic information.*

**\*1. Please select the academic institution to which you belong**

University of Nairobi

Jomo Kenyatta University of Agriculture and Technology

Kenyatta University

Moi University

Egerton University

Other (please specify)

\_\_\_\_\_

**\*2. To which disciplinary area do you belong? Tick one option**

Agriculture

Engineering

Health Science

Computing

Other (please specify)

\_\_\_\_\_

**3. What is your area of specialisation?**

\_\_\_\_\_

**4. Would you describe the nature of your area of specialisation predominantly as: (Tick one option)**

Experimental

Theoretical

Applied

Theoretical and experimental / applied components are somehow equal

Other (please specify)

\_\_\_\_\_

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**Research collaboration in Kenya**

**\*5. Have you been involved in any collaborative research project(s) in the last 10 years?**

*A collaborative research project in this case is defined as a project involving two or more individuals, working together, whether locally or remotely, to achieve a common goal. A post graduate research project (at masters or PhD level) is not considered a collaborative project within the context of this study*

- Yes
- No

**Research collaboration in Kenya**

**3. SECTION B-1**

*This section seeks to find out why you have not been part of a collaborative research project*

**1. What could be the reason(s) for your non – involvement in collaborative research projects (you can select more than one choice)**

- I like working individually
- I am still new in my research career
- Lack of information on available collaborative projects
- Lack of information on funding opportunities
- I lack experience in writing project proposals
- The grant proposals I have written have not succeeded
- I have not been offered an invitation to a collaboration
- I have not been able to get suitable collaborators
- My disciplinary area promotes individual research
- People in my field of research compete with each other more than they collaborate
- Lack of facilities and resources to do collaborative work
- Lack of institutional support
- Lack time to commit to research due to heavy teaching loads
- Lack time to commit to research due to administrative duties
- Lack time to commit to research due to family obligations
- Other (please specify)

**Research collaboration in Kenya**

**4. SECTION B-2**

*This section seeks to find out more about your collaboration*

**1. How many collaborative research projects are you currently actively involved in?**

**2. How many completed collaborative research projects have you been part of in the last 10 years?**

**3. How important has each of the following been in your criteria of choice of a collaborator? Please select one choice per row.**

	Very important	Important	A little Important	Not important	N/A
Sharing a common goal	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Collaborator has Special skills / expertise	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Collaborator has / can provide access to Special equipment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Collaborator has access to funding	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Mentoring junior colleagues	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Collaborator has strong work ethics	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Quality and value of previous collaboration with the person	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Collaborator has a strong reputation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Institutional / Organisational affiliation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Nationality	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Friendship	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Other (please specify)

**4. Would you describe your collaboration as inter disciplinary?**

*An interdisciplinary research collaboration involves interaction of individuals, knowledge and concepts across two or more different disciplines.*

- Yes  
 No

**Research collaboration in Kenya**

**5. How would you describe the predominant nature of tasks in most collaborative projects you are/have been involved in? (Please tick one)**

- Independent - My daily tasks do not depend on actions of others  
 Sequential - Work and activities flow between us in one direction  
 Reciprocal - Work and activities flow between us in a back and forth manner over a period of time  
 Teamwork - We diagnose problems, solve and collaborate as a group at the same time to deal with the work  
 We use a combination of the above methods in the different phases of a project

**6. To what extent has each of the following been a problem in your collaboration?**

	Major Problem	Problem	Minor Problem	Not a problem	N/A
Availability and Access to special equipment and facilities	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ease of getting funding	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Amount of funding	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Administration of the funding	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Availability of skilled personnel	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Defining roles	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Co ordination of members' activities	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Timely delivery of results	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Diverse disciplinary training of collaborators	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cultural differences	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Resolving conflicts	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Scientific competition	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Information security	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Authorship inclusion and order	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Selection of a publication forum (especially for interdisciplinary research)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Leadership and control	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Availability of time to commit to research	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**Research collaboration in Kenya**

**5. SECTION C-1**

Your access to and use of Information and Communication Technologies, ICT, for general research activities

**1. Please select the resources currently available to you in the list below: (select as many as apply)**

- Computer / laptop in your workplace
- Computer / laptop at home
- Internet connection at work place
- Internet connection at home
- A fax machine
- A scanner
- A printer
- A telephone
- A mobile phone
- Internet on mobile phone

Other (please specify)

**2. Some people are relatively sophisticated in their use of computers, e.g writing programs and configuring hardware, while others use computers in more basic ways e.g typing documents, entering data and sending emails.**

**How would you characterise your use?**

- Sophisticated
- More than basic, but not sophisticated
- Basic
- Do not use computers

**Research collaboration in Kenya**

**3. How many hours do you spend in a typical week using the internet for research related activities?**

- 0-5 hours
- 6-10 hours
- 11-20 hours
- Over 20 hours
- Not at all

**4. Thinking of the following means of communication, please indicate their importance to your research work:**

	Very Important	Important	A little Important	Not Important	N/A
Phone (both landline and mobile)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Email	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Web forums / blogs / wikis	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Instant messaging services / chat	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
VOIP e.g. Skype, Google talk	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Social networking sites e.g. Face book, Twitter	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Fax	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Postal mail	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**5. To what extent has the following been a problem in your use of the internet?**

	Major Problem	Problem	Minor Problem	Not a Problem	N/A
Time taken to connect to the internet	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Internet down time	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cost of connection	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Finding desired information	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sites and material that require payment for use	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**\*6. Do you use Information and Communication Technologies, ICT, such as email, to facilitate exchange of information in your collaboration?**

- Yes
- No
- N/A



**Research collaboration in Kenya**

**6. SECTION C-2**

*This section seeks to find out how you use ICT to support the activities of your collaboration, and challenges faced*

**1. What kind of ICT do you use for the following activities in collaborative research projects (you can select more than one choice for an activity)**

	Email	Phone	VOIP eg Skype	Web forums/Blogs	Chat	Fax	Face to Face	Other
Contacting members within your locality e.g your institution	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Contacting members outside your locality	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Planning project activities Within your locality	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Planning project activities remotely	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Monitoring progress	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Soliciting input for a decision	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Giving updates on progress	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Sharing documents/information	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Communicating results	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**2. If you use other type(s) of technology not listed above, please give the name and a brief explanation of how it / they are used.**

**Research collaboration in Kenya**

**3. With respect to your use of ICT, to what extent is each of the following a challenge in your collaboration?**

	Major challenge	Challenge	Minor Challenge	Not a Challenge	N/A
Contacting members	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Planning project activities	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Monitoring progress of an ongoing project/experiment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sharing documents and information	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Communicating results	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Security of data / information	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Lack of skills in using appropriate technology	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Other (please specify)

## Research collaboration in Kenya

### 7. SECTION D

This section seeks your opinion on some of the needs of the Kenyan research system, and a little information about yourself

#### 1. Please give your opinion on how important the factors listed below are to the improvement of the Kenyan Research system

	Very Important	Important	A little Important	Not Important
Increasing salaries	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Increasing funding for research projects	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Improving electronic communication networks	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Institutional support in provision of resources	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Improving communication between researchers and policy makers	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Improving communication between researchers and industry	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Improving links with international research organisations	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Improving communication about grants	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Reducing bureaucracy within the work place	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Improving access to digital resources	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Other (please specify)

#### 2. Now, a little information about yourself:

Your name?

#### 3. What is your age bracket?

- 25 - 30  
 31 - 40  
 41 - 50  
 51 - 60  
 Over 60

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## Research collaboration in Kenya

#### 4. What is your Gender?

- Male  
 Female

#### 5. What department are you attached to?

#### 6. Currently, what is your highest degree?

- PhD  
 Masters  
 Bachelors  
 Diploma

Other (please specify)

#### 7. In what year was your highest degree attained?

#### 8. From which country / Region was your highest degree received?

- Kenya  
 Africa (not Kenya)  
 Europe  
 United States  
 Asia  
 Australia

Other region (please specify)

#### 9. How many articles have you published in the last 10 years?

#### 10. Out of these articles, how many were as a result of a collaboration, therefore co-authored?

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8. SECTION E: Project details

Finally, please give some details of three of your most recent collaborative projects, if any.

1. Project 1

Project Title:

Project Start Date: (mm/yy)

Project End Date: (mm/yy)

Sponsor/Funder: (indicate if its your institution, government organisation in Kenya, NGO in Kenya, organisation outside Kenya, or not funded. )

Type of Output (intended or actual): e.g publications, reports

Collaborator Details: For each collaborator, please indicate the name (one name and initials), gender and institutional affiliation, e.g Muriithi P., (F), JKUAT

Details of collaborator 1:

Details of collaborator 2:

Details of collaborator 3:

Details of collaborator 4:

Details of collaborator 5:

Details of collaborator 6:

Details of collaborator 7:

Details of collaborator 8:

Details of collaborator 9:

Details of collaborator 10:

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2. Project 2

Project Title:

Project Start Date: (mm/yy)

Project End Date: (mm/yy)

Sponsor/Funder: (indicate if its your institution, government organisation in Kenya, NGO in Kenya, organisation outside Kenya, or not funded. )

Type of Output (intended or actual): e.g publications, reports

Collaborator Details: For each collaborator, please indicate the name (one name and initials), gender and institutional affiliation, e.g Muriithi P., (F), JKUAT

Details of collaborator 1:

Details of collaborator 2:

Details of collaborator 3:

Details of collaborator 4:

Details of collaborator 5:

Details of collaborator 6:

Details of collaborator 7:

Details of collaborator 8:

Details of collaborator 9:

Details of collaborator 10:



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**3. Project 3:**

Project Title:

Project Start Date: (mm/yy)

Project End Date: (mm/yy)

Sponsor/Funder: (indicate if its your institution, government organisation in Kenya, NGO in Kenya, organisation outside Kenya, or not funded. )

Type of Output (intended or actual): e.g publications, reports

Collaborator Details: For each collaborator, please indicate the name (one name and initials), gender and institutional affiliation, e.g Muriithi P., (F), JKUAT

Details of collaborator 1:

Details of collaborator 2:

Details of collaborator 3:

Details of collaborator 4:

Details of collaborator 5:

Details of collaborator 6:

Details of collaborator 7:

Details of collaborator 8:

Details of collaborator 9:

Details of collaborator 10:

**4. Please indicate if:**

	Yes	No
You would be happy to be contacted about the study in future:	<input type="radio"/>	<input type="radio"/>
You would like me to send you a free copy of the report when ready:	<input type="radio"/>	<input type="radio"/>

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**9.**

**THANK YOU VERY MUCH  
FOR YOUR HELP**

#### **Appendix 4: Validating the model in Table 5.4- predictors of collaboration**

The -2 log likelihood statistic and percentage of classification are indicators of how well the model fits the data, by the amount of change from an empty model (with only the constant) to the full model (with predictors included). Smaller log likelihoods mean the model fits the data better, and the classification percentage is an indication of 'how well the model predicts group membership' (Field 2009, p.286). The log likelihood statistic, is 190.599 in the full model, which is less than the value when only the constant was included in the model (was 269.47), which is an indication that the model is better at predicting the outcome with the addition of the predictor variables, and the model classifies correctly 76.4% of the participants, as compared to 62.1 % in the model with only a constant. The model chi square of 76.57, with  $P < .001$  is also an indicator that the model with predictors is better than one without (Field 2009, p. 286). the Hosmer and Lemeshow goodness of fit test shows a non-significant chi square ( $\chi^2 = 8.171$ ,  $P = .417$ ), thus the predictors fit well into the model (a non-significant chi square indicates that the data fits the model well)

#### **Appendix 5: Explaining the factor analysis of problems in collaboration**

Basically, factor analysis tells us what variables group or go together. Factor analysis boils down a correlation matrix into a few major pieces so that the variables within the pieces are more highly correlated with each other than with variables in the other pieces <http://luna.cas.usf.edu/~mbrannic/files /pmet/factor1.htm>). Field (2009) advises looking at the inter-correlation between variables as a first step in factor analysis, excluding variables with non or very little correlation and those with very high correlation, because if the test question is measuring the same underlying dimension, then the variables would be expected to correlate with each other, while very high correlation could be an indication of multicollinearity, masking the unique contribution to a factor of the variables that are very highly correlated (Field 2009, p. 648). The correlation matrix shows each of the variables has majority of the significance values less than .05 (indicating significant correlations), and none is too highly correlated (the highest correlation is  $r = .626$ , which is below the recommended limit of  $r < .8$ ). The determinant of the correlation matrix, which should be greater than the recommended value of 0.00001 is .001, meaning the questions correlate fairly well, thus no need to eliminate any of them.



A factor analysis, with Orthogonal (Varimax) rotation yielded a KMO statistic of .852, which Hutcheson & Sofroniou (1999) in Field (2009) classifies as great<sup>42</sup>, meaning the sample size is adequate and the factor analysis should yield distinct and reliable factors. The KMO for individual variables, are all above 0.5 – any values below 0.5 should be excluded from the analysis (Field, 2009), which is in support of my decision not to exclude any variable from the analysis. Bartlett’s measure, another test of the appropriateness of factor analysis shows that the original correlation matrix is not an identity matrix ( $p < .000$ ), meaning there are some relationships between the variables to be included in the analysis, thus factor analysis appropriate.

Table A1 lists the eigenvalues associated with each linear component / factor before extraction, after extraction and after rotation<sup>43</sup>. Before extraction, the factors = the number of variables = 17. The eigenvalue associated with each factor represents the variance explained by the particular factor/linear component, including the % explained e.g. the eigenvalue associated with the first factor is 6.051, accounting for 35.6% of the total variance. I had directed SPSS to extract/retain all factors with eigenvalues greater than 1<sup>44</sup>. This resulted in 3 factors after extraction. After rotation, the relative importance of the three factors is equalized – the % variance each accounts for is more evenly distributed among the factors (Field, 2009).

The output in Table A2 represents the rotated component matrix – matrix of factor loading for each variable onto each factor: the factors are listed in the order of size of their factor loadings, suppressing absolute values less than 0.4 (loadings greater than 0.4 represent substantive values, as recommended by Stevens (2002) in Field (2009)<sup>45</sup>, p. 644 who argues that this cut off is appropriate for interpretive purposes, making interpretation easier.

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<sup>42</sup> The KMO statistic varies between 0 and 1, indicating the appropriateness of factor analysis in providing a stable factor solution. Hutcheson & Sofroniou (1999) in Field (2009) terms values below 0.5 as not acceptable, 0.5 to 0.7 as mediocre, 0.7 to 0.8 as good, 0.8 to 0.9 as great and above 0.9 as superb

<sup>43</sup> Rotation maximizes the loading of each variable on one of the extracted factors while minimizing loading on the other factors for easier interpretation (Field, 2009)

<sup>44</sup> Keiser (1960) in Field (2009) recommends eigenvalues greater than 1 as they ‘represent a substantial amount of variation’ (p. 640)

<sup>45</sup> Stevens (2002) recommends a loading of 0.722 for a sample size of 50, a loading  $> 0.512$  for a sample size of 100, a loading  $> 0.364$  for a sample size of 200,  $> 0.298$  for a sample size of 300,  $> 0.21$  for a sample size of 600, and  $> 0.162$  for a sample size of 1000.

Total Variance Explained									
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.051	35.595	35.595	6.051	35.595	35.595	3.728	21.927	21.927
2	1.976	11.624	47.219	1.976	11.624	47.219	3.480	20.472	42.398
3	1.475	8.676	55.895	1.475	8.676	55.895	2.294	13.497	55.895
4	.956	5.623	61.518						
5	.878	5.164	66.682						
6	.748	4.399	71.080						
7	.734	4.319	75.400						
8	.656	3.861	79.261						
9	.614	3.612	82.873						
10	.520	3.061	85.935						
11	.498	2.930	88.864						
12	.411	2.415	91.279						
13	.360	2.118	93.398						
14	.347	2.038	95.436						
15	.308	1.814	97.250						
16	.241	1.420	98.669						
17	.226	1.331	100.000						

Extraction Method: Principal Component Analysis.

**Table A1 Factors analysis of problems in a collaboration**

Rotated Component Matrix<sup>a</sup>

	Component		
	1	2	3
Scientific competition	.854		
Cultural differences	.739		
Information security	.710		
Resolving conflicts	.697		
Authorship inclusion and order	.630		
Diverse disciplinary training of collaborators	.587		
Selection of a publication forum	.563		
Coordination of member's activities		.778	
Timely delivery of results		.743	
Defining roles		.711	
Availability of time to commit to research		.674	
Leadership and control		.638	
Availability of skilled personnel		.503	
Administration of the funding		.481	.454
Ease of getting funding			.830
Amount of funding			.794
Problem of availability and access to special equipment			.730

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 5 iterations.

**Table A2 Extracted factor dimensions on problems in a collaboration**

## **Appendix 6: Details of multiple regression of a number of factors on publication productivity**

A multiple regression analysis was carried out to determine the effect of a number of variables on publication productivity. Field (2009) recommends a choice of predictor variables with sound theoretical reasons for expecting them to have an effect on the outcome, and first running the analysis using enter method for all predictor variables identified to establish which of the variables are important in predicting the outcome (p.225). The choice of predictor variables in this case is based on measures adapted from various relevant studies in literature as identified in section 5.6.1. The regression analysis using enter method with all the variables produced a correlations matrix<sup>46</sup> showing significant correlations for publication productivity as academic qualifications (.501\*\*\*), collaboration level (.312\*\*\*), age (.292\*\*) and disciplinary field (Agriculture = .390\*\*\*, Engineering = -.221\*\*and public health = -.234\*\*)<sup>47</sup>. Disciplinary field was coded using dummy variables, with computing being the reference category. Study region and gender did not produce significant correlations. The next step therefore was to rerun the analysis, including only the significant predictors, using forward stepwise analysis method to find out the individual contribution of each predictor. The model summary table below shows 3 models, reflecting summary statistics in each stage as the stepwise method was chosen. Model one refers to the first stage, when professional qualification is the only predictor, model 2 for the next stage involving professional qualification and number of past research projects, and model three includes professional qualification and number of past research projects and the disciplinary field agriculture, which turned out to be most important in predicting the outcome.

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<sup>46</sup> The correlation matrix gives a preliminary look for multicollinearity (indicated by large correlations with  $r > .9$ ), which is not a problem in this case.

<sup>47</sup>  $P < .01$  represented by \*\*,  $P < .001$  represented by \*\*\*

Model Summary <sup>d</sup>										
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.493 <sup>a</sup>	.243	.237	6.175	.243	42.648	1	133	.000	
2	.587 <sup>b</sup>	.344	.334	5.768	.101	20.421	1	132	.000	
3	.609 <sup>c</sup>	.371	.356	5.671	.027	5.546	1	131	.020	2.318
a. Predictors: (Constant), professional qualification coded as (1,0)										
b. Predictors: (Constant), professional qualification coded as (1,0), No. of past research projects in ten years										
c. Predictors: (Constant), professional qualification coded as (1,0), No. of past research projects in ten years, Recoded agriculture dummy										
d. Dependent Variable: Number of publications in the last 10 years										

**Table A3 Multiple Regression of factors affecting publication productivity**

### *Validating the model*

R contains the values of the multiple correlation coefficient between the predictors and the outcome, and equals .609 when professional qualifications, past projects and disciplinary area (agriculture) are used to predict the outcome (note that the value of R=.493 when only professional qualification is used to predict the outcome), meaning the other two variables bring substantial improvement to the model. R square gives the amount of variability accounted for in the outcome by the predictor. For model 1 it is 24.3%, when the second predictor is added, increases to 34.4%, with third predictor 37.1% etc. The adjusted R squared give an indication of how generalisable the model is (better if the same or very close to the value of R Squared. For model 3, for instance, the difference is .015, (.371 - .356 = .015), meaning that if the model were derived from the population rather than a sample, it would account for approximately 1.5% less variance in the outcome. The change statistics tells us about the difference made by adding new predictors to the model eg the change in variance that can be explained by adding past projects in the second model gives rise to an F ratio of 20.421, significant at (p<.001). Adding a third predictor also produces a significant change. The Durbin Watson statistic, which indicates whether the assumption of independent errors is tenable = 2.3, which is reasonable, as ‘a value <1 or >3 should raise concern => should be as close as possible to 2’, Field A 2009, p. 236. In our case, the data meets this assumption.

The ANOVA test, shows the F ratio, which gives an indication of if the model is better at predicting the outcome as compared to the level of inaccuracy in the model is 42.648 for the first model, 34.648 for the second model and 25.743 for the third model, all significant at  $p < .001$ . This means the model is relatively good at predicting the outcome. The resulting model show publication productivity as being a function of academic qualifications, number of past research projects and disciplinary area, the significant one in this case being agriculture.

One of the assumptions of multiple regression in SPSS is no multicollinearity in the data. Multicollinearity exists when there is a strong correlation between the predictors, thus making it difficult to assess the amount of unique contribution of each of the predictors, Field (2009). Field A (2009: p.242) gives the guidelines for assessing multicollinearity in, as:

- If the largest VIF is greater than 10, there's cause for concern
- If the average VIF is substantially greater than 1, then the regression may be biased
- Tolerance below 0.1 indicates a serious problem
- Tolerance below 0.2 indicates a potential problem

VIF values are well below 10 (1.15, 1.07 and 1.18) and tolerance statistics above 0.2 (0.87, 0.93 and 0.85) for the three predictors respectively, thus the conclusion that there is no problem of multicollinearity in the data.