Paving the Silk Road: Sub-Saharan Africa’s Collaboration with China and India in Health Biotechnology

by

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A thesis submitted in conformity with the requirements for the degree of Masters of Science
Institute of Medical Science
University of Toronto

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Abstract

This research aims to understand the role of China and India’s collaboration with sub-Saharan African countries in health biotechnology development on the African continent. I conducted a scientometric analysis and case study research to identify the key drivers, challenges, and impacts of South-South collaboration in health biotechnology and investigated the factors that shape it. The main messages resulting from this study indicate that: China and India are active collaborators of sub-Saharan Africa in technology intensive fields, collaboration in traditional medicine is of high priority, drivers for collaboration with China and India are not uniform, and shared health concerns are a key in motivating and fostering South-South collaboration between sub-Saharan Africa, China and India. This research study illustrates that sub-Saharan Africa can harness South-South collaboration to improve capacity, innovation potentials, and promote the development of health biotechnology solutions appropriate for the African context.
Acknowledgments

Let me begin by addressing a special thanks to my supervisor Dr. Halla Thorsteinsdóttir. You have made a challenging academic journey both rewarding and exciting. Your guidance and valuable advice at every stage of this process has helped me immensely and has motivated me to complete this enjoyable journey. Although you have always had an innumerable number of other things on your plate you have always found time to sit and talk with us, encourage us, laugh with us, and cry with us. Your commitment to providing me every opportunity to travel the world, talk to people in developing countries, and present my work across the globe, has not only made me a better person but grounded me, and given me memories that will endure a lifetime.

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<th>Description</th>
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<tbody>
<tr>
<td>ADB</td>
<td>Asian Development Bank</td>
</tr>
<tr>
<td>AMCOST</td>
<td>The African Ministerial Council on Science and Technology</td>
</tr>
<tr>
<td>ANDI</td>
<td>African Network for Drugs and Diagnostics Innovation</td>
</tr>
<tr>
<td>AU</td>
<td>African Union</td>
</tr>
<tr>
<td>BRIC</td>
<td>biotechnology regional innovation centers</td>
</tr>
<tr>
<td>CASTEP</td>
<td>China-Africa Science and Technology Partnership Program</td>
</tr>
<tr>
<td>EAC</td>
<td>East Africa Community</td>
</tr>
<tr>
<td>ECOWAS</td>
<td>Economic Community of West African States</td>
</tr>
<tr>
<td>EU</td>
<td>European Union</td>
</tr>
<tr>
<td>GMO</td>
<td>genetically modified food</td>
</tr>
<tr>
<td>HBT</td>
<td>health biotechnology</td>
</tr>
<tr>
<td>HPLC</td>
<td>high performance liquid chromatography</td>
</tr>
<tr>
<td>IAVI</td>
<td>International AIDS Vaccine Initiative</td>
</tr>
<tr>
<td>IBSA</td>
<td>India, Brazil, South Africa Trilateral Agreement</td>
</tr>
<tr>
<td>ICT</td>
<td>information and communications technology</td>
</tr>
<tr>
<td>ICGEB</td>
<td>International Centre for Genetic Engineering and Biotechnology</td>
</tr>
<tr>
<td>IMF</td>
<td>International Monetary Fund</td>
</tr>
<tr>
<td>KEMRI</td>
<td>Kenya Medical Research Institute</td>
</tr>
<tr>
<td>MDG</td>
<td>Millennium Development Goals</td>
</tr>
<tr>
<td>MRC</td>
<td>McLaughlin-Rotman Centre for Global Health</td>
</tr>
<tr>
<td>NABDA</td>
<td>National Biotechnology Development Agency</td>
</tr>
<tr>
<td>NBC</td>
<td>National Biosafety Council</td>
</tr>
<tr>
<td>NEPAD</td>
<td>New Partnership for Africa’s Development</td>
</tr>
<tr>
<td>NGO</td>
<td>non-governmental organization</td>
</tr>
<tr>
<td>NIPRID</td>
<td>Nigerian Institute for Pharmaceutical Research and Development</td>
</tr>
<tr>
<td>NMR</td>
<td>nuclear magnetic resonance</td>
</tr>
<tr>
<td>OECD</td>
<td>Organization for Economic Co-operation and Development</td>
</tr>
<tr>
<td>ONCG</td>
<td>Oil and Natural Gas Corporation India</td>
</tr>
<tr>
<td>R&amp;D</td>
<td>research and development</td>
</tr>
<tr>
<td>REC</td>
<td>Regional economic community</td>
</tr>
<tr>
<td>S&amp;T</td>
<td>science and technology</td>
</tr>
<tr>
<td>SADC</td>
<td>Southern African Development Community</td>
</tr>
<tr>
<td>SINOPEC</td>
<td>China Petroleum and Chemical Corporation</td>
</tr>
<tr>
<td>SME</td>
<td>small and medium enterprise</td>
</tr>
<tr>
<td>SOE</td>
<td>state owned enterprise</td>
</tr>
<tr>
<td>SSA</td>
<td>sub-Saharan Africa</td>
</tr>
<tr>
<td>TIA</td>
<td>Technology Innovation Agency</td>
</tr>
<tr>
<td>TWAS</td>
<td>Academy of Sciences for the Developing World</td>
</tr>
<tr>
<td>UNCTAD</td>
<td>United Nations Conference on Trade and Development</td>
</tr>
<tr>
<td>UNDP</td>
<td>United Nations Development Programme</td>
</tr>
<tr>
<td>UNESCO</td>
<td>United Nations Educational, Scientific and Cultural Organization</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organization</td>
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<tr>
<td>WTO</td>
<td>World Trade Organization</td>
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1 CHAPTER ONE

Introduction and Background

1.1 Introduction

China and India are two giant economies and emerging powers that, in reality, are not new to the African continent. But in recent years their presence has grown immensely, and they have appropriately become known as the ‘new’ players in Africa’s development. While their collaboration with much of Africa has traditionally focused on resource extraction, trade, and investment, both China and India have extended their collaborations with sub-Saharan Africa into other areas including science and technology intensive fields. China and India’s rapidly increasing political and economic ties with sub-Saharan Africa parallel their increasing roles as knowledge producers in health biotechnology; however, at present there is no research that specifically examines sub-Saharan Africa’s collaboration with India and China in this field. Health Biotechnology is a field many developing countries single out as being important to their development and has been promoted within their biotechnology strategies. As China and India, like the nations of sub-Saharan Africa, are classified by the World Bank as low and middle-income countries, I refer to these partnerships between developing countries as ‘South-South collaboration’ (see definition below), even though China is located above the equator. It is therefore of interest to understand the role of China and India’s collaboration with sub-Saharan African countries and its contribution to health biotechnology development on the African continent. This study will present a critical examination of sub-Saharan Africa’s collaboration with India and China in the health biotechnology field with a focus on identifying the main linkages, drivers, challenges, and impacts of collaboration between these countries.
1.2 Background and Rationale

The influence of China and India’s increasing global power is being felt across the African continent. Both countries have established linkages within many sectors in sub-Saharan Africa including: natural resources, infrastructure, information and communication, healthcare and science and technology (Broadman, 2007; Goldstein, Nicolas et al., 2006). Traditionally, much of sub-Saharan Africa’s history has been shaped by the influence of European nations and the outcome of the Berlin Conference, of 1884-1885, which lay out how Africa would be partitioned, thus formalizing its colonialisation. Europe’s ‘scramble for Africa’ was driven by the interest of wealthy European nations to dominate African trade and control its resources (Fage & Tordoff, 2002; Zeleza, 1997). Colonialism came, but eventually so too did independence. In sub-Saharan Africa it began with Ghana gaining its independence in 1957, and by 1966 most countries in sub-Saharan Africa had achieved the same feat. After independence, the countries continued to have strong ties with many former colonial powers, and trade relations with Africa remained largely controlled by former European colonial powers (UNDP, 2009; Zeleza, 1997). However, half a century of failed aid and economic policies in Africa (Moyo, 2008; Sahn, Dorosh, & Younger, 1999), and continued reliance on post-colonial ties has intensified the need for alternative solutions to the trade, economic, and human development problems facing Africa.

As both China and India are becoming global powerhouses, it is not surprising that they are playing an increasing role in Africa. The political and economic relationships they are forging with other countries in various areas are becoming particularly important to understand. China and India now account for 37.5 percent of the world population (World Bank, 2010) and rank as the second- and fourth-largest global economies respectively (UNCTAD, 2009). As result, there is growing interest in China and India’s increasing collaboration with Africa. However, it should be noted that China and India’s collaboration with Africa is not a contemporary phenomenon: Africa has economic ties to China and India that date back several centuries to the early days of the Silk Road. But it has been over the past decade that trade has increased and there has been a renewed emphasis on Sino-African and Indo-African relations. Africa’s annual trade with India soared from $967 million in 1991 to $35 billion in 2008, while over the same period China’s trade with Africa jumped from $1.8 billion to $106 billion, representing a forty and sixty fold
trade increase respectively (Broadman, 2007; Schwab, Zoellick, & Kaberuka, 2009; Toyoshima, Yoshino, & Leechor, 2004; WTO, 2008). A noticeable reorientation of Africa’s trade towards China and India has occurred over the past decade and major African economies such as Kenya, Nigeria and South Africa now list both China and India among their top five trade partners (Frew et al., 2009; Schwab, Zoellick et al., 2009; Toyoshima et al., 2004).

Evidence of considerable collaborative ties can be seen across the private sector and significant Chinese and Indian investments have been made on the continent by firms who have invested billions in the manufacturing, telecommunications, and pharmaceutical sectors, such as Tata Steel (Mumbai, India), Essar group (Mumbai, India), ZTE (Shenzhen, China), Holly Cotec (Beijing, China), and Ranbaxy (Gurgaon, India). While entrepreneurial collaboration has traditionally focused on trade in goods and investment, both China and India have extended their firm collaborations with sub-Saharan Africa into sectors including science and technology. There are many established Indian and Chinese biopharmaceutical firms operating in sub-Saharan Africa, bringing low-cost generic drugs and diagnostics to the continent. China and India have both placed emphasis on their health biotechnology sectors, and now have advanced research infrastructures and strong private sectors (Frew, Rezaie et al., 2007; Frew, Kettler, & Singer, 2008a; Frew, Sammut et al., 2008). They are therefore likely to be well-positioned to move into African markets in health biotechnology, share newly gained expertise, and build private sector capacity through collaboration with African countries.

Many nations in sub-Saharan Africa have also begun to develop science and technology infrastructure. South Africa, for example, is nurturing a promising biotechnology sector with strong international ties (Al-Bader, Frew et al., 2009; Louët, 2006) with active participation of universities and public research institutions, such as the University of Cape Town (Cape Town, South Africa), and the Medical Research Council of South Africa (Cape Town, South Africa) (Motari, Quach et al., 2004). Universities and research institutions within Kenya, Nigeria, and South Africa have become increasingly active in knowledge production and account for 41% of Africa’s total research output as measured by scientific publication (Pouris & Pouris, 2009). Kenya, Nigeria and South Africa consistently rank as the three largest contributors to health-
related research publications in sub-Saharan Africa, including in subfields such as Biology & Biochemistry, Clinical Medicine, Molecular Biology & Genetics, and Immunology, among others (Pouris & Pouris, 2009). However, even though within Africa these nations have shown some research strengths, they have limited collaboration with each other, and only five percent of peer-reviewed articles published from 2004-2008 involved institutions in more than one African country (Mboya-Okeyo, Ridley et al., 2009; Nwaka, Ilunga et al., 2010).

Most of sub-Saharan Africa’s collaboration is still undertaken with the United States and the European Union, often with the leadership, funding and ownership for the research residing outside Africa (Mboya-Okeyo, Ridley et al., 2009). Still, sub-Saharan African countries place a political emphasis on collaboration with other low and middle income countries and want to reduce their dependence on the North. To lessen dependence on Northern countries, sub-Saharan Africa needs to find countries to work with that have similar research needs in health and biotechnology but also still have significant capacity in research and development to share. With an increasing emphasis on science and technology, and an international agenda that is positioned to strengthen African relations, emerging producers of biotechnology knowledge in the South such as China and India are increasingly sought after partners for nations in Africa.

### 1.3 Research Gaps

Despite South-South collaboration in science and technology being high on the agenda of many developing nations for the past several decades, there is a surprisingly limited amount of evidence that examines who is collaborating, why they are engaged in collaboration, the barriers they face, and the factors that promote successful collaboration among regions of the global south. This is especially the case regarding the linkage between Africa and emerging economies such as China and India (also Brazil). There have been a limited number of studies conducted investigating science and technological collaboration and these studies have relied primarily on applied scientometric analysis. These existing studies have examined levels of collaboration specifically within sub-regions of Africa such as the countries of the Southern African Development Community (Boshoff, ; Jeenah & Pouris, 2008; Pouris & Pouris, 2009), nations of
Central Africa (Boshoff, 2009a), and a few studies have examined levels of collaboration specifically between China and India (Arunachalam, Srinivasan, & Raman, 1994; Arunachalam & Doss, 2000; Arunachalam & Viswanathan, 2008). There have been no studies conducted that look specifically at collaboration in science and technology between sub-Saharan Africa and China/India. Further, there is a lack of research on potential strategies that promote South-South collaboration or how it can have more impact in developing countries. There is a need for qualitative case studies to uncover the drivers, barriers, and impacts of China and India’s South-South collaborations with sub-Saharan Africa as well as policies that could strengthen it to promote local development and increase innovation potentials. This research will examine where the collaborative linkages lie and identify the main factors that influence and promote collaboration. Based on the research I will then identify recommendations as to how sub-Saharan African nations can harness collaboration with China and India for development and economic gain.

In summary this research seeks to address several gaps in the literature with respect to collaboration in the health biotechnology field. First, there is limited empirical research on the extent and patterns of China and India’s health biotechnology collaboration both with respect to entrepreneurial and research collaboration. Second, there is limited empirical research examining why and how countries in sub-Saharan Africa are collaborating with China and India in health biotechnology and what differences there may be between China and India’s collaboration with sub-Saharan Africa. Third, there is a limited understanding of the factors that influence South-South collaboration between sub-Saharan Africa, China, and India and strategies that may be useful in strengthening it.

1.4 Research Objective and Aims

The objective of this study is to understand the role of China and India’s collaboration with sub-Saharan African nations, in health biotechnology development, on the African continent.

Specific research aims:
1. To examine the extent and patterns of China and India’s health biotechnology collaboration with sub-Saharan Africa by mapping research and entrepreneurial collaborations.

2. To understand why and how sub-Saharan Africa countries collaborate with China and India by carrying out comparative qualitative case study research on the potentials, drivers, challenges and impacts of the health biotechnology collaborations.

3. To formulate recommendations that will enable sub-Saharan Africa countries to leverage benefits from their health biotechnology collaboration with China and India.

**Study Scope:**

This study investigated collaboration occurring broadly between individuals in select sub-Saharan African countries and China/India. The individuals were working at universities, research institutions, firms and other organizations in Kenya, Nigeria, and South Africa and focused on producing knowledge, products/services, or building capacity in health biotechnology. Specifically, this study examined two main types of collaboration (1) research collaboration and (2) entrepreneurial collaboration. Research collaboration involved the joint work between individual researchers, academic institutions, or public research organizations; whereas entrepreneurial collaboration typically involved work jointly undertaken by private sector firms or other entrepreneurial organizations. Joint entrepreneurial activity involved anything along the spectrum from marketing & distribution to research & development.

**Aim 1: Mapping of Collaboration**

The objective of this examination is to understand the landscape of collaboration both from a research and entrepreneurial perspective. To examine the extent and pattern of research collaboration between sub-Saharan Africa and China/India an analysis of joint publications listed...
in the international peer-reviewed literature was conducted and used as a proxy for collaboration. To examine the extent and pattern of firm collaboration between sub-Saharan Africa and China/India I used data from a previous survey conducted by Thorsteinsdóttir et al. on the collaboration of Chinese, Indian, and South African biotechnology firms (Thorsteinsdóttir, Melon et al., 2010). An examination of industry databases, joint patents, news briefings, and internet searches was also conducted to try to identify any additional partnerships particularly involving Kenya and Nigeria. Extensive sectoral and policy research on the focal countries further supported the co-publication and survey data.

Aim 2: Case Study Research

The objective of this aim is to gain in-depth knowledge on why and how researchers and firms in sub-Saharan Africa are engaging in collaboration with China/India and examine the factors that shape such collaborations. The case study method was employed as the main research tool to accomplish this aim. Case study research is the most appropriate methodology for this work as it provides the opportunity for an in-depth examination of collaboration and the potential to learn from previous and current experiences with collaboration. The cases were selected based on the results of the mapping exercises conducted to fulfill aim one of this study, and field interviews were subsequently conducted in Kenya, Nigeria, and South Africa.

Aim 3: Formulation of Recommendations

To address this aim I specifically asked interviewees in Kenya, Nigeria, and South Africa to suggest possible policy recommendations that might strengthen their collaboration and amplify the impacts of collaboration in their respective nations. I further analyzed data themes highlighting the drivers, challenges, and current impacts of collaboration to support this data. Recommendations were then formulated addressing how the drivers of collaboration could be strengthened, how barriers could be overcome, and how nations in sub-Saharan Africa could leverage collaboration to strengthen their capacity in the health biotechnology field. These recommendations are put forward in chapter five and have been oriented to influence three main
target audiences: government policy makers, researchers, and entrepreneurs in sub-Saharan Africa, but could also have relevance to these groups in China and India.

1.5 Expected Contribution of Research

The primary contribution of this study is towards knowledge on how sub-Saharan Africa can effectively leverage its health biotechnology collaboration with two increasingly important partners, China and India, to improve capacity, research potentials, and innovation in the health biotechnology field. The results of the case study research helped identify key drivers and barriers facing both researchers and entrepreneurs from sub-Saharan Africa when engaging in collaboration with China/India. The results will further identify the main impacts these collaborations may be having and identify possible strategies and policy options that may help sub-Saharan African nations leverage and influence these impacts. This research study aims to provide policy options that facilitate collaboration but also to provide empirical evidence to support the need for collaboration to be prioritized among existing policies so as to decrease barriers and strengthen efforts in capacity building. Such policies include those dealing with: scientific collaboration, biotechnology, science and technology, innovation, as well as health promotion. This input will serve to strengthen collaboration and increase the awareness among policy makers, entrepreneurs, and researchers about the potential benefits of South-South collaboration in health biotechnology for their strategic and economic development.

This research will be of significance to the following groups:

a) Policy Makers: It would be of interest to policy makers in the governments of sub-Saharan Africa, China, India or other countries of the global south. It provides an empirical basis upon which to understand how South-South collaboration can be leveraged with China and India as a potential strategy to build capacity, support economic development, and support local health innovation in sub-Saharan Africa.
b) Entrepreneurs and firms: This work highlights the opportunities South-South collaboration can bring to health biotechnology firms in sub-Saharan Africa, China, and India. It further provides insight into the barriers firms face in engaging in collaboration and how they can overcome them.

c) Researchers and public research institutions: This work provides health biotechnology researchers in the South with information on the opportunities and challenges facing collaboration with China and India and strategies they can use to build capacity and leverage its benefits.

1.6 Definition of Concepts

I will present a more detailed discussion of the Methods used to conduct this study in Chapter 3, however it is useful to present three key definitions of terms that will be used throughout this study.

‘South-South’:

I defined South-South collaboration as partnerships between two low- or middle-income countries. Even though China is in the Northern hemisphere I have considered it ‘South’ as it is classified by the World Bank as a middle-income country. Likewise India also falls into the World Banks classification of low- or middle-income economies.

‘Health biotechnology’:

The OECD definition of biotechnology was used for this study and states that biotechnology is “the application of science and technology to living organisms, as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services.” (Van Beuzekom & Arundel, 2009) I further narrowed the definition of
biotechnology to include only those that are directly related to the production of goods or services for the health sector.

‘Collaboration’:

For the purpose of this study I used a general definition of collaboration proposed by Jane Maienschein which stresses that a collaboration should minimally involve individuals working together toward a common product, or that they have come together in pursuit of a common goal (Maienschein, 1993). This study, focused on collaboration among both researchers and entrepreneurs working in China or India and sub-Saharan Africa aimed at producing knowledge, products and services, or capacity in health biotechnology. The definition is therefore broad, and covers a wide spectrum of collaborative activity ranging from marketing & distribution to joint research & development.

1.7 Dissemination of this work

This study was designed mindful of the need to disseminate its findings. Efforts have already been made to accomplish this and include: meetings with international stakeholders and multilateral organizations, presentations at international conferences, publications in peer-reviewed journals, and through its contributions to a larger study on South-South collaboration which is being published as a book.

1.7.1 Publications

The publications listed here have resulted directly from this research study. My main contributions to these publications have been in the form of: participation in research design, data collection and analysis, as well as the preparation of manuscripts for the following publications.


1.7.2 Conference Presentations

The results of this study have also been presented at several national and international conferences including the following:


3. Kapoor, AK. “South-South Collaboration in Health Biotechnology: China, India and sub-Saharan Africa” Presented at Institute for Medical Science Research Day, University of Toronto, ON, May 2010. (Poster Presentation)


1.8 Summary and Organization of Chapters

This study is presented in five chapters. The current chapter presents the rationale and objectives of this research study, and frames my central research question. I highlight the current gaps in knowledge with respect to South-South collaboration in health biotechnology, provide a background to contextualize this work, and outline some of the key ways this work has been disseminated. I conclude by defining several salient definitions needed in interpreting this study and further discuss the expected contributions of this research along with its target audience.

Chapter Two reviews literature relevant to this study including a discussion of science and technology for development and South-South collaboration. It further discusses the policy landscape that contextualizes this work with specific attention to the political context of China-Africa and India-Africa relations and the biotechnology landscapes found in Kenya, Nigeria, and South Africa.

Chapter 3 outlines the methods used to carry out this study including those used to conduct the scientometrics, survey, and case studies. In addition it presents the data analysis methods and the steps taken to enhance the analytical validity of this research study.

Chapter 4 contains the results of this study. I first present results from the mapping exercises which highlight levels of research collaboration between sub-Saharan Africa and China/India. It further presents the results from the mapping of entrepreneurial collaborations between these same nations. This is then followed by the in-depth presentation of the bilateral case study work on research and entrepreneurial collaboration detailing for each the main drivers and challenges followed by their impacts.
Chapter 5 presents the main messages stemming from this research and puts forth practical recommendations. This chapter then highlights some of the studies inherent limitations and concludes by looking at areas of future research.
2 CHAPTER TWO

Literature Review and Policy Landscape

2.1 Introduction

This chapter will highlight relevant areas of literature that will serve to contextualize this study on South-South collaboration in health biotechnology. The key areas of literature that will be reviewed include: science and technology for development and scientific collaboration. This chapter will also provide a review of the policy landscape relevant to the study of biotechnology collaboration between China, India, and sub-Saharan Africa. This includes a discussion of China/India – sub-Saharan Africa’s political interactions in science intensive fields. Further I will provide a brief overview of science and technology policy in Africa and more specifically overviews of the biotechnology policy landscapes in Kenya, Nigeria, and South Africa.

2.2 The Importance of Science and Technology for Africa’s Development

Traditionally, biotechnology and genomics research have been pursued by developed nations. Until recently, the prevailing perception was that these types of technologies were better suited to address the health needs of developed countries. However, governments of developing nations are beginning to realize that advancements in health biotechnology can be used to improve the health of their populations and improve their economic, social, and human capacity. Molecular
diagnostics, recombinant vaccine technology and other science intensive tools are critical in the fight against infectious diseases like HIV, TB and malaria, and other neglected and tropical diseases which are burdening much of the developing world (Acharya, Daar, & Singer, 2003; A. S. Daar, Thorsteinsdottir et al., 2002). The belief that investments in science and technology can bring about social and economic change has now been discussed widely in the literature (Watkins & Esht, 2008; Chataway, Smith, & Wield, 2005; Fagerberg, 2005; Kraemer-Mbula & Wamae, 2010; Malecki & Malecki, 1991). However it is also clear that advances in science and technology cannot be the sole solution to complex myriad of challenges facing global development. There are many other areas of research focused on furthering the development agenda, these include but are not limited to, health systems, water, food security, agriculture, and governance; and there exist a variety of additional tools being used in the development arena including microeconomic strategies involving microfinance (Armendáriz & Morduch, 2010; Novogratz, 2009; Yunus & Jolis, 2003) and macroeconomic strategies involving trade (Kose & Riezman, 2001; Sen, 1999; Zafar, 2007). Advancements in science and technology play an important practical role among these various approaches but there remain concerns about intellectual property rights (Rai, 1996; Rai, 1999), environmental implications (Brooks, 1994; Dreher, 2004), and ethical questions about its use (Bell & Lederman, 2003; Marshall, 1999). Despite these contrarian views, there is an increasing body of literature supporting science and technology as an important strategy to improve health and promote economic and social development in developing countries (Acharya, Daar et al., 2003; Coloma & Harris, 2008; A. S. Daar, Berndtson et al., 2007; H. Thorsteinsdottir, Quach, Daar, & Singer, 2004a).

There are numerous writings that discuss the relationships between scientific development and development but in my view there are two landmark reports that have grounded this literature; these include a 2001 report from the UNDP titled “Human Development Report: Making new Technologies work for Human Development”(UNDP, 2001) and a report published in 2002 by the World Health Organization titled “Genomics and World Health”(WHO, 2002). The UNDP report provides strong evidence that technological advances such as vaccines, antibiotics, fertilizers, and plant breeding technologies have historically played an important role in improving human health and productivity. These technology based health improvements in turn lead to further improvements in health as a result of the productivity increase and economic
development they stimulate (UNDP, 2001). The WHO report further advances this belief specifically highlighting the potential for an emerging technology, genomics, to improve global health. It further discusses the potential benefits of advances in genomics research for developing countries for the treatment of both communicable and neglected diseases.

The globalization of science and technology has increasingly brought to light evidence in the literature that scientific and technological developments have indeed had impacts on the health of those in developing countries. One example is the development of Highly Active Anti-Retroviral Therapy (HAART) which has improved both the life expectancy and the quality of life for those living with HIV/AIDS (Badri, Wilson, & Wood, 2002) across the world both in developed and developing nations. Other such examples include advances in information communications technologies that allow HIV patients to be monitored via cellular phone (Puccio, Belzer et al., 2006), and advances in therapeutics for malaria with the advent of combinational artimisinin therapy (Breman et al. 2004). Advances in basic sciences such as virology, genomics, and microbiology have more recently supported the development a novel preventative therapy for HIV in the form of a microbicide gel (Karim et al., 2010). Developed in South Africa, these scientific advances continue to affirm that investments in science and technology can indeed improve lives in developing countries.

In recent years, biotechnology in particular, has emerged as a promising subset of tools provided by science and technology that are being considered as essential for socioeconomic development by an increasing number of developing countries. Genomics and biotechnology hold great potential to fight diseases that disproportionately affect the world's poorest people. Developing nations are now taking steps to build long-term plans to benefit from biotechnology (Thorsteinsdóttir, Singer, & Daar, 2007; Thorsteinsdóttir, Quach, Daar, & Singer, 2004; WHO, 2001) and emerging economies, such as China and India, which are home to 37% of the world’s population, have built up significant capacity in the health biotechnology field (Frew, Rezaie et al., 2007; Frew, Kettler, & Singer, 2008b; Frew, Sammut et al., 2008). Several authors have made attempts to identify technologies that appear to provide significant opportunity in combating diseases of the poor (A. S. Daar, Thorsteinsdóttir et al., 2002; J. Sachs & McArthur,
They have identified several such technologies and “the results offer concrete guidance to those in a position to influence the direction of research and development, and challenge common assumptions about the relevance and affordability of biotechnology for developing countries” (A. S. Daar, Thorsteinsdóttir et al., 2002)

Developing nations are a heterogeneous group. The annual economic data published by the World Bank shows that countries classified as ‘developing nations’ exhibit enormous variation across many basic economic indicators such as nominal GDP (See Figure 1). For example, in 2009 Niger, a landlocked, resource poor nation, recorded a GDP of $5.6 billion, while China an ‘emerging economy’ posted a GDP of $5.7 trillion, one thousand fold larger than that of Niger’s (The World Bank, 2010; UNCTAD, 2009). In practicality many African governments face the challenge of distributing limited resources across many ministries and both domestic and international political support for science in Africa has been limited. Donor and technical support agencies have also been reluctant to redirect parts of their investments towards science and technology. However, this trend is in stark contrast to a growing voice in the literature calling for increased investments in science on the continent (Chataway, Chaturvedi et al., 2007; M. Hassan, 2007b; Mugabe, 2003; NEPAD, 2006; Nwaka, Ilunga et al., 2010), and the strong body of research supporting science and technology as a promising development instrument for Africa. I believe this begs an obvious question, given the level of abject poverty, hunger, civil war, and poor governance across Africa; should large-scale investments be made in science and technology?

Figure 1: This figure illustrates the considerable variance with respect to GDP per capita across the globe. It further highlights the huge variance among the ‘global south’ and among those nations considered to be developing. (Source: IMF World Economic Outlook, 2008)

In fact, there is a great deal of literature that supports the idea that African governments should be investing in science intensive fields. The literature supporting this comes from a variety of sources including prominent international organizations, such as the UN, as well as from Africans themselves (Kagame, 2006; M. Hassan, 2007a; Juma, 2005; Juma, Gitta et al., 2005; NEPAD, 2006). Most importantly there is increasing evidence from the continent itself that science and technology is a tool African leadership and Africans at large believe can have significant impacts. In a 2006 in a speech delivered by Paul Kagame, the President of Rwanda, on the importance of science and technology for Africa he said “We all know that the application of science and technology is fundamental, and indeed, indispensable in the social and economic transformation of our countries. Productive capacities in modern economies are not based merely on capital, land, and labour; but are also dependent on scientific knowledge and sustained technological advances” (Kagame, 2006). Leaders from Rwanda, South Africa, Kenya, Nigeria and increasingly other nations in sub-Saharan Africa have been begun to emphasize the importance of building infrastructure in science, technology and innovation for the development of their nations. There is a belief that this will translate into progress towards the UN Millennium Development Goals (MDGs) aimed at reducing poverty, disease, and hunger in the world (Juma, Serageldin, & Union, 2007). The African Union has made progress in
supporting science and technology. It has established a science and technology program through NEPAD, a body responsible for the implementation of pan-African development programs. The program is supported by financial institutions, and by many international governance institutions like the United Nations. The UN Millennium Project also set up a Task Force in 2004 to investigate the role of science and technology for development and subsequently many high-level reports have also begun to stress the importance of science, technology, and innovation for Africa’s development including the Commission for Africa Report in 2005 (Commission for Africa, 2005).

As mentioned earlier, intensive solutions from, for example, science and technology, biotechnology, or advances in biomedical science, are not a panacea for developing countries and a number of social and economic measures are called for to improve the quality of life sustainably in developing nations. However, I draw specific attention to them here because of a growing body of research that supports the importance of science based solutions in developing regions such as Africa (Coloma & Harris, 2008; UNCTAD, 2004; Zeleza & Kakoma, 2003). Despite the perceived potentials of biotechnology in promoting economic development in developing countries, it remains one of the least developed technological resources in developing countries (Juma & Institute for Natural Resources in Africa, 2000). As a discussion paper from the World Bank's recent Global Forum on Science, Technology, and Innovation states, there is no longer a question of whether countries should build science and technology capacity that promotes biotechnology innovation, "but what type of capacity to build, given their economic constraints, and how best to implement these capacity building action plans" (Watkins & Ehst, 2008)

Most countries in Africa continue to have low levels of research and development output. No African country except South Africa has yet reached the investment target of 1% of GDP spending on R&D set out in the African Union’s Science and Technology Consolidated Plan of Action (Gilbert, 2009; Khan, 2008). However, in 2010 even South Africa which has maintained a steady growth in its research and development (R&D) expenditure over the past decade dropped back below the 1% marker (Khan, 2008; South African Department of Science and
There is also little collaboration between biomedical R&D centers across Africa. As discussed above, only 5% of peer-reviewed articles published from 2004-08 involved institutions in more than one African country (Boshoff, 2009a; Boshoff, 2009b; WHO, 2009). In addition, most international collaboration is undertaken with the US and EU, often with the leadership, funding and ownership for such research outside Africa. This can result in misalignments between actual research efforts and African needs (Sagasti, 2004).

In 2005, the Commission for Africa estimated that nearly half of the African continent did not have regular access to essential medicines (Commission for Africa, 2005). Currently there are still few effective diagnostic, preventive, or therapeutic options for many of the health challenges such as HIV, TB, malaria, among others. The continent accounts for just 1.1 per cent of the total value of the global pharmaceuticals market which has meant that pharmaceutical companies in developed countries have not prioritized Africa’s health needs (Commission for Africa, 2005). Developing countries are now striving to lessen their reliance on the politically dominant developed countries, diversify from their colonial ties and trade with new partners. This trend may represent an opportunity for Africa to move towards partnerships with other Southern countries. South-South partnerships with emerging economies such China, India, and Brazil may become increasingly practical for African nations in developing their science and technology capacity precisely because they too are developing countries. The opportunity to share and build knowledge on locally relevant challenges common to these countries may be an important strategy in addressing the current challenges Africa faces in developing technology driven health solutions. I will now shift the discussion from the importance of science and technology for Africa’s development, to the nature of South-South collaboration as a potential tool in boosting science and technology capacity among developing countries.

2.3 South-South Collaboration for Building Science and Technology in Africa

Many developing countries have undergone rapid economic growth over the past decade including nations such as Brazil, China, India, and South Africa (Goldstein, Nicolas et al., 2006;
The World Bank, 2010) and have begun to change the global landscape of collaboration. This economic growth has brought increased trade, technological capacity, and is providing developing countries increasing opportunities to collaborate. Over the past decade, the global South has begun awakening to the potential South-South collaboration may offer in terms of development and international trade. Between 1990 and 2000, South-South trade grew at an annual average of 10 percent in comparison to the world trade average of 6 percent (UNCTAD, 2010; UNCTAD, 2009). Even more strikingly South–South trade more than tripled from 1995 to 2006, increasing from 577 billion to over 2 trillion (OECD, 2006; UNCTAD, 2004) and in 2006 accounted for 37% of the total trade in developing countries (UNDP, 2009).

As the previous section discussed, governments of China and India and those in Africa, and elsewhere, are becoming aware that they must take the lead and use biotechnological and other science-intensive tools to solve endemic health problems. This growing need requires new strategies to be employed in meeting the health challenges of developing countries and the trend of increasing South-South trade may present novel opportunities. However, developing nations have traditionally teamed up with developed countries in what is typically referred to as “North-South” collaboration (Sagasti, 2004; L. Velho, 2002). A review of the literature suggests that there are several factors that appear to motivate North-South collaborations these include:

- Gain access to expertise and technology (Bradley, 2007; Melon, Ray et al., 2009; Ray & Thorsteinsdóttir, 2010; L. Velho, 2002a)
- Gain access to research samples and materials (Ray & Thorsteinsdóttir, 2010; Sagasti, 2004; L. Velho, 2002a; Wagner, 2006)
- Decrease costs and risks (Bradley, 2007; Ray, Daar et al., 2009)
- Address challenges that cross national boarders (Brandt, 1980; Ray & Thorsteinsdóttir, 2010; Wagner, 2006)

Over the years, despite the many positive outcomes of pairing up with Northern collaborators with those in the South, there have been undesirable effects as well. The Southern partners often entered into the arrangements expecting equal partnership; however, with more funding coming from Northern partners, access to instrumentation and expertise, the Northern collaborators typically ended up as the principal investigators, the lead authors, and the one filing the patents
In other cases, active involvement with the international scientific community leads scientists from developing countries to lose sight of the problems facing their own regions, primarily because prestige and financial incentives are biased towards research on topics of interest to the developed countries (Juma, Gitta et al., 2005). This has generally resulted in some North-South collaborations being both unidirectional in flow and heavily one-sided.

Such undesirable outcomes have driven Southern researchers and industry-workers to consider collaborating with other Southerners. It is thought that the motivations underlying South-South collaboration include several of the same incentives for collaborating with Northern partners, but in this instance one sees several extra reasons:

- Lessening dependence on the North (Juma, Gitta et al., 2005; Rath & Lealess, 2000; Zhou & Gitta, 2000)
- Common history, needs, and goals (M. Hassan, 2000; Rath & Lealess, 2000)
- Bridging the South-to-South divide (Juma, Gitta et al., 2005; UNDP, 2009)

The eminence of emerging economies such as China, India, Brazil and South Africa is providing an increasing number of opportunities for South-South collaboration. There has been growing emphasis on collaboration involving science and technology amongst developing countries, and countries in the South are increasingly signing agreements between themselves aimed at fostering their collaboration (Dickson, 2003b). For example, in 2000, the Forum on China-Africa Cooperation (FOCAC) was established. Early in 2008, India too launched an African Forum Summit where India’s emphasized its common path and struggles of colonialism and apartheid with Africa (Dutz, 2007; India-Africa Forum Summit 2008, 2008b). Chinas and India’s biotechnology sectors have experienced rapid growth during this time and have grown at rates of 30% per year between 2000 and 2005 totaling jointly at over 5.5 billion (BioSpectrum Bureau, 2007; H. Jia, 2007). Both their fast growing economies and substantial governmental investments in biomedical research and health biotechnology make them interesting southern
cases to study with respect to their collaboration with sub-Saharan Africa in this field. The World Bank suggests that India and China can serve as models for the developing world, particularly Africa, to stimulate inclusive and sustainable growth, reduce poverty, and improve public health (Pefile, Li et al., 2005). Both the governments of China and India have placed focus on becoming “nations of innovation” (Frew, Kettler, & Singer, 2008b), and many African nations may be able to gain from capacity building efforts afforded by South-South partnerships with China/India.

It has now been over 50 years since the landmark ‘Bandung conference’. This conference, held in Indonesia in 1955, marked the beginning of a movement towards South-South collaboration as a strategy for developing countries to decrease their dependence on the West. It was a catalyst for the formation of various South-South groups such as the Non-Aligned Movement (1961) and the Group of 77 (1964). But South-South collaboration has evolved greatly since Bandung and now takes many forms. It can involve bilateral collaboration between two developing countries. Such as the collaboration that is being examined in this study between China/India and select nations in sub-Saharan Africa. It can also take the form of regional collaboration which has become common among developing countries as a way to foster closer political and economic relations. Examples of this type of collaboration include the Association of Southeast Asian Nations (ASEAN), South America’s Southern Common Market (MERCOUSUR), as well as Africa’s several regional trading blocs including the Southern African Development Community (SADC), and the Common Market of Eastern and Southern Africa (COMESA). Generally these regional associations have focused on political and economic cooperation but many of them have now incorporated cooperation programs in science and technology. In addition to bilateral, and regional cooperation multilateral agreements between developing countries have also begun to take shape. The India, Brazil, South Africa, or IBSA, initiative (Discussed in more detail in Chapter 4) is a strong recent example. It focus is to promote South-South cooperation and exchange in several areas including energy, education, health, trade, and science and technology.

Despite this increasing emphasis on South-South collaboration and growing emphasis on scientific and technological collaboration, there is limited research examining South-South collaboration in scientific and technology intensive fields. As discussed above in Chapter 1, the
few studies that have focused on examining South-South scientific collaboration have mostly involved scientometric analysis, for example, of India and China’s co-publications (Arunachalam and Viswanathan 2008) and of within African co-publications (Boshoff 2009, Boshoff 2010a). These studies have measured collaboration looking purely at scientific output, but there remains little empirical evidence about, the challenges faced in collaborating, the motivations for engaging in it, or the practical impacts it is having in developing countries. Further, there is also a gap in knowledge with respect to entrepreneurial collaborations between firms in sub-Saharan Africa and those in China and India. The firm survey conducted by Thorsteinsdóttir et al. (Thorsteinsdóttir, Melon et al., 2010) highlighted the need to understand the qualitative nature of these partnerships, where they lie, what barriers they currently face, and what factors motivate firms to collaborate. Therefore there remains a significant gap in knowledge when it comes to understanding the qualitative aspects of collaboration in science intensive fields. Though some research has been previously done it has lacked the depth necessary to accurately analyse how and why nations in sub-Saharan Africa are engaging in South-South collaboration with China/India in health biotechnology and how they can better harness the collaboration for health and development.

2.4 Governmental Will and Policy Landscape

To better understand the context of China and India’s collaboration with sub-Saharan African countries in health biotechnology, I will discuss the political context behind the science and technology initiatives being taken between these governments. I provide an overview of some of the important economic, trade, international relations, and political issues that currently influence the interactions of these countries and discuss specific programs aimed at promoting closer ties in science and technology. I will then focus on the policy and institutional framework of science and technology in Africa and subsequently provide a brief overview of the biotechnology sectors in Kenya, Nigeria, and South Africa, the three focal countries of this study.
2.4.1 The Political Context of Collaboration: China and India in Africa

There is no longer any doubt that China and India have become two of Africa’s most important economic partners (Cheru, F., Obi, C., 2010; Goldstein, Nicolas et al., 2006; Rotberg, 2008), and their growing footprint on the continent is transforming Africa’s international relations in a fundamental way. Collaboration among these regions is not new, but the increasing attention these collaborations are gathering through the media is garnering skepticism among other nations. Though this study examines China and India’s role in Africa with respect to biotechnology, it is imperative to understand the underlying political, economic, and international relations context within which such collaborations are happening.

2.4.1.1 Policy Landscape: China and Sub-Saharan Africa

China’s new role as a major investor and development partner in Africa has in particular attracted much attention in the region and elsewhere, not least among the western countries that have been dominant in Africa since the colonial times. China’s entrepreneurial collaborations with Africa have been a central part of this attention and there has been much debate about the activity of Chinese state owned enterprises (SOE) and their interests in commodities. These interests have been characterized by huge investments in sub-Saharan Africa from firms such as China National Petroleum Corp. and Sinopec. Critical discussion mainly from Western media and analysts (Manji & Marks, 2007; McBride, 2008; Robert I. Rotberg, 2008) have scrutinized China’s approach to Africa particularly its no-strings-attached ‘non-interference policy’ which imposes few political, human rights or environmental conditions on African governments. China has been criticized by the governments of many developed nations who believe this ‘undemocratic’ approach perpetuates corruption, poor governance, and human rights abuses. This ‘exploitation’ of African natural resources by the Chinese SOE’s has motivated much of the negative discourse and given China the title of being Africa’s ‘new colonialists’ (McBride, 2008; Muekalia, 2004; Rotberg, 2008).

However, this clout has not deterred the Chinese from continuing to pursue Africa as a partner but rather has encouraged China to formalize many of its collaborations through high level
agreements. The creation of the Forum on China-Africa Cooperation in year 2000 and the China-Africa Business Council in 2005 have defined efforts to reinforce and accelerate existing and emerging partnerships. The biennial meetings of the cooperation forum are attended by statesmen from over 45 African countries, heads of regional, international, non-governmental organizations as well as influential entrepreneurs (Beijing Summit, 2006; Ministry of Foreign Affairs of the People's Republic of China, 2009; Naidu, 2007; The Sharm El Sheikh Summit, 2009). As a result of the meetings in 2000 many African governments set up ministerial commissions to plan and coordinate the implementation of their evolving bi-national collaboration with China.

In addition to the cooperation in commodity driven sectors the forum focuses on other core areas such as: cooperation in education, science and technology, and health. During the 4th meeting of the Forum in 2009 Chinese President Hu Jintao announced the launch of the China-Africa Science and Technology Partnership Program (CASTEP) which will be administered through the Chinese Ministry of Science and Technology. The program’s focus is to find ways to strengthen scientific cooperation over the next three years. It will provide capacity in the form of workshops and technical training courses, technology transfer, equipment donation, joint research projects and the designing of high-tech science parks. The partnership program will also foster 100 new joint research partnerships and provide 100 African postdoctoral scientists an opportunity to carry out research at Chinese institutions (Government of the Peoples Republic of China, 2009). China has continued to pursue these forums as instruments to strengthen ties between China and Africa; and the China-Africa Science and Technology Partnership Program explicitly states this interest with a particular focus on strengthening collaboration in Science and Technology. According to Hu Jintao the President of China, “China values its friendship with Africa; Strengthening unity and cooperation with Africa is a key principle guiding China's foreign policy.” (Ministry of Foreign Affairs of the People's Republic of China, 2009)

China has shown further governmental will to collaborate with Africa by signing more than 10 inter-governmental agreements on scientific and technological cooperation with countries including Kenya, Nigeria, and South Africa. These collaborative agreements span research
projects in areas such as biotechnology, medicine, agriculture, energy, mining and manufacturing (Kaplinsky & Morris, 2009; Robert I. Rotberg, 2008). Specifically within the area of health, China has committed to cooperate on malaria treatment and prevention. It has agreed to provide 70 million USD worth of medical equipment and herbal based artemisinin anti-malarial drugs to 30 hospitals and 30 malaria clinics built by the Chinese across sub-Saharan Africa (Jia, 2007; Ministry of Foreign Affairs of the People's Republic of China, 2009; Naidu, 2007). With few cases of malaria left in China, but a wealth of expertise and pharmaceuticals for treating the disease this type of partnership may provide common benefit.

There remains a significant degree of criticism about China’s engagement with Africa, so it will be of interest to see how health biotechnology experts in sub-Saharan Africa perceive the role of China in the health biotechnology field. China has been scrutinized more heavily by the media than India in its engagements with Africa due to its non-interference policy and its belief that democracy is not a precursor to development. Though developed nations continue to emphasize democracy as a condition for development, China’s rapid economic rise has challenged development scholars to question this widely held view (Collier & Rohner, 2008; de Mesquita & Downs, 2005). The state dominated nature of China’s economy means that it can offer a one stop shop approach, this combined with its avoidance of conditionality, has allowed it to accelerate its collaboration with African nations. However many have raised legitimate questions about the potential implications of China’s relationship with African governments for the advancement of human rights and democracy in Africa. Africa must be cautious in proceeding to far to fast with China, critical thought must be given to the desired outcomes of this fast growing friendship, and policies must be leveraged by African nations to protect African interests. China’s large-scale investments on the continent represent an opportunity for Africa and with careful planning, strong leadership, and well informed policies may help many African nations take important steps towards development and improve economic growth.
2.4.1.2 Policy Landscape: India and Sub-Saharan Africa

Africa’s mineral wealth and its large populations of Indian descent have also bolstered collaboration between sub-Saharan Africa and India. Although China’s deepening engagements with Africa have tended to overshadow India’s growing relationship, it has allowed India to come under less scrutiny in its relations with Africa than China. India’s democratic ideals and a more closely aligned imperial history and India’s involvement in the anti-apartheid movement of South Africa have allowed it to forge a different kind of relationship with sub-Saharan Africa in comparison to China. Significant Indian investments on the continent have been made in telecommunications, transport construction, tourism, education, science and technology, pharmaceuticals, manufacturing, agriculture, among other retail and commercial ventures. Firms such as India’s Ranbaxy, Tata Steel, Vedanta, Essar group, and ONCG Videsh, have invested billions within sub-Saharan Africa in the pharmaceutical, manufacturing, and telecommunications sectors. When asked to define India’s collaborative efforts with Africa Prime Minister Manmohan Singh stated “We don’t seek to impose any pattern in Africa. It’s for the African people to decide on their future.” Despite this, India’s strong private sector presence and extensive collaboration with commodity based sectors in Africa’s economy cannot be overlooked.

India’s strategy of economic diplomacy in Africa mirrors much of China’s Africa Policy; and similarly to China, India actively collaborates with Africa’s resource based sectors (Goldstein, Nicolas et al., 2006). Although, India does not have a ‘non-interference policy’ its political and economic engagements imply that sub-Saharan Africa countries engaging India in the trade of natural resources risk collaborations being one-sided. However, India has also promoted the establishment of South-South collaboration in science and technology with sub-Saharan Africa; though it has taken a slower, longer term approach, compared to China. Similarly to China, India has held a number of high level governmental summits with Africa focusing on issues shared by both Asian and African counterparts in an attempt to provide structure and focus its collaboration with Africa. For example, the India-Africa summit was held in 2008 and was attended by leaders from a select 14 countries chosen by the African Union. The meeting was intended to strategically strengthen collaborative ties in areas such as science, technology, research and
development, health, social development, and capacity building (India-Africa Forum 2008, 2008a). The output was the Africa-India framework for cooperation that covers issues of bilateral, regional and international interest to both India and Africa, including their common positions on UN reforms, science and technology, intellectual property, trade, and agriculture among other areas.

A trilateral initiative between India-Brazil-South Africa (IBSA) that commenced in 2003 has also fostered stronger ties between the three countries. The IBSA agreement is a developmental initiative for promoting South-South cooperation and exchange. It encourages linkages between the countries on an equal footing in many areas including energy, education, health, trade and science and technology (IBSA, 2009; IBSA, 2007; IBSA, 2005; Puri, 2007). Several focused areas of health research collaboration have been identified as relevant and have been divided among the countries according to national strength. For example South Africa is leading priority areas in biotechnology and tuberculosis whereas India is taking the lead in HIV and nanotechnology research. Other modes of cooperation in science and technology will include specialized scientific exchanges, training and workshops in areas of national strength, information exchange on traditional knowledge, and collaboration in basic research and development (IBSA, 2005; Puri, 2007; South Center, 2006). Specifically within health the priority areas include intellectual property, traditional medicine, drug R&D, vaccines and regulation. Notably the three countries also agreed to share information on arrangements for technology transfer and intellectual property rights issues related to the protection of biodiversity and traditional knowledge. A South African policy maker highlighted the importance of such agreements stating that “we want to be a bit more proactive as the south and to drive our own agenda and look at things ourselves, take care of issues ourselves and not only to be reacting to the north’s agenda or to be dependent on the north’s agenda.” The IBSA agreement has provided a platform for dialogue and action on southern issues and is a key policy in the promotion of South-South collaboration.
2.5 Summary

Although both China and India’s involvement in Africa has been subject to criticism it is clear that collaboration has moved beyond the extractive and resources sectors. The governments of China and India are demonstrating an increasing political will to collaborate with sub-Saharan Africa as evidenced by large increases in trade, signing of numerous bi-national agreements and the creation of several ongoing forums and technology partnership programs (Broadman, 2007; Goldstein, Nicolas et al., 2006). It is also clear that two distinct classes of both Chinese and Indian entrepreneurship have emerged in sub-Saharan Africa; state owned enterprises (SOE) active at the national level, as well as small and medium enterprises (SME) active throughout the private sector. It is through the second channel, the SME, that significant development in Africa may be taking place. While China and India’s interest in securing resources tends to dominate the headlines, a greater diversification of China and India’s investment has been occurring over the past decade particularly through SMEs interested in African markets.

This has led to huge increases in trade flows; Africa’s has doubled its exports to Asia over the past decade, and Asia now receives 27% of Africa’s exports in contrast to only 14% in 2000. As a percentage, sub-Saharan Africa’s exports to Asia are now almost on par with its exports to its traditional trading partners the United States and the European Union (WTO, 2008). Shifts in global supply and demand have positioned China and India as increasingly important partners for countries in sub-Saharan Africa and represent an emerging new entrepreneurial opportunity. Within the context of such opportunity, governments in sub-Saharan Africa continue to cite the economic growth and development opportunities in S&T intensive sectors such as biotechnology can bring to Africa (Watkins & Whst, 2008; Kagame, 2006; UNCTAD, 2004). Interestingly, both China and India have put science and technology consistently among their top priorities in bi-national agreements, summits, and forums with sub-Saharan Africa countries. Overlapping interests of China and India and countries such as Kenya, Nigeria, and South Africa has placed a renewed emphasis on the importance collaboration in science and technology for Africa (Watkins & Ehst, 2009; Kagame, 2006; India-Africa Forum Summit 2008, 2008b; Ministry of Foreign Affairs of the People's Republic of China, 2009). Although none of the countries under study have any specific policies on South-South collaboration in health biotechnology, the
emergence of specific national biotechnology policies in South Africa, Nigeria and Kenya has created a policy environment for supporting such collaborations. This emergent policy environment and increasing political will is providing a new platform for sub-Saharan Africa to engage China and India in health biotechnology collaboration.

2.6 Biotechnology on the African Continent

This section will now turn to focus on the policy environment that has developed specifically in Africa with respect to biotechnology. The intention is to contextualize this study by providing a brief overview of the biotechnology landscapes in Kenya, Nigeria, and South Africa to facilitate a better understanding of the results of this study. The purpose of this section is not to give an exhaustive overview of the biotechnology policy and development of Africa or each nation, but rather to point out a few salient features.

2.6.1 An Overview of Biotechnology in Africa

Advances in biotechnology offer considerable opportunity for addressing many of Africa’s pressing challenges in fields related to human development, international trade, and health. As discussed above, evidence that African leaders are starting to view science, technology, and innovation as critical to the continent has begun to accumulate. The African Union has been spearheading initiatives to promote biotechnology, and has developed or contributed to, many continent wide initiative, programs, and policies, supporting African biotechnology (Juma, Serageldin et al., 2007). I will highlight here a few of the major policies that have shaped biotechnology development on the African continent and detail some of the progress that has been made towards developing Africa’s biotechnology potential.

The African Union (AU), which succeeded the Organization of African Unity (OUA), was formed in 2002. The objectives of the AU include the promotion of sustainable development at the economic, social and cultural levels as well as the integration of African economies and the
advancement of the development of the continent by promoting research in all fields, but particularly in science and technology. In 2003 The African Ministerial Council on Science and Technology (AMCOST) was established in collaboration with both the African Union and the New Partnership for Africa’s Development (NEPAD), a semi-autonomous program within the framework of the African Union (AU) (Chataway, Chaturvedi et al., 2007). It was established as a high-level platform for developing policies and setting priorities on science, technology and innovation for African development (Juma, Serageldin et al., 2007).

In order to address the issue of inadequate resources to develop and safely apply biotechnology (human, infrastructure, and funding) the AU through the NEPAD Office of Science and Technology also established the African Biosciences Initiative in 2005 (Oyelaran-Oyeyinka, 2005). This initiative has been implemented through the establishment of regional networks of centers of excellence throughout the continent. Each of these regional biosciences networks consists of a secretariat, hub, and several nodes distributed throughout the region. There are currently four regional networks the African Biosciences Initiative has been able to put into place, they are: the Biosciences Eastern and Central Africa Network (BecANet) in Kenya, Southern African Network for Biosciences (SANBio) in South Africa, West African Biosciences Network (WABNet) in Senegal, and the North African Biosciences Network (NABNet) in Egypt (Mugabe, 2003). Shortly after the creation of this initiative in 2006, Africa’s Science and Technology Consolidated Plan of Action was developed, and AMCOST was tasked to provide the political and policy leadership for the implementation of Africa’s first continent wide plan promoting science and technology. Important developments specific to the field of biotechnology included NEPAD’s collaboration with the AU to establish a high level African panel on biotechnology (NEPAD, 2006; NEPAD, 2001). The goal of this panel was to “facilitate open and informed regional multi-stakeholder dialogue on, inter alia, scientific, technical, economic, health, social, ethical, environmental, trade and intellectual property protection issues associated with or raised by rapid developments in modern biotechnology” (Juma, Serageldin et al., 2007)

The consolidated plan allowed the member states of the African Union to seek the guidance needed to develop the appropriate measures to deal with biotechnological development. This lead to the recommendation of the AU and NEPAD for the adoption of National Biosafety
Frameworks (NBFs) across Africa, the key components of the NBF include: (a) a policy on biotechnology; (b) laws and regulations on biosafety constituting a regulatory regime for biotechnology; (c) an administrative system for handling applications and issuance of permits; and (d) a mechanism for public participation on biosafety decision-making (Kameri-Mbote, 2002; Morris & Koch, 2002). As of now only seven African countries (South Africa, Burkina Faso, Kenya, Togo, Mali, Nigeria and Zimbabwe) have developed their NBFs with 11 countries having developed interim NBFs (Senegal, Ghana, Cameroon, Uganda, Tanzania, Malawi, Mozambique, Ethiopia, Namibia, Madagascar and Zambia) and the remaining 30 countries with no NBF (Zidenga, 2003). It is clear that the sustained effort of the AU and NEPAD has supported the policy development in many African nations (See Appendix 6). However there have emerged some clear leaders with respect to biotechnology policy development in Africa. Aside from being economic powers in their regions Kenya, Nigeria, and South Africa have all taken steps towards adopting biotechnology policies. I will now provide a brief overview of the biotechnology landscape and specific policy environment shaping collaboration within these three focal African countries included in this study: Kenya, Nigeria and South Africa.

2.6.2 Biotechnology Landscape in South Africa

South Africa’s turbulent political history and relatively strong economic standing have made it somewhat of an anomaly on the African continent. In particular, international sanctions and South Africa’s political isolation during the years of Apartheid fostered a strong inward perspective (Lachman & Bercuson, 1992; Sachs, 2003). As a result of this need for self-reliance South Africa was able to build capacity in areas such as education, infrastructure, and mining, which rival what can be found in many developed countries (Bunting, 2006; Motari, Quach et al., 2004). Although the trade embargos against South Africa forced the Apartheid government to become as self-reliant as possible, after the fall of Apartheid government, South Africa’s isolation still left it with a great deal of catching up (Beinart & Dubow, 1995). Its development was unbalanced and though it had still progressed in many ways, South Africa suffered from many of the same health, social, and economic, challenges faced elsewhere in Africa (Carter & May, 2001). These circumstances along with a myriad of other complex factors created a unique environment for the growth of a new South African health biotechnology industry (Al-Bader,
In addition to the confluence of a number of complex factors that shall not be discussed in detail here, the Apartheid government left South Africa equipped with strong universities and research infrastructure in comparison to the rest of sub-Saharan Africa (Gastrow, 2008). This is an important point of interest; as it helped to start post-apartheid South Africa on a solid foundation towards developing capacity in the health biotechnology field.

In 2000, the South African government began to focus on, and substantially increased, its research support for biotechnology. Among the countries of sub-Saharan Africa, South Africa was the first to develop a policy on biotechnology. The biotechnology strategy for South Africa was written in 2001 and committed an initial US$70 million for the development of biotechnology (Cloete, Nel, & Theron, 2006; Government of the Republic of South Africa, 2001). The strategy was set in place to catalyze the development of a ‘bio-economy’ to create commercially viable biotechnology products with local relevance (UNCTAD, 2004). One of the main results of this new strategy was the call for creation of four Biotechnology Regional Innovation Centers (BRICS) in South Africa which were established to identify and develop commercial opportunities in biotechnology. The BRICS were set up strategically across South Africa to also implement the biotechnology strategy and cultivate the development of biotechnology clusters in some of South Africa’s major urban centers. These include CapeBiotech (Cape Town), BioPAD (Pretoria), LIFElab (Durban) and PlantBio (Pietermaritzburg) (Al-Bader 2009, Frew et al., 2009).

However, seeing the initial success of the publicly funded BRIC model, and of the various agencies linked to supporting the development of biotechnology, the South African government decided to try and further develop a unifying platform to streamline the activities of these semi-autonomous agencies. In 2009 South Africa’s Ministry of Science and Technology established the Technology Innovation Agency (TIA) unifying the activities of the main technology based enterprises in South Africa, including the BRICS, as well as the main funders of biotechnology including the Innovation Fund (Government of the Republic of South Africa, 2007; Government...
of the Republic of South Africa, 2001). The Innovation fund acts in part as a life science fund venture capital fund but is comprised of public funds. The TIA was established as an umbrella organization to improve the coordination of the biotechnology actors in South African and to ensure that local research and development is converted into commercial products and services. As such, its primary objectives are to “stimulate the development of technology-based products, services and enterprises; to develop a technology base for the South African economy; and to facilitate the development of human capital for innovation.”

Aside from the publically funded BRICS, the biotechnology strategy was further designed to create incentives for the biotechnology industry within South African. Although it involves several government departments namely the Department of Science and Technology (DST - http://www.dst.gov.za) which leads its implementation, the Department of Trade and Industry (DTI - http://www.dti.gov.za) plays a strong supporting role in the innovation and the commercialization activities of the biotechnology sector. In particular, the DTI is responsible for the Patents Act and, in 2002, through its agency the Industrial Development Corporation, contributed to the establishment of the first dedicated biotechnology venture capital fund in South Africa, Bioventures (Al-Bader, Frew et al., 2009), which provides seed funding and funding for start-up biotechnology companies. This is the only biotechnology venture capitol firm in Africa and adds to the unique landscape unfolding within the South African biotechnology sector (Cloete, Nel et al., 2006; Louët, 2006).

In addition, South Africa also has a network of universities doing research broadly speaking in biotechnology including: Tshwane University (Pretoria), The University of the Witwatersrand (Johannesburg), The University of Kwazulu-Natal (Durban), The University of Stellenbosch (Stellenbosch), The University of Cape Town (Cape Town), The University of Limpopo, University of Free state, Durban University of Tech, Rhodes University, among others. South Africa also has a network of government research institutions active in health biotechnology development. The Center for Scientific and Industrial Research (CSIR) and the Medical Research Council (MRC) are among the most prominent institutions. These bodies are able to do
basic research and develop early stage products that can subsequently be fed into the Technology Innovation Agency to be incubated, scaled, and taken to market.

Thus South Africa has developed a strong institutional and policy environment for the growth of a South African health biotechnology industry. It is well positioned to contribute knowledge targeted at diseases of the developing world and has the potential to develop niche health products for global markets, drawing on its R&D base, unique funding opportunities, and great biodiversity. However, though South Africa has moved its biotechnology policy forward significantly since its adoption in 2001 it has yet to address international collaboration in the health biotechnology sector. Although collaboration has potential to build capacity within and expand the reach of South Africa’s globalizing health biotechnology sector, South Africa has not developed specific policy instruments to structure or engage international collaborators.

2.6.3 Biotechnology Landscape in Nigeria

Following South Africa’s lead, Nigeria also formulated a biotechnology policy in 2001. Nigeria adopted a National Biotechnology Policy designed to take advantage of the potential benefits biotechnology could bring in agriculture, industry, health care delivery and environmental science. Its ambitious mission stated that Nigeria shall “as a matter of priority, initiate appropriate steps to explore the use of biotechnology for the benefit of Nigerians and thus ensure that Nigeria becomes one of the international leaders in biotechnology”. Nigeria’s government has declared biotechnology development as one of the two major priority areas in its science and technology development portfolio along with information communication technologies (ICT). As a result of creating the national biotechnology policy Nigeria set up a national agency called the ‘National Biotechnology Development Agency’ to implement the ambitious policy (Government of the Federal Republic of Nigeria, 2005).

The National Biotechnology Development Agency (NABDA) was established as an institution in 2001 and created as a parastatal of the Federal Government of Nigeria. Falling under the
Ministry of Science and Technology it has been an important actor in the implementation of the National Biotechnology Policy. Its specific goals are to coordinate, promote, and regulate all biotechnology activities in the country with a view to making available this cutting-edge technology for the promotion of a healthy environment, ensuring national food security and providing affordable health care delivery as well as the alleviation of poverty.

In 2004, the USAID gave the Nigerian government 2.1 million US dollars to develop their biotechnology sector (Raufu, 2004). This accelerated the development of policies to govern the safe use of biotechnologies in the country and assembled a National Biosafety Committee (NBC) supervised by the Federal Ministry of Environment as a regulatory body for biotechnology activities in Nigeria. The NBC drew up a biosafety framework for Nigeria, which currently is a Bill with the National Assembly. However Nigeria has yet to adopt a biosafety law that would improve the potential for biotechnology development and applications. In Nigeria this has been specifically hindered by strong opposition to the introduction of GM crops (Morris & Koch, 2002). The overall objective of the draft biosafety Bill is to provide a regulatory regime and guidance for the sustainable development of modern biotechnology, its application and safe use of GMOs and the products thereof; specifically without prejudice and risk to public health, environmental health, national sovereignty, human dignity and fundamental human rights (Morris & Koch, 2002; Zidenga, 2003). For a variety of complex reasons including ongoing resistance to GM in Nigeria as well as the political deceleration and turmoil caused by the President of Nigeria recent death the bill has yet to be completely passed and enacted into law.

In 2009 the Nigerian Minister of Science and Technology launched the Biotechnology Information Core Facility (BCIF) at the University of Ibadan, one of Nigeria leading scientific universities (Nash, 2009). The facility is a component of the National Biotechnology Development Agency (NABDA) and is playing a role in moving Nigeria towards a regionally centered strategy similar to South Africa’s system of ‘BRICs’. However it has chosen to house these biotechnology centers within prominent research universities across the country. Nigeria has well over 70 Universities, but academics and industry leaders have identified the lack of university-industry partnerships as one of the significant barriers to rolling out the biotechnology
plan (Adeoti & Adeoti, 2005). Housing these centers within research universities aims to close this gap and bridge this university-industry divide. Nigeria has made slow but steady progress in instituting its biotechnology plan but passing the biosafety bill will be an important step towards the generating future investments in the biotechnology sector as a whole.

2.6.4 Biotechnology Landscape in Kenya

Kenya developed its own biotechnology policy in 2006 and the policy has placed an early focus on prioritizing: public education and awareness, public access to information, and the formation of regional and international collaboration (Government of the Republic of Kenya, 2006). The policy charts the vision of the Kenyan government towards the development and safe application of biotechnology and provides those developing and applying the technology with a framework under which to operate. However Kenya is still in the infancy of its policy implementation in comparison to South Africa and Nigeria. The approval of the National Biotechnology Development Policy 2006 signaled the first official go-ahead for the use of biotechnology in the country (Government of the Republic of Kenya, 2006). It outlines the safety procedures for biotechnology in the context of research and development, technology transfer and the commercialization of products that would result from research undertaken in Kenya. The policy will be broad based and will cover research, development and use of biotechnology in various fields such as agriculture, environment, human health and industry.

Biotechnology policy in Kenya has largely focused on agricultural and the issues surrounding genetically modified foods. Kenya, the National Council for Science and Technology (NCST) is the government agency currently responsible for overseeing the implementation of the biosafety regulatory system. In 1998, the National Council for Science and Technology (NCST) developed the guidelines for biosafety in biotechnology. The NCST through the National Biosafety Committee (NBC) is the coordinating office on all issues related to biosafety. Kenya has developed a number of legal documents to turn its interim biosafety regulatory system into a permanent and comprehensive system. Those documents included regulations, a Biosafety Law, and a National Biotechnology and Biosafety Policy. Both the National Biotechnology and
Biosafety Policy were approved in 2006 and the Biosafety Law was passed by Government in 2008. The Biosafety Law was later signed into an Act in 2009 by the President of Kenya. This is an act that is more strongly focused on agriculture than health and it has paved the way for Kenya to undertake commercial production of genetically modified crops, placing it among a select few African nations to do so.

Kenya has also supported high quality institutions for higher education including several universities and technical institutes. The key universities pursuing biotechnology research in the country include: University of Nairobi’s Institute of Biotechnology and Bioinformatics and the College of Agriculture and Veterinary Science, Jomo Kenyatta University of Agriculture and Technology Institute of Biotechnology Research, Moi University School of Biotechnology and Agriculture, and Kenyatta University. However most are focused in line with the country’s keen interest in agriculture. Relevant government institutions that also play an important role in the new biotechnology environment in the country will include: National Council for Science and Technology, Kenya Agricultural Research Institute, National Biosafety Authority, Kenya Bureau of Standards, Kenya Industrial Property Organization and the National Environment Management Authority and the Kenya Medical Research Institute.

2.7 Summary

As one can see from the discussion above, shifting trade flows, a renewed emphasis on science and technology for Africa’s development, and increasing political support for South-South collaboration are some of the salient features that are shaping the landscape of collaboration with respect to sub-Saharan Africa and China/India. The literature and policy landscape laid out in this chapter illustrates the potential that South-South collaboration has in strengthening capacity within sub-Saharan Africa. However, there is a dearth of policy focused on promoting international collaboration; further, there is a lack of emphasis on its potential role in contributing towards the development of capacity needed in the health biotechnology sectors of African nations. The increasing political interest in promoting science and technology, along with the development of biotechnology policies in many African nations, presents an opportunity
to use international collaboration as a tool to develop the health biotechnology sectors of African countries. With continued commitment to the development of the biotechnology sectors in sub-Saharan Africa and recognition of the contributions South-South linkages may have, this study may be useful in helping to understand how collaboration can be leveraged to build increased capacity in Africa. Further it may be useful in understanding specifically what roles China, India, and sub-Saharan Africa, can play in leveraging collaboration and what policies may be needed to support its potential. The following chapter will now present the main methods used in conducting this study, and highlight some of the important methodological concepts that underpin this work.

3 CHAPTER THREE
Methods

3.1 Introduction

This study is part of a large-scale project studying South-South collaboration that is being carried out at the University of Toronto along with groups in five other developing countries. This larger study is examining collaborations in health biotechnology among 13 developing nations from the global south and this research contributes to the study by focusing on the collaborations between sub-Saharan Africa, China, and India. As discussed in Chapter 1, the goal of this particular study
is to understand the role of China and India collaboration with sub-Saharan African countries in health biotechnology. In order to address these questions a mixed methods approach was taken using both qualitative and quantitative methods. I examine three major objectives to achieve the overall study goal (see Chapter 1) and use a combination of scientometric, survey, and qualitative case study methodologies (discussed below). The first objective was to examine the extent and patterns of sub-Saharan Africa’s research and entrepreneurial collaboration with China/India. The second was to use qualitative case studies to identify how and why sub-Saharan African nations collaborate with China and India, looking specifically at the drivers, challenges, and impacts of collaboration. The third objective focused on formulating policy recommendations to help nations in sub-Saharan Africa leverage the benefits of health biotechnology collaboration with China and India.

As I have already introduced, this study uses three main methodological approaches to address these objectives and the goal of this study: scientometric analysis of co-publication, a survey of biotechnology firms, and in-depth country case studies. The scientometric analysis was used to map the extent and patterns of China and India’s research collaboration in health biotechnology with sub-Saharan Africa. To map entrepreneurial collaboration a brief survey was conducted on collaborations of health biotechnology/pharmaceutical firms in developing nations. I used this mapping data to identify where research and entrepreneurial collaborations were strongest and used it to identify which African countries had the strongest collaborative ties to both China and India. I then conducted in-depth case studies on bilateral collaborations to examine the potentials, drivers, challenges and impacts of the health biotechnology collaborations.

This chapter will describe in detail the three main methods briefly discussed above, and will break the discussion down into three sections. Section (1) will address both the scientometric and survey methods, section (2) will then describe the qualitative case study, followed by section (3) which will discuss the primary data analysis methods.
3.2 Survey and Scientometric Analysis

In order to understand the role of China and India’s collaboration with sub-Saharan African countries in health biotechnology I first conducted two scoping exercise aimed at mapping the (1) research collaborations occurring between China – sub-Saharan Africa and India – sub-Saharan Africa, and (2) mapping the entrepreneurial collaboration between China – sub-Saharan Africa and India – sub-Saharan Africa. Both scoping exercises informed the subsequent in-depth case studies and helped to determine the countries selected to be studied in further detail.

3.3 Design

3.3.1 Scientometric Analysis

To examine the extent, geographic distribution, and key characteristics of research collaboration I analysed co-publications of researchers from different low- and middle-income countries in health biotechnology and used them as a proxy for collaboration. To conduct my preliminary analysis I used the Science Citation Index Expanded (SCI-Index) to look at the patterns and levels of co-publication among all sub-Saharan African nations with India and China. Specifically in this initial analysis, research collaboration was defined as co-authored papers by researchers with addresses in either China or India and at lease one sub-Saharan African country. I defined the countries of sub-Saharan Africa using the definition applied by the World Bank which considers sub-Saharan Africa to be composed of 47 nations (World Bank, 2010). To augment this preliminary analysis and map research collaboration, our research team collaborated with members of the firm Science-Metrix (Montreal, Canada) which has specialized expertise in scientometric analysis. Universities and research institutes in developing countries in the biomedical field typically emphasize publishing in international peer-reviewed journals; therefore, examining patterns of health biotechnology publications can give valuable insights into the development of science in developing countries (Faulkner et al. 1995; Powell and Owen-
The Elsevier’s Scopus database was used for the scientometric analysis by Science-Metrix, and a subset of all papers published between 1996–2009 that fall within the field of ‘health biotechnology’ were selected. Scopus has a broad coverage of natural and social science literature, including more than 15 000 peer-reviewed journals from over 4000 international publishers (de Moya-Anegón, Chinchilla-Rodríguez et al., 2007). Scopus makes it possible to identify papers that are co-authored by researchers from institutions in different countries, by linking all the authors of papers to their institutional addresses. Only documents that were peer-reviewed prior to being accepted for publication were retained in the dataset. The document types are mainly articles, conference papers, and reviews, and will be collectively referred to as ‘papers’.

The method used by Science-Metrix to select health biotechnology papers has been developed and refined over the course of several years. Their keywords (which are proprietary) were selected using the following method: firstly, papers were randomly selected from journals specializing in biotechnology; keywords and keyword combinations were then chosen from the titles and author keywords of these papers in order to retrieve other papers in the field of biotechnology. Subsequently, a subset of papers from the biotechnology dataset was built to delineate specific areas of health biotechnology. In order to identify papers belonging to biotechnology, a classification scheme of fields and subfields from the United States National Science Foundation applied in its *Science and Engineering Indicator* was used. To limit the dataset to papers specifically in health biotechnology, only journals classified in the following subfields of science were included: biomedical research, clinical medicine, and the health sciences. Finally, keyword searches (in-title, in-author-keyword, and in-abstract) were performed to identify additional papers related to health within the biotechnology dataset.

This method in combination with the preliminary analysis was used to provide an overview of the salient linkages present between India and sub-Saharan Africa and China and sub-Saharan Africa with respect to health biotechnology. The mapping data generated using these two methods was used to identify which countries in sub-Saharan Africa had the strongest research collaborations, and later used to select which linkages to examine in more detail. It should again
be pointed out, that this analysis was used as a proxy for collaboration and was not intended to measure Africa’s total scientific or biotechnology research output, nor was it intended to provide a complete set of collaborative linkages.

3.3.2 Survey of Biotechnology Firms

To map entrepreneurial collaboration I used secondary survey data on health biotechnology collaboration among developing countries carried out as part of the larger study on South-South collaboration (Thorsteinsdóttir, Melon et al., 2010). The brief survey was sent to firms in six developing countries that have been identified as having relatively strong health biotechnology sectors, Brazil, China, Cuba, India, and South Africa. To initially identify health biotechnology firms to survey in China, India and South Africa, the results of a health biotechnology survey conducted by H. Thorsteinsdóttir et. al was used (Thorsteinsdóttir et. al, 2010). These researchers sent the survey to the chief executive officers and heads of research and development and/or partnership development of the health biotechnology firms, as well as other organizations heavily involved in entrepreneurial activities asking about their international collaboration. To encourage a good response the research rate the survey questionnaire the survey was kept brief, asking a total of 10 questions. When firms indicated they were engaged in South-South collaborations, additional information on the country and/or firm name(s) as well as the activities involved, reasons for the collaborations, output of the collaborations, who initiated the collaboration, etc. was collected.

The secondary analysis of this data focused on responses gathered only from India, China, and South Africa. The firms in these countries were asked about their linkages with all other low and middle-income countries. The survey considered South-South entrepreneurial collaboration to be any work jointly undertaken by firms and organizations in two or more low/middle-income countries that contributes to the production of knowledge, products, or services. The definition used is therefore broad, and involves all types of collaborative activity ranging from marketing to R&D. The logistics of sending the survey to all health biotechnology firms in every developing country was beyond the scope of this project. Instead, the survey was sent to a total of 467
companies in the six countries of focus and the overall response rate to the survey was 62 per cent. Additional gaps in this data, particularly with respect to Kenyan and Nigerian collaborators, were filled by conducting internet searches, consulting country directories, direct inquiries, and additional snowballing techniques employed in the field.

3.3.3 Qualitative Case Study

To understand the drivers, challenges, and impacts of the sub-Saharan Africa’s South-South collaborations with China and India, and to identify possible strategies that could be used to strengthen it, qualitative case studies were selected as a research method. The objective of this was to try to understand why and how sub-Saharan Africa countries collaborate with China and India by carrying out comparative qualitative case studies at the country level. The previous mapping data were used to identify where research and entrepreneurial collaborations were strongest and subsequently to choose which linkages to examine in more detail. This resulted in the selection of three main African countries to focus on specifically – Nigeria, Kenya, and South Africa. These nations had the strongest relative levels of collaboration with China and India (country selection discussed further below). The aim of these case studies was to learn from researchers and entrepreneurs who have had direct experience with South-South collaboration and as such, I defined six cases of bi-national collaboration to study in further detail:

1. Kenya’s collaboration with China
2. Kenya’s collaboration with India
3. Nigeria’s collaboration with China
4. Nigeria’s collaboration with India
5. South Africa’s collaboration with China
6. South Africa’s collaboration with India
These six case studies inform sub-Saharan African perspective(s) on health biotechnology collaboration with China and India. In seeking to understand the role of China and India collaboration with sub-Saharan African countries in health biotechnology development I wanted to explore the views on the potential drivers, challenges and impacts of the health biotechnology collaborations within the context of these cases.

3.3.3.1 Case Study Design

The qualitative case is a type of empirical inquiry well suited to investigate contemporary phenomena in-depth within its real-life context (Yin, 2009). It is also advantageous when the understanding of such real life phenomena occur within a context that is relevant but inseparable from the phenomena itself; one such phenomenon is South-South collaboration. This method is particularly useful when addressing ‘how’ and ‘why’ questions (Strauss & Corbin, 1990; Yin, 2009). It has been used previously to study collaboration by gathering descriptions, experiences, insights, accounts, perceptions and interpretations of collaboration from the various actors involved in this complex phenomena (Chataway, Smith et al., 2005; Oyelaran-Oyeyinka, 2005; Thorsteinsdóttir, Melon et al., 2010; Wagner, Brahmakulam et al., 2001). This method of inquiry is consistent with the standards set among scholars in qualitative research where it has become a widely accepted method of inquiry (Patton, 2002; Taylor & Bogdan, 1998).

I chose here to employ a multiple case study strategy to examine the possible differing perspectives on collaboration between Kenya, Nigeria, South Africa with China/India. To accomplish this I relied on multiple sources of data including interviews with health biotechnology researchers, entrepreneurs active in South-South collaboration, and other actors within the innovations systems of each country asking them each about their collaboration experiences. I interviewed wider actors to gain better insight into the factors that may influence South-South collaboration, including the policies and programs in place to promote it as well as the institutional, regulatory, and intellectual property regimes that impact South-South collaboration in health biotechnology (see appendix 5). The individuals interviewed included
policy makers who promote collaboration, representatives from drug regulatory agencies, and intellectual property rights experts.

Research and entrepreneurial interviewees were asked about their views on South-South collaboration in the field of health biotechnology, and about their specific collaborative projects (see appendices 3 and 4). The interviews included discussions about the reasons for collaboration; their roles in the contributions; and the projects’ impacts, etc. Furthermore, I asked questions regarding the factors and conditions that either contribute towards successful collaboration, or have been found to hinder collaborations. Representatives from governments and other relevant institutions were asked questions about the possible impacts of the collaboration, and the factors that have challenged or encouraged the collaborations’ impacts. They as well as the other interviewees were also asked about potential strategies to strengthen South-South collaboration and how its impact on improving the health of local populations could be strengthened.

3.4 Sample

3.4.1 Country Selection

Because it was not possible to investigate all 47 countries I decided to limit the scope of this study to: Kenya, Nigeria, and South Africa. The selection of Kenya, Nigeria, and South Africa from the 47 states of sub-Saharan Africa was supported by evidence that they: (1) are China and India’s most active collaborators in health biotechnology within sub-Saharan Africa, (2) differ greatly economically with South Africa representing a relatively high income African country and Nigeria and Kenya representing middle and low income African countries, (3) Together they represent one quarter of the African population and represent sub-Saharan Africa’s diverse cultural, ethnic, and social value systems, (4) represent the largest regional economies in three of the four main sub-regions in sub-Saharan Africa; namely East Africa (Kenya), West Africa (Nigeria), and Southern Africa (South Africa), (5) represent varying stages of biotechnology
policy development (6) represent varying levels of political will and commitment to science and technology as a development tool for sub-Saharan Africa.

Figure 2: Map of the study countries in Africa and their respective collaborative partners in Asia

- Within South Africa interviews were conducted in: Johannesburg, Pretoria, Durban, Cape Town, and Stellenbosch.
- Within Kenya interviews were conducted in: Nairobi and Mombassa.
- Within Nigeria interviews were conducted in: Lagos, Abuja, Zaria, Ibadan, Ile-Ife, Keffi.

These cities were identified as having the highest density of researchers and firms in collaboration with China and India. Not surprisingly they represent the main urban centers of these African countries where a majority of the government, public research institutions, universities and firms are located.

The study focused only on the sub-Saharan Africa perspective of collaboration with China and India and as such I did not conduct interviews in China or India. Though it was not within the
scope of this study, it would be of interest to pursue this research further using the same methods in China and India to explore their perspectives on the issue of their health biotechnology collaboration with sub-Saharan Africa. Time and budget considerations were a main factor in choosing to focus specifically on sub-Saharan African perspectives.

3.4.2 Identification of Participants

I targeted three specific groups of participants for this study namely: researchers, firms, and policy makers who play a supporting role in international collaboration. I will describe below the procedure of selection for each group however all were conducted using purposive and snowball sampling. Our sample of researchers, firms and key informants make up our total sample of interviewees and are not meant to be a representative sample. Purposive sampling techniques select participants strategically based on the criteria set out by the study (discussed below) in combination with their degree of knowledge with respect to the issues being investigated. The main objective of this type of method is to ‘focus on selecting information-rich cases whose expertise will illuminate the questions under study’ (Creswell, 2009).

In addition to the purposeful sampling technique I relied on snowball sampling to select researchers, firms, and key informants. I identified as many possible individuals who met the inclusion criteria (see below) and further asked them to recommend others who either had first hand experience in collaborating with China or India or had relevant expertise on such collaborations. This method was extremely useful within the African/developing country context as it allowed us to identify additional researchers, firms, and key informants that were not identifiable through purposive sampling.

3.4.3 Selection of Researchers

The research cases were selected from the co-publication data and I focused on China and India’s health biotechnology collaborations with Kenya, Nigeria, and South Africa individually. I used the previous scientometric analysis that identified co-publications between the 47 sub-
Saharan African countries and China/India. I found out which countries were the main collaborators with China and India chose to focus our study on the top three countries in (see country selection) and then identified all the papers that were co-published in health biotechnology between Kenya-China/India; Nigeria –China/India; and South Africa-China/India. I then examined each paper individually to gather more information about the nature of research and collaboration that took place. Finally I prioritized the papers based on a set of selection criteria developed to identify collaborations that would provide the most in-depth information. Researchers selected for participation in this study needed to be currently involved in collaboration, or have had relatively recent collaboration, with India or China in the field of health biotechnology as indicated by their publications.

Research selection criteria:

(1) Papers must have been published between 1995-2009
(2) The collaborating pair had to have addresses in one of either: Nigeria, Kenya, South Africa, and one of either China or India.
(3) Preference was given to researchers with collaborations that involved the output of more than one publication
(4) Preference was given to researchers who published papers that did not involve additional authors from developed countries

Once selected the researches identified were contacted by email and invited to participate. The email (see appendix 2) introduced to them the purpose and aims of the study highlighting the joint publications that I had identified them as collaborators on. I informed them that their participation would involve meeting with us for approximately 60 minutes to share their thoughts and insights with regards to South Africa/Kenya/Nigeria’s collaboration with China and/or India. I informed them that I wanted to consult with them to better understand the complex conditions that shape such international collaborative initiatives and what factors encourage them to be effective. I also attached a one page description of our study (see appendix 1) and directed them
to the McLaughlin-Rotman Center for Global Health’s (MRC) website for specific information regarding our research group. If they agreed, I proceeded to set up a mutually convenient time to meet them in their respective countries, at their offices.

3.4.4 Selection of Firms

Data from the survey on health biotechnology collaboration of developing countries (Thorsteinsdóttir, Melon et al., 2010) was used as a starting point to select potential firms for an interview. The survey data was followed up with inquiries to ensure these firms were still operating and had correctly identified themselves as having collaboration with China or India. However, because the survey data only included responses from China, India, and South Africa additional scoping in the field was necessary to identify firms in these countries with unreported collaborations. To address this I conducted internet searches, consulted industry specific databases, made informal inquiries with companies, and with people holding country specific knowledge related to the biotechnology industry. I further relied heavily on the recommendations of CEO’s and industry experts in Nigeria and Kenya to identify additional local firms I had missed that may be involved in health biotechnology collaboration with China and India. Because the relative size of the biotechnology sectors in Kenya and Nigeria was small I was able to identify with a high level of certainly the firms involved in collaboration with China and India.

The firms were selected for participation in this study must have had or be currently involved in collaboration with either India or China; and were prioritized based on the following selection criteria.

*Entrepreneurial selection criteria:*

(1) Firms that were involved in innovation, production, or distribution of products preferentially relevant to the disease profile of their counties

(2) Firms could be either locally or foreign owned but must have a physical presence within the study country
Multinational firms were excluded from this study

Once selected the firms that were identified were contacted by email or phone and invited to participate. Contact was directed to the upper management (CEOs) of the firms as they are best positioned to discuss their firm’s entrepreneurial activities holistically. The email introduced to them the purpose and aims of the study highlighting that their participation would involve meeting with us for approximately 60 minutes to share their thoughts and insights with regards to South Africa/Kenya/Nigeria’s collaboration with China and/or India. They were further informed that I wanted to gain a deeper understanding of their personal experiences and consult with them about any programs or policies that could strengthen such collaboration and asked if they would like to participate. In addition, a one page project description was attached to describe the study and they were directed to the MRC website for any additional information regarding our research group. If they agreed I proceeded to email or telephone them to set up a mutually convenient appointment for us to meet in their offices.

3.4.5 Selection of Wider Actors

I identified national stakeholders including: policy makers, directors of R&D institutes, regulatory agency representatives, patent experts, etc. with knowledge of the health biotechnology environment in Kenya, Nigeria, or South Africa. Stakeholders were identified to be those who are directly involved in the health biotechnology innovation systems of each of the respective countries. These wider actors needed to be current or former employees of the government or national organization involved in health biotechnology development, national science policy, intellectual property, medical research, regulatory affairs, or any other body deemed relevant to the study. Background searches were conducted on the major organizations in each country listed above and potential interview candidates were identified. I also relied heavily on the recommendations of researchers, firms, and other experts in the field to supplement and broaden the wider actors identified. It was especially important to snowball sample when identifying the wider actors within each country, as researchers, firms, and others
involved in the health biotechnology sector have practical experience engaging with important actors of their respective innovation systems.

Once identified, I contacted the experts by phone or email and invited them to participate. An email was sent to introduce them to the purpose and aims of the study. I requested their participation involve a meeting with us for approximately 60 minutes to share their thoughts and insights with regards to South Africa/Kenya/Nigeria’s collaboration with China and/or India. I further informed them that I wanted to gain a deeper understanding of their personal experiences and consult with them about any programs or policies that could strengthen such collaboration and asked if they would like to participate. If they agreed I proceeded to set up a mutually convenient appointment for us to meet in their office.

### 3.5 Data Collection Methodology

Data was collected over a period of 4 months from January 2009 to April 2009. There were three main sources of information for this study (1) Semi-structured interviews (2) Key documents (3) Investigator observation.

#### (1) Semi-structured interviews

All interviews with researchers, entrepreneurs, and key informants were done face-to-face and took place in their offices (with the exception of one that was conducted over the phone). Interviews followed a semi-structured format. This format utilizes an interview guide that is composed of open ended questions and follow-up questions that cover a specific range of topics related to research collaboration. The guide allowed the interviewer flexibility to cover questions in any order, and allowed for additional questions to be posed during the interview. The interview guide was developed by Dr. Halla Thorsteinsdóttir and members of the research team as a standard tool to be used in all 13 study countries part of the large scale study on South-South
collaboration. There were separate interview guides developed for interviewing entrepreneurs, researchers, and wider actors, and each set of guides was adapted slightly were necessary for each country (See interview guides in Appendix 3-5). In addition the guides used to interview wider actors were adapted slightly depending on the background of the individual (i.e. embassy officials, regulatory officials, patent experts etc.) Interviews were lead by one of two investigators either Dr. Halla Thorsteinsdóttir or Andrew Kapoor. All interviews with researchers were conducted in English, tape recorded, and were approximately one hour in duration.

A total of 63 interviews were conducted and a total of 93 people were interviewed. Figure 3 shows the breakdown of interviews both by type and by country. In some cases more than one person was interviewed at the same time in group interview fashion. This encouraged debate and deliberation among the interviewees and increased the validity of the data being collected.

<table>
<thead>
<tr>
<th>Countries</th>
<th>Number of Interviewees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kenya</td>
<td>26</td>
</tr>
<tr>
<td>Nigeria</td>
<td>34</td>
</tr>
<tr>
<td>South Africa</td>
<td>33</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>93</strong></td>
</tr>
</tbody>
</table>

Table 1: Total number of interview participants by country
(2) Key documents

Policy documents, institutional profiles, web-site descriptions, annual reports, press releases, financial reports, biographical information and other news articles were collected and analyzed. Additional documents were collected during the interviews (such as institutional reports, annual reports, publications, programmatic brochures etc.) and were voluntary given to the investigators.

(3) Investigator observation

Field notes were taken in addition to the tape recorded interviews that noted important aspects of the interviews and additional observations such as the equipment and condition of research labs, physical appearance and infrastructure supporting firms, behavioral attributes of the interviewees, and other nuances not captured through audio recording. After each interview the investigators discussed the salient features of the interview and noted additional observations that may have been missed.
3.6 Data Analysis

This study takes both a quantitative and qualitative approach to the analysis of our data. The focus of the data analysis phase was to gather salient themes from the dataset. Specific areas of analytic interest were the: drivers, challenges, and impacts of sub-Saharan Africa’s collaboration with China and India. I used the emergent themes to support my understanding of the role China and India play in using collaboration with sub-Saharan African countries to further health biotechnology development on the African continent. Where relevant the themes were crosschecked using the results from the mapping exercises discussed above. The analysis described here was also used to create a foundation upon which policy recommendations could be developed.

3.7 Data Analysis Methodology

The analysis of the data from this was assisted by the qualitative data analysis software ATLAS.ti. The program provides tools that enhance the researcher’s ability to code, group, and annotate findings in the primary data. It further allows for analysis of the importance of the codes and the relationships between them. Additional coding and grouping was done manually however both processes follow the same methods of thematic analysis which can be broken down into three main stages (1) immersion, (2) data coding, and (3) theme formulation.

The general approach of thematic analysis was taken to identify, analyze and reporting patterns and themes within my data set. It involves the creation and application of ‘codes’ to data which are organized into emerging themes (Ryan & Bernard, 2003). The data analyzed took a number of forms: interview transcripts, field notes and policy documents. The interviews and other documents were processed using the software that allows putting notes and coding the transcribed audio files. A first round of coding identified chunks of data that related to a theme or
idea (called ‘open coding’ or ‘coding’) (Ryan & Bernard, 2000). I then organize similar themes into conceptual categories (called ‘axial coding’ or ‘super codes’). Last, I looked for an emergent core concept or central themes considering the relationships between the super codes (and codes) indicating not only frequency but groundedness. I have categorized the process of thematic analysis broadly into three main stages discussed above and provide more detail about my specific use of them below.

(1) **Immersion** - The stage of analysis overlaps with the data collection phase when you are collecting and reading documents, conducting interviews and beginning to think familiarize yourself with the information being amassed. The object of immersion is to become familiar with the depth and breadth of your data set and familiarize yourself with the raw data you have collected. The process involved: reading field notes, listening to audio files of interviews, transcription of interviews, reading and re-reading transcripts, reviewing key documents, noting down initial ideas about the data (Ryan & Bernard, 2000; Taylor & Bogdan, 1998). This step allows you to be familiar with the entire data set and leads you to begin the formulation of codes and your preliminary analysis.

(2) **Data coding** – this is the initial stage of coding where you code broadly using some of the predefined codes developed (i.e. ‘Equipment’, ‘Funding’, ‘collaboration programs’) and develop news ones as you move through the data set (Taylor & Bogdan, 1998). It forms the initial classification and labeling of concepts or ideas that are emerging from your data. The data is broken down into ‘chunks’ that relate to a specific concept and are then collected into a ‘code’ which represents the concept. This was done with the help of the ATLAS.Ti program as mentioned above. Additional coding was also done manually with transcripts and other key documents and pooled together to produce a composite of key concepts.

(3) **Theme formulation** – this stage assembles concepts into broader theme categories and make links between the concepts that open coding had identified. The main objective of this stage is to
start to analyze your codes and consider how they combine to form an overarching theme (Ryan & Bernard, 2003). The main themes that resulted at this stage of analysis were: Entrepreneurial Challenges, Entrepreneurial Drivers, Entrepreneurial Impacts, Research Challenges, Research Drivers, Research Impacts, Policy recommendations. These themes presented categorizations that addressed different aspects of our initial research question and had clear and identifiable distinctions between them that each supported the research aims or objectives. This stage incorporates back and forth between the interviews, concepts from the coded data and other key documents to ensure that the themes were distinct and were exclusive of conflicting information (i.e. conflicts between interview data and other sources) (Ryan & Bernard, 2003).

3.8 Validity of Research

Validity and reliability are a concern when conducting both quantitative and qualitative research. However often qualitative work is subject to criticism with respect to its validity and this issue has been discussed by many authors (Creswell, 2009; Patton, 2002; Strauss & Corbin, 1990; Taylor & Bogdan, 1998). When conducting case study research it is necessary to judge the quality of both the research process and the quality of the product (narrative) (Morse & Field, 1995). Good quality research means that the findings are reliable and the qualitative method used to answer the research question is appropriate (Mays & Pope, 2000).

Validity is taken to mean ‘the determination of whether a measurement instrument actually measures what it is purported to measure’ (LoBiondo-Wood & Haber, 1998), or ‘the degree to which an instrument measures what it is intended to measure’ (Polit & Hungler 1995). It is therefore an important construct to ensure that the results of the study are not those imposed by the researcher but reflect the realities narrated by the data (interviews, policy documents, etc.). Aside from careful selection of the methods and attention to the design of the research project there are four key approaches that I have applied to ensure the validity of the research findings these include: triangulation of data; members check; reflexivity; repeatability of methods.
3.8.1 Data Triangulation

This is a powerful method to reduce bias and have specifically used this technique in 3 ways: Data triangulation, investigator triangulation and methodological triangulation.

Data triangulation: I used multiple sources of data collection in this study, each with intrinsic strengths and weaknesses which I collectively analyzed to reduce the effect of any bias. The data was collected from three main sources as mentioned above: Interviews, key documents and observation. Within the set of data collected from interviews triangulation was also employed. I selected three distinct groups of interview participants each of which alone may have presented a serious bias (especially with respect to the firm collaboration data). Interview data was triangulated with the other two groups of informants in each country and the scientometric data so as to ensure the information collected was as unbiased as possible.

Investigator triangulation: there were multiple researchers involved in the data collection thus reducing the bias that may have been presented by one researcher alone (Patton, 2002). Interviews and collection of data were conducted by more than one interviewer and observer.

Methodological triangulation: I used more than one method to gather our data. Primarily I used a survey, scientometrics and case studies. This use of both primary and secondary data; as well as qualitative and qualitative data work to enhance the validity of this research study.

3.8.2 Members Check

Sections of text being prepared from this research for publication, which directly referred to specific collaborations, were sent so participants for verification. The verification was both a fact checking exercise and verification of the resulting key messages and themes. This process of informant feedback helps to validate the interpretation of the data set to ensure that it is
consistent with the realities as reported by interviewees. The feedback from interviewees is then taken into account and used to reshape the final analysis ensuring there are no discrepancies between the realities of sub-Saharan Africa’s collaboration with China and India and our interpretations.

3.8.3 Reflexivity

“Reflexivity requires an awareness of the researcher's contribution to the construction of meanings throughout the research process, and an acknowledgment of the impossibility of remaining 'outside of' one's subject matter while conducting research." (Nightingale and Cromby, 1999). As I have spent a significant amount of time working in Africa I was particularly cognizant of personal biases that could potentially influence this work. My experience in Africa has shaped my ideas about the relative levels of development found across Africa, my personal research interests, and influenced my political and historical knowledge of many African nations. Particularly, working at a community level could have potentially influenced my perceptions about government policies and their potential impacts. Although this previous experience is advantageous, I took several measures to ensure it did not influence the way this research was conducted or influence the findings of this research.

During the research process members of the research team were involved in preparing the interview materials, devising the questions, interviewing participants, and in the interpretation of data. Given this work was a part of a larger study on South-South collaboration the perspective and insights of the wider research team were able to help to inform the major themes and provided clarity of the themes as they emerged from during the data analysis and helped me avoid introducing any biases previously held because of my work in Africa. The members of my program advisory committee (PAC) also helped in shaping the interpretation of the findings. Utilizing this consultative process has been critical in avoiding single researcher bias that may be created by having one person involved in the process of data collection and interpretation. Triangulation as mentioned earlier in this section was also an important mechanism by which reflexivity was enhanced. Using multiple sources of data and having multiple individuals involved during each phase of this research project has allowed me to strengthen the objectivity and reflexivity of this work.
3.8.4 Reliability of Sampling Methods

I selected a diverse range of people from several areas of the health biotechnology sector who were knowledgeable or participated in collaboration with China or India. This provided us with contrasting and converging views. I feel that it is representative of the scope of health biotechnology collaboration in sub-Saharan Africa especially because our study recruited the views of policy makers, firms, and researchers in contrast to any previous work which has exclusively focused on the views of a single group.

The process of conducting this research was rigorously documented and communication, transcripts, field notes have been compiled and archived. Though it is impossible to repeat the sample exactly as I have done; our systematic approach (which is repeatable) should yield the same/similar results if it was repeated within a reasonable time frame. I am confident our methods captured the salient themes through the careful selection procedures; I am also confident that I reached saturation as evidenced by the repeated messages during the final phase of the interview process in each country and the overall large number of interviewees.

3.9 Methodological Weaknesses

The methods of this study were carefully selected for their appropriateness in addressing and answering our research questions. However there are several weaknesses and cautions that should be considered when considering the results of this study.

3.9.1 Time and place

This data is reflective of the time period I conducted our interviews and it expresses the opinions of the interviews not necessarily any one individual, institution or nation. However it is meant to capture and understand the collective views of all participants. The data was collected over a
period of 4 months in Kenya, Nigeria and South Africa and is subject to the influence of the time and context of these countries at the particular stage of data collection.

Use of co-publication data: It should be noted that although co-publication data was used, it was not used to assess the absolute amount of collaboration. It was rather used as a tool to identify the trends, key nations, and best cases of collaboration. Using this method and the Scopus database has limitations. The Scopus database is more likely to include journals that are published in English and by those in developed countries. This may result in the absence of some publications from appearing in the results of Scopus Database searches. However, the database is more likely to find higher impact papers and thus direct attention to more successful cases of collaboration. It is also worthy to mention that the Scopus Database has greatly improved its coverage of journals published in developing countries over the past five years.

3.9.2 Limitations of Qualitative Case Study Method

Rigor has been a main point of contention among the critics of this type of research. In the past people have not applied a sound methodical approach and as a result have been careless in conducting case studies lending it a reputation for being biased. However, there is a renewed thrust in academics for the value of well designed case study research in providing answers to ‘How?’ and ‘Why?’ questions, and in this role can be used for exploratory, descriptive or explanatory research (Yin, 2009). I have aimed to minimize bias though careful design and execution of this studies methods, data collection procedures, and analytical methods ensuring sound reasoning behind each step of the research design and implementation process. A second main criticism of the case study method has been that there is little basis for generalization. For example “how can you generalize from specific cases/single case?”. This question is best answered by conducting multiple case studies as I have done to try and broaden the scope of information collected. In addition, because of the relatively few cases of collaboration, I was able to speak with a large proportion of the potential cases helping decrease the abstractness of generalization. I also aimed to make broad policy recommendations based on strong recurrent themes present across the entire data set.
3.10 Research Ethics

Our research project involved the use of human subjects by way of their participation in an interview with a researcher(s) from the University of Toronto. This project was approved by the Research Ethics Board at the University of Toronto and classified as low risk. Due to the minimal risk associated with this study the project obtained expedited review. The following sections will outline the ethical considerations undertaken with this study including: consent procedures, confidentiality and anonymity, risks and benefits, and conflicts of interest.

3.10.1 Consent Procedures

Informed consent was obtained from all the participants prior to engaging them in an interview. Participants were asked to sign a consent form which was given to them with the study summary (Appendix 7). It outlined what the purpose of the study was and covered important aspects of our ethical commitment to the participants. The interview participants were assured both verbally and in writing that: quotes or opinions provided during the interview would only be used in academic publications or public presentations after obtaining permission; that they will not benefit from participating in the study but are freely contributing to knowledge on international collaboration; that they are free to refrain from answering any question posed to them; and that they are free to withdraw from the study at any time.

Written informed consent was the preferred method of consent but was not always possible or culturally acceptable. Some interviewees felt uncomfortable signing a consent form and speaking on behalf of the organization, in these cases I allowed interviewees to sign on behalf of themselves rather than the organization. In the cases where written consent was not possible to obtain I sought verbal consent (audiotaped) as an acceptable alternative as I felt that this did not compromise or wave any of the participant’s rights. Participants were also asked if they felt comfortable having the interview digitally recorded and were free to decline if they did not.
3.10.2 Confidentiality and Anonymity

As outlined above the participants received a package summarizing the purpose of the study and a consent form reminding them of their rights as a participant and seeking their permission to be included in the study. Interviews were transcribed with few identifying features and are stored in digital form under password protection. No individuals or institutions have been cited without seeking the direct permission of those involved. All instances where a quotation has been used the information has been verified by the individual and authorization for use has been obtained. The information package made it clear that any information gathered could be used for publication, presentations, or by the research group. Firm’s were assured that the integrity of their intellectual property, trade secrets or proprietary knowledge would not be published and if their firm were to be mentioned in any publication they would be contacted to ensure the information was safe for public disclosure.

3.10.3 Risks and Benefits

Though no study poses a ‘zero’ risk to the participants, this study carries a very low risk factor. The only potential risk identified was that of the accidental disclosure of proprietary knowledge to the investigators. However it was made explicit in the consent procedure that such knowledge would never be disclosed and request would be sought before any information would be published regarding the information they had disclosed. It was made explicit in the consent procedures that no monetary or other personal benefits would result from this study.

3.10.4 Data Storage

The data from this project was collected and stored in two separate locations. Copies of this data were stored on the primary investigators computer and an external hard drive both under password protection. The data was never compromised and all efforts were made to ensure it was only accessible to the investigators.
3.10.5 Conflicts of Interest

The investigators have no conflicts of interest to report. The following chapter will now present the main findings stemming from this research study. It will focus on presenting the drivers, challenges and impacts of sub-Saharan Africa’s South-South collaboration with China and India.
4 CHAPTER FOUR

Results

4.1 Introduction

This chapter presents the results of data collected to examine China and India’s role in collaboration with sub-Saharan African countries in health biotechnology development on the African continent. This study relies on the data obtained from three different sources, a scientometric analysis of co-publication, a survey of health biotechnology firms, and qualitative case studies that rely heavily on interview data.

This chapter will begin by presenting the results of the scientometric and survey data that map sub-Saharan Africa main research and entrepreneurial linkages with China/India in health biotechnology. It will then put forth the findings from the case study research which is organized into three major themes that support the objective of this study: (1) the drivers of collaboration, (2) the challenges of collaboration, and (3) the impacts of collaboration.
4.2 Mapping Collaboration: The Geography of Sub-Saharan Africa’s Health Biotechnology Collaboration with China and India

4.2.1 Mapping Research Collaboration

To examine sub-Saharan Africa’s levels and distribution of South-South collaboration in health biotechnology, I mapped its research collaboration with China and India, and identified papers co-authored by researchers from China and India with researchers from sub-Saharan Africa between 1996 and 2009 (see Chapter 3 for details of the methodology). I identified a total of 538 papers co-authored by researchers from one of the 47 nations in sub-Saharan Africa, and researchers in China or India from the SCOPUS database between 1996 and 2009. Both China and India had similar levels of collaboration with sub-Saharan Africa; the data showed that China co-authored 280 papers with sub-Saharan Africa while India co-authored 258 papers. The top five sub-Saharan Africa countries with the largest numbers of co-publications were the same for China and India. These were South Africa, Nigeria, Kenya, Tanzania and Cameroon respectively (Figure 3). More than 50% of these co-publications have occurred between 2005 and 2008, demonstrating the increase in collaboration between sub-Saharan Africa, China and India over the last five years.

I also saw that when looking at all the joint publications between sub-Saharan Africa and both China and India, collaboration with the top five sub-Saharan Africa countries accounts for one-third of all joint research publications of these countries with Africa. When considering China’s joint publication record with other low- and middle- income countries in health biotechnology over the period from 1996 to 2009, I saw that collaboration with sub-Saharan Africa accounts for 23% of the total. When considering India’s collaboration in the same manner I saw sub-Saharan Africa accounting for approximately 30% of all India’s collaborations with low and middle countries.
Figure 3. The main countries China and India collaborate with in health biotechnology research in sub-Saharan Africa, based on the number of co-authored papers between 1996-2009.

The data shows that China and India have published more with South Africa than any other country in sub-Saharan Africa. Considering that South Africa is the strongest African country in health biotechnology and has the highest publication rate of all African countries (Boshoff, 2009; Jeenah & Pouris, 2008), this is not a surprising result. South African researchers published a total of 104 joint research papers in health biotechnology with Indian and Chinese scientists between 1996 and 2009, Nigerian researchers published 42 joint papers and Kenyan researchers published only 15 joint papers with India and China over the same time period. There does not seem to be much difference in the extent or distribution of China’s versus India’s co-publications with Africa, except China seems to publish slightly more health biotechnology papers with South Africa than India does.
The three sub-Saharan Africa countries differ somewhat in their more general South-South collaboration patterns. Nigeria’s and South Africa’s main Southern collaborators are China and India, in addition to Brazil in the case of South Africa and South Africa in the case of Nigeria. But Kenya’s main Southern collaborators are other African countries, South Africa, Tanzania and Uganda. Kenya’s level of South-South collaboration in the health biotechnology sector is, however, so low that this pattern can easily change with increased collaborative efforts with another Southern country. Kenya places a relatively heavy emphasis on collaboration in health biotechnology with Northern countries with 78% of its international collaboration with the North and 22% of its collaboration with other Southern counties. South Africa does that as well with 84% of its papers in collaboration with developed countries versus 16% of its papers in South-South collaboration. In comparison Nigeria has 66% of its collaboration with the North versus 34% of its collaboration with Southern countries.

For all three countries the most common subfield of health biotechnology for South-South collaboration was Genetics & Heredity. This is the same subfield of health biotechnology that has the heaviest South-South collaboration in general. The second most common subfield differed and was Virology for South Africa, potentially reflecting the high level of the country’s South-South collaboration in HIV/AIDS research (Thorsteinsdóttir et al in press). For Kenya the second most common subfield was Parasitology and for Nigeria it was Biomedical Engineering. Tropical Medicine was a relatively common subfield for South-South collaboration for Nigeria and Kenya, in third and fourth place respectively but was only in seventh place for South Africa.

4.2.2 Mapping Entrepreneurial Collaboration

In order to examine the extent of entrepreneurial collaborations between sub-Saharan Africa and China and India secondary data was used from a survey administered to all Indian, Chinese and South African firms that our research group could identify as being involved in health biotechnology activities. These firms were asked about their collaborations with all low and middle income countries (see detailed methodology in chapter 3). This data was supplemented with additional research, inquiries, and with scoping in the field to capture any collaboration that
may have missed with the survey data. I presented the firms with a broad definition of collaboration, as including any work contributing to the production or commercialization of knowledge, products, or services in health biotechnology jointly undertaken by firms/organizations in China and India. I followed up the survey with inquiries with expert and scoping in the field to capture an expanded breadth of firms. I identified a total of 37 firm level linkages between the three sub-Saharan Africa countries of study, with China and India (Figure 4). The firm survey data showed 9 entrepreneurial linkages between sub-Saharan Africa and China in health biotechnology, as compared to 28 firm linkages identified with India. The survey showed that the greatest number of collaborations occurred between South Africa and India, with a total of 12, followed closely by India-Nigeria linkages at 10. There were fewer linkages with China; South Africa, for example, only had four firm linkages one-third the number of linkages seen with India. According to our survey, most of the collaborative activities with China and India were focused almost exclusively on marketing, sales and distribution, with the exception of two South African firms who described joint R&D activity with India, and one which had collaboration with China.

**Figure 4:** Entrepreneurial collaborations in health biotechnology between the most active countries in sub-Saharan Africa and China and India
From this mapping I see two noteworthy trends. First, it is clear that both China and India are collaborating both in research and entrepreneurial activities with the same countries in sub-Saharan Africa: Kenya, Nigeria, and South Africa. Secondly, when it comes to research collaboration, China and India’s levels of collaboration seems to be on par, whereas India is evidently more actively collaborating in entrepreneurial collaboration. However, it would be interesting to see how these trends change over time.

4.3 Case Studies on Research Collaboration

To gain a better understanding of sub-Saharan Africa’s collaborations in health biotechnology, I conducted six cases of bi-national collaboration interviewing researchers in Kenya, Nigeria and South Africa about their collaboration with China and India. These six cases included (1) Kenya’s collaboration with China; (2) Kenya’s collaboration with India; (3) Nigeria’s collaboration with China; (4) Nigeria’s collaboration with India; (5) South Africa’s collaboration with China; and (6) South Africa’s collaboration with India. All three sub-Saharan Africa countries have leading medical research institutes and universities with a degree of research output. In Kenya, the University of Nairobi (Nairobi, Kenya), as well as the Kenyan Medical Research Institute (KEMRI, Nairobi, Kenya) are the country’s leading institutions responsible for the production of health related research in Kenya. Nigeria also has a network of research-focused universities (over 70) such as the University of Ibadan (Ibadan, Nigeria), the University of Lagos (Lagos, Nigeria), and Obafemi Awolowo University (Ile-Ife, Nigeria) in addition to national institutes such as the Nigerian Institute for Pharmaceutical Research and Development (NIPRID, Abuja, Nigeria). NIPRID has had previous success with the development and commercialization of novel health products from traditional knowledge, one such example being Niprisan, a novel sickle cell anaemia drug (Wambebe, 2007). Both the institutions in Kenya and Nigeria have established collaborations with a number of leading institutions in India and China such as: the Council of Scientific and Industrial Research (New Delhi, India), several universities, such as the University of Lucknow (Lucknow, India) and Zhejiang University (Huangzou, China), as well as government ministries such as China’s Ministry of Science and Technology (Beijing, China). Not surprisingly, South Africa has by far the largest and most internationally competitive network of biomedical research institutes, the Medical Research
Council of South Africa (Cape Town, South Africa), Center for the AIDS program of Research in South Africa (Durban, South Africa), the Council for Scientific and Industrial Research (Pretoria, South Africa) and leading universities like the University of Cape Town and the University of the Witwatersrand (Johannesburg, South Africa). These institutions have established scientific collaborations across the globe including strong links with China and India.

4.3.1 Drivers of Research Collaboration

As Africa is such a large and heterogeneous continent socially, culturally and economically, I expected the motivations for engaging in collaboration with China and India would vary. Indeed, factors motivating the research collaborations I studied were diverse and varied by country. However, some of the more salient reasons for the research collaboration between sub-Saharan Africa and China and India that our interviewees stressed include:

4.3.1.1 The need to test samples and access appropriate technologies

Researchers in sub-Saharan Africa emphasized the need to fill gaps in their research created by an absence of specialized knowledge and equipment through exchange of samples and consultation with researchers in China and India. For example, they expressed the need to send samples for chemical testing to China and India. These included samples such as plant isolates, synthetic compounds they had developed, or other biological agents that needed further analysis. Several researchers at Universities and public institutions in South Africa, Nigeria and Kenya had established these types of collaborations with scientists at the Council of Scientific and Industrial Research in India, citing them as critical to the advancement of their work. These collaborations are mainly in the area of synthetic chemistry, working to increase the activity of isolates identified from traditional African plant extracts. South African researchers have also begun to collaborate with China, sending compounds they have developed to be tested specifically in animal models. The main reason for the need to send samples to China and India was the dearth of high technology scientific equipment in sub-Saharan Africa, particularly in
Kenya and Nigeria. Many expressed a need to gain access to equipment such as nuclear magnetic resonance (NMR) and high performance liquid chromatography (HPLC) machines which are critical in the identification of basic compounds, synthetic chemistry, and drug development. One Nigerian researcher emphasized this motivation for sending samples abroad and said “my samples are being tested in an Indian lab for diabetes, it’s much cheaper than conducting the same experiment here...there are so many more institutions (in India) that do animal work it’s much easier (there) because here we have to write many applications and it’s very expensive”.

Although the nature of the technology and sample exchanges varied by country in sub-Saharan Africa; researchers viewed both China and India as equally suitable collaborators.

4.3.1.2 Access to training and capacity-building opportunities

Another critical motivator for researchers in sub-Saharan Africa to pursue collaboration was the opportunity for research personnel from sub-Saharan Africa to visit institutions in China and India for training and capacity-building. Researchers said that the ability to travel to China and India and gain exposure to new information, research strategies, complementary expertise, pool resources, and seek scientific advice was necessary to the advancement of their research projects. They noted that participating in such exchanges particularly with China and India provided a familiar scientific landscape which helped translate directly into a rich educational experience. Sub-Saharan Africa scientists found counterparts in China and India working on projects more closely aligned with their work in communicable diseases (HIV, TB, and Malaria) as well as areas of traditional herbal medicines. Researchers felt these types of expertise were more relevant than the expertise they gained through collaboration with Northern countries: as many of the techniques and strategies had been developed in a resource constrained environment, rather then adapted to a developing context. One researcher commented that

“It appears in the western world the focus is different. I would rather, in fact, send a student of mine to India to [a] lab to go and learn some basic things or to evaluate some similar things rather than send student to the US where perhaps we may be rather talking at some very high molecular level, which, I believe, is not the thing that is needed in this environment.”
Many researchers emphasized that working with China and India where scientists understood the challenges of conducting research in the developing world but had also amassed a wealth of expertise and knowledge in health biotechnology was an important motivation for pursuing South-South collaboration.

Interviewees also highlighted the role the Chinese government has been playing in providing educational opportunities to young African students, particularly from the less-developed African states. The Chinese Scholarship Council offers scholarships to both Chinese citizens wishing to study abroad and to foreign citizens wishing to study in China, with a particular focus on educational, scientific and technological exchanges. In 2007 it provided 2733 scholarships to African students, comprising almost one third (27%) of the total number of scholarships granted worldwide, the vast majority of which are granted in science, engineering and medicine. Africa received the second largest number of scholarships globally, second only to Asia itself (Government of the Peoples Republic of China, 2007; M. Hassan, 2007a). Many South African universities such as the University of the Witswatersrand, University of Pretoria (Pretoria, South Africa), and the University of Cape Town have received Chinese students studying on the Chinese Government scholarships. This has created a bidirectional exchange whereby Chinese students are also benefiting from programs at leading African Institutions. African researchers noted the high proportion of students who return to sub-Saharan Africa after furthering their education in these countries as compared to those who travel to the west. One university researcher stated “The future is very bright because if you see the number of students that are going to China and India, that would give you an idea that the future is bright for Africa” emphasizing that they may be playing a larger capacity-building role in the sub-Saharan Africa research context.

According to our interviewees, organizations such as the Academy of Sciences for the Developing World (TWAS) have also been key promoters of research exchanges. They have dedicated funds to facilitate both scientific and educational exchanges, which have benefited many scientists, particularly in Nigeria and Kenya. These programs have helped scientists across sub-Saharan Africa advance their work in Chinese and Indian labs in acquiring new skills and
techniques, building capacity, and gaining international experience. The International Center for Genetic Engineering and Biotechnology (ICGEB) has begun to play a similar role in South Africa since setting up a branch in Cape Town to complement its New Delhi, India and Trieste, Italy offices. When comparing China and India, it is apparent that China has been significantly more active than India in providing educational opportunities; whereas India seems to be more focused on providing opportunities for visiting research fellows and professional exchanges. However, in both cases it is clear that third-party organizations such as TWAS and ICGEB play a key role in brokering collaboration.

4.3.1.3 Advancement and exchange in traditional herbal medicine

Several researchers in sub-Saharan Africa expressed interest in the development of traditional herbal medicines, and I identified many scientists carrying out collaborative work in this area. Researchers in all three sub-Saharan Africa countries cited the economic benefits that could be realized through the licensing and commercialization of compounds screened for drug development in India or China. However, interviewees also emphasized that although sub-Saharan Africa has a strong culture of traditional medicine; it remains informal and lacks the scientific grounding needed to exploit its potential value. Researchers in sub-Saharan Africa identified India particularly as a key partner in helping African scientists build the scientific base for a traditional medicines industry. Scientists underscored that collaboration with Indian scientists and institutions and to a lesser extent the Chinese, has built capacity and advanced African knowledge and expertise in this area.
The Nigerian Institute for Pharmaceutical Research and Development has maintained longstanding collaborations with herbal scientists at India’s Council of Scientific and Industrial Research, and has carried out a number of collaborative projects exploring the efficacy of compounds identified in Nigerian flora with specialists in India. Their research collaborations in traditional herbal medicine have focused both on isolation and screening of active constituents in plant extracts, and on the analysis and synthesis of compounds. Elsewhere in Nigeria a group of University researchers were also interested in acquiring traditional knowledge through technology transfer from firms in India. An Indian firm was working with researchers from the University of Amadou Bello, Zaria, Nigeria to transfer knowledge and technology related to the Neem plant. Researchers were interested in learning how to take advantage of the locally grown plant that has been used in Indian Ayurvedic medicine for centuries, and were working on transferring extractive technology, purification protocols, product formulations, and packaging. The Nigerian researchers were interested in harnessing the Neem oil properties to produce various antiviral and antifungal products locally.

Our research highlighted specific areas of collaboration in traditional herbal medicine which can be grouped broadly into two areas: isolation and screening of active constituents in plant extracts; and analysis or synthesis of compounds (Text Box 1). Interestingly, South African researchers engaged in a different type of collaboration with respect to herbal medicine. They preferred joint work where they could learn from Indian counterparts about regulation, patent protection issues, standardization of traditional medicinal products, management of traditional knowledge databases, distribution of benefits and the prevention of exploitive science. India has made strides in helping South Africa set up an electronic database to manage traditional knowledge comparable to the one set up by the Center for Scientific and Industrial Research in India (Dickson, 2003a).
4.3.1.4 Common health concerns

Researchers in sub-Saharan Africa identified collaboration with China and India as a mechanism to increase research on local problems that have low priority in the North and subsequently lack funding and political will. They emphasises a strong common research focus on disease areas like HIV, TB and Malaria, the major diseases which affect sub-Saharan Africa, China and India. One researcher emphasized the importance of setting research priorities with a Southern focus saying that

“If you do research that others are not interested you will not get anything. I think that if malaria was a problem of the west, there would have been a vaccine in market now, but because it’s not their problem we have to engineer that research in the South and solve the problem ourselves.”

Researchers in sub-Saharan Africa cite South-South collaboration as a main strategic advantage in the path to finding appropriate, low-cost solutions that work in the challenging conditions found in many sub-Saharan Africa countries. While discussing the importance of such a Southern advantage, a Kenyan scientist also pointed out that “You normally go where you are going to be getting the solutions. So the people who understand the problems the best are going to offer you the best solutions”. The IBSA initiative has also encouraged a research focus on common health concerns. Scientists in India, Brazil and South Africa have joined forces as a part of the IBSA initiative to tackle some of these key diseases areas with teams working on ways to reduce HIV infection using novel treatments, develop TB diagnostic tools, and a malaria vaccine (Mokoena, 2007).

4.3.1.5 Lessen dependence on the North

Researchers in sub-Saharan Africa also emphasize the need to lessen their dependence on the North as a motivation for pursuing South-South collaboration. There is strong interest among researchers in sub-Saharan Africa to shift away from a North-based model in favour of a more Southern approach. This view was particularly emphasized by South African interviewees. South Africa has been successful in acquiring research funds though the highly competitive European framework program securing 21 projects with FP6 (European Commission, 2010). However, the
framework projects primary goals are to “to improve European science” and encourage third country participation only as a distant secondary objective. Researchers and policy makers suggest this as a risk for developing countries that may be easily swayed from local, regional and national priorities in favour of a Northern-focused research agenda. It was also stressed that the role of sub-Saharan Africa researchers cannot be confined to being providers of research material, and as a South African policy maker stated “...if you want to test our people we want our researchers to be part of it. Not only as guinea pigs but to be involved right back from the basic sciences.” The strong research base in South Africa has allowed researchers there to be more selective in collaboration and thus less likely to accept collaborative arrangements that do not align with their scientific priorities. Researchers note that China and India provide attractive alternatives to the North and are able to provide collaboration on more relevant and equitable terms.

In contrast, researchers in Kenya and Nigeria find it difficult to lessen their dependence on the North as their access to funding is limited. Researchers feel it is harder to negotiate terms and a local research agenda when they have minimal funds to contribute towards joint research projects. Consequently researchers in these countries state they are more likely to be involved in research collaborations that limit their contributions to carrying out data collection tasks rather than being involved in protocol development and experimentation. Researchers in Kenya and Nigeria further expressed concern over the marginalization of their work due to the poor international scientific reputations of their countries. They emphasized their difficulty in getting publications accepted by international journals and noted that this challenge pushed them to seek collaborators to increase the acceptance of their work. Where traditionally these may have been mainly researchers from former colonial powers, they are now including Chinese and Indian scientists with increasing regularity.
4.3.2 Challenges of Research Collaboration

Below I discuss the main challenges for collaboration with China and India, as described by our interviewees.

4.3.2.1 Lack of funding

Financial support for scientific research and joint scientific collaborations comes from a variety of sources but is quite limited in most sub-Saharan Africa countries. None of the countries I studied in sub-Saharan Africa had funds dedicated to support collaboration in health biotechnology research. Governmental funding for basic research is extremely limited in sub-Saharan Africa, and funds for collaboration must often be squeezed from other areas, making it difficult for African researchers to initiate collaborative projects. When speaking about funding collaborative work one researcher stated

“It comes from my salary you have to save towards it...so for example I have students who must travel by the end of this year, I have started saving for them, I must because I believe in the work that they are doing and I believe that this kind of collaborative work is going to benefit us.”

Researchers said that the lack of funds prevents collaborative work from continuing after a research fellowship as the resources necessary to continue the joint work are not available in their home countries. Several researchers who participated in research exchanges were disappointed that their collaborations were hampered when they returned back to sub-Saharan Africa because no funding was available to continue. One researcher stated “We are trained, we gained the skills but we are not able continue our work. In China I get the state of the art equipment, I come back here and I don't have the same infrastructure or funding, so how am I going to continue to do that research?”. The ICGEB has begun to change this model by providing funding for scientific exchange and further providing seed grants for researchers returning home allowing them to continue their work.
Even though South Africa fares significantly better than the rest of sub-Saharan Africa in terms of funding for science and technology, with a larger national budget and dedicated funding for biotechnology, researchers noted that they still face several challenges in funding collaborative research. Interestingly, researchers in South Africa suggested that although funds are often available, they are broken up into numerous small grants which prevent collaboration from moving beyond the basic science level, which is available in South Africa, to the proof of concept or clinical trial stage. This makes it necessary to seek funding from larger pots that are often being offered by developed countries through for example, the EU framework programs or the U.S. National Institutes of Health, encouraging them to collaborate with well-established Northern partners rather than others in the South. Researchers stated that larger grants dedicated to collaborative research are needed to help develop larger scale, higher-level collaborations that they currently cannot establish easily with countries like China and India.

Researchers also highlighted that some of these barriers could be overcome through third party organizations such as the TWAS and ICGEB, identifying them as critical players in the provision of funds specifically for research collaboration. TWAS, ICGEB and the European framework program have been strong funders of basic scientific collaboration, providing research scientists with funds to carry out joint work across the developing world. Researchers explained that collaborations with emerging economies such as China and India still face major funding challenges as collaborators in those countries often cannot afford to fully fund joint projects as many Northern partners are able and willing to do. As one researcher stated “In the South people are much poorer than those we are talking about in the North, so when it comes to making funds available, they are not as readily available as they would be from our traditional Northern partners”.

4.3.2.2 Scientific and Supporting Infrastructure

Infrastructure still remains a key barrier to both research and research collaboration in sub-Saharan Africa. With a shortage of equipment, reagents, and laboratory facilities many scientists find it hard to pursue the type of research they have been trained to do. One scientist said that
“Personally I started with organic synthetic chemistry and ran into problems with analytical equipment and so it was easier to go into the natural products industry because it is not equipment intensive.” Even when equipment is obtained through grants and assistance from Northern counterparts, scientists find it hard to maintain the equipment. It often requires carefully controlled temperature and humidity conditions or a constant power supply of which can be difficult to ensure, especially in countries that suffer lengthy power outages such as Nigeria. Researchers indicate that these local barriers thwart collaboration as it disables otherwise productive researchers and either prevents them from carrying out their portion of collaborative work or dissuades collaborators from engaging them. Researchers further state that although they collaborate to gain access to infrastructure there is a base level of local equipment necessary for them to be able to engage in any research. Without this basic level of infrastructure in place they are not able to add value to joint research projects, which makes it difficult for Chinese and Indian researchers to justify the benefits of collaborations with scientists in sub-Saharan Africa.

Conversely, South African researchers with higher levels of basic research infrastructure cite they are often frustrated at international conferences and meetings by being “lumped with the rest of Africa”. They cited only highly specific technical equipment such as proton NMR as a challenge to South African research which necessitated collaboration. South African researchers emphasized that their being labelled as African undermined their research capacity and thus tended to generate scepticism about their competencies when courting potential collaborators. In contrast to researchers in Kenya and Nigeria, researchers in South Africa highlighted that they felt China and India were less developed then South Africa in terms of scientific infrastructure. This interesting reversal further illustrates the contrast between South Africa and other sub-Saharan Africa countries.

The cumulative frustrations, including working in a disabling environment, drives many bright young African researchers to find posts in the Europe the United States or Canada where they may pursue collaborative work or further education. One researcher stated “you would find that in Africa we train a lot of people, there are a lot of good researchers. But they are no longer
living in Africa”. Subsequently many decide to stay abroad, leaving large gaps at even the top research institutes in sub-Saharan Africa. This effectively limits the number of prominent scientists who are available to collaborate between top African institutions and those elsewhere in the South. South Africa has particularly suffered the impact of this phenomenon and though it is ahead of the rest of sub-Saharan Africa in terms of its facilities, funding and resources it lacks the equivalent force of skilled scientists and researchers. The absence of these eminent researchers who work for long periods of time abroad has ultimately impacted sub-Saharan Africa’s ability to initiate, sustain and leverage high level scientific collaboration.

4.3.3 Impacts of Research Collaboration

When I asked researchers in Kenya, Nigeria and South Africa to indicate the main impacts of the collaboration, a common response was that it led to: (1) capacity-building adjusted to their needs and conditions (2) the ability to focus on a local research agenda. Respondents stated that these two key areas increased publications, allowed sub-Saharan Africa scientists to focus on a locally relevant research agenda, provided the opportunity to acquire new knowledge, and allowed for capacity-building. Researchers also highlighted that the confluence of these impacts could result in local health solutions being developed to address their respective countries immediate health needs. Respondents stated that these were key areas where North-South collaboration comes up short, and noted that for the specific reasons discussed in this chapter that there were important areas where South-South collaboration may have huge advantages. A researcher commented on the impacts of their collaboration with scientists in India stating that,

The ability to learn new skills, the ability to hone the skills that you have already and then the ability to - if I may use the phrase - better yourself. When you come back you are able to do more than you were able to do before and have the ability to publish papers on whatever you have done. I think for me these have been big successes of my collaboration.
This highlights that there are important benefits sub-Saharan Africa countries stand to gain from the advances in both Chinese and Indian biotechnology. Scientists cite that the collaboration has made it possible for them to be able to publish in higher impact journals and thereby increase the visibility of their research. Another common impact was the ability for researchers to access training opportunities in the form of fellowships, research sabbaticals, conferences and additional degrees for both them as well as their graduate students. Researchers felt this was slowly building skills and knowledge within the various research communities across sub-Saharan Africa. Researchers also cite that there has been a significant increase in collaborations between sub-Saharan Africa and China and India in health biotechnology specifically over the past few years, which is well supported by our analysis of joint publication between these regions. Unfortunately, building capacity and developing a stronger local knowledge base takes years to materialize tangible results. Measuring the impacts of research collaborations is similarly difficult as there are few tools that are able to measure the complex intangible benefits that accrue during the course of such collaborations.

4.4 Case Study on Entrepreneurial Collaboration

Mapping of sub-Saharan Africa’s entrepreneurial collaboration with China and India showed firms involved varied widely in their business structure and included locally owned firms and Chinese and Indian owned subsidiaries. Also, as mentioned above our research also illuminated two consistent trends at the firm level. Firstly, there were far more Indian firms collaborating in health biotechnology with sub-Saharan Africa than Chinese firms. Secondly, the data showed that collaborations between India, China and sub-Saharan Africa are heavily focused on two main activities: marketing and distribution, as well as provision of supplies (active pharmaceutical ingredients, formulations, packaging, equipment etc.). There was little evidence of joint innovative activity and the marketing, distribution, and supplies, seem to be moving largely from China and India towards sub-Saharan Africa. South Africa appeared to be the most common partner of both China and India followed by Nigeria and Kenya.
4.4.1 Drivers of Entrepreneurial Collaboration

Interviewees indicated several key factors that motivated their collaboration at the firm level. Below I will highlight the overarching drivers of entrepreneurial collaboration and provide a brief discussion of each.

4.4.1.1 Access to markets and products

Both the survey and the follow-up interviews showed market access to be the major motivation for both Indian and Chinese firms to collaborate with Kenya, Nigeria and South Africa. This result is consistent with China and India’s recent efforts to bolster trade with African markets (OECD, 2006; Rotberg, 2008). Interviewees in these three countries also indicated that access to their markets provided gateways more broadly in Africa for distribution and sale of health and pharmaceutical technologies from China and India. This was particularly important for Indian and Chinese firms in Nigeria and South Africa, two of Africa’s largest markets. In addition, South African firms also viewed China and India as significant markets for the distribution and sale of locally developed South African technologies and products. It is worth noting that several well-established firms are also preparing to move from marketing and distribution into local production including Dr. Reddy’s Laboratories (Hyderabad, India), and Holly Cotec (Beijing, China).

Our research underscored that while Indian firms didn’t seem to be involved in any specific type of product; Chinese firms seemed to focus on the niche market for malaria therapeutics. Sixty percent of Chinese firms interviewed in sub-Saharan Africa are involved in the marketing, distribution or production (through sourcing of active pharmaceutical ingredients) of artemisinin-based products for treatment of malaria. Entrepreneurs cited this as a strategic advantage for firms collaborating with China, as they have significant strengths in this area. Chinese entrepreneurs in Kenya also stated that this niche area developed when China, a leader in artemisinin based products, no longer had a domestic market for malaria medications. A Chinese
entrepreneur in Kenya stated “we share our Chinese experience on malaria control and prevention. 30 years ago China also had a malaria epidemic. But right now there are no more malaria cases in China; I think this is a very good experience to share with Africa”.

4.4.1.2 Access to technologies and technical expertise

Despite the low numbers of entrepreneurial R&D collaborations, African firms cited the importance of collaboration in gaining access to the knowledge and technology that China and India have to offer (Text Box 2). I found India to be an important supplier of technologies, including technologies for producing low cost generic drugs to sub-Saharan Africa specifically for diseases such as TB, HIV; as well as a key supplier of technology for traditional herbal medicines. Both China and India have begun to establish a record of innovation in health biotechnology and an increased ability to share their experiences of innovation (Frew, Rezaie et al., 2007; Frew, Sammut et al., 2008). For example, East Coast Rapid Diagnostics and Life Assay of (Durban, South Africa) are a joint venture between the publicly funded LIFElabs (Durban, South Africa) and the Indian Tulip Group Diagnostics (Bambolim, India). The Indian company agreed to transfer several diagnostic technologies to South Africa including rapid malaria diagnostic kits, pregnancy diagnostic kits, and urine dip stick technology. A formal agreement was signed where Tulip Group Diagnostics committed to transfer not only the technology but also provide substantial capacity and technical assistance. The Tulip Group assisted with the establishment of a local South African manufacturing operation which will produce the kits for use in South Africa as well as other African nations with high rates of malaria and infectious disease. Officials from the Ministry of Science and Technology in Nigeria reinforced the idea that “The main reason for collaborating is to acquire the technology. We feel it is much easier and cheaper to get biotechnology from the South than from the North and we feel we can quickly learn and be at par if we deal with the South.” However, not all the benefits lie in Africa. Chinese and Indian firms benefit in several key ways by opening up new markets; they are able to expand their customer base via increased market access, increase revenue, ultimately adding to their bottom line.
Text Box 2: Advancing South African Biotechnology through Collaboration: (South Africa – China)

South African firms are involved in more advanced types of collaboration in comparison to many of their counterparts in sub-Saharan Africa. They encompass a wide range of activities outside simple marketing and distribution including: manufacturing, vaccine research, bioinformatics, and gathering data for clinical trials. The South African firm Altis Biologics (Pty) Ltd (Pretoria, South Africa) works for example with the First Affiliated Hospital of Xinjiang Medical University (Xinjiang, China) on bone morphogenetic proteins and their effects on bone induction and bone remodeling in rabbits to gather preclinical data. Altis Biologics specializes in the research and development of osteogenic biomaterials for use in skeletal regeneration therapies and has developed a new osteogenic biomaterial for use in healing fractured bone. However, due to expense and lack of local expertise, Altis forged collaborations with Xinjiang Medical University. It supplied their newly developed bone regeneration material to Chinese researchers with expertise in orthopedics and carrying out animal trials to advance their understanding of its capabilities in vivo. This helped the South African firms gather valuable pre-clinical data and meet the requirements of South Africa’s Innovation Fund (now part of Technology Innovation Agency)to apply for funding to move the product to clinical trials.

4.4.1.3 Cost advantage of doing business

Most biotechnology firms in sub-Saharan Africa are not engaged in intensive R&D activities and thus not producing new-to-the world products. Though there is some collaboration in manufacturing, it is mainly in the filling and finishing of products. Many firms cited that the high domestic costs of manufacturing in Africa have limited the scope of more innovative collaborations and have discouraged manufacturing and R&D outfits from leaving China and India in favour of Africa. The availability of low-cost technologies and generics from China and India thus heavily favours collaborations in marketing and distribution as a more cost-effective strategy for firms in sub-Saharan Africa at this stage.
Firms in sub-Saharan Africa emphasized that to stay competitive in such markets, they needed to keep costs down; and interviewees emphasized that the shift in their business collaborations towards China and India was driven by a comparative cost advantage relative to developed countries. One entrepreneur in Nigeria who sources vaccines from Shanta Biotechnics (Hyderabad, India) in India stated:

“If we collaborate with Southern partners it makes a lot of sense for us because without Shantha vaccines if we had to buy the hepatitis vaccine from GSK for example, you can imagine what people will pay. I think that South-South model that we have in place with India is going to help us to crash the prices and make these products more affordable for all those that need them.”

At present, many firms find it preferable to access products and technologies through China and India as their main method of generating revenue and the strong overall message was that China and India are able to provide sub-Saharan African countries with the requisite products at prices far lower than developed countries.

When firms were asked to compare their collaborations with China and India, many cited a main advantage in collaborating with India was its ability to offer goods on credit. This was echoed by capital-poor firms, particularly in Kenya and Nigeria as a huge advantage over collaborating with China, which provides less credit options. One firm commented that “we look for any sort of collaboration whether it be R&D whether it be technology transfer were obviously looking to keep costs down so that we can satisfy our mission of providing cost effective, affordable therapeutics. And that’s where I see particularly India becoming very very important in the future”.

4.4.2 Challenges to Entrepreneurial Collaboration

4.4.2.1 Scientific and Supporting Infrastructure

Most countries in sub-Saharan Africa face huge challenges without the basic infrastructure necessary to support commercial activity in health biotechnology. Firms cited poor roads, fuel shortages, sporadic electricity, reliance on generators, and difficulties clearing goods as the main challenges in this respect. The main impact felt by firms was an overall increase in the end cost of their products and challenges in exchanging goods with their collaborators. In Nigeria, power is a particular problem for companies especially those with voltage sensitive scientific equipment. "Electricity is not reliable here it’s zero almost all the time. Right now we’re running on the generator. So out of 24 hours I think we hardly get four hours on average.” Firms in South Africa, Kenya, and Nigeria, also identified secondary factors such as: inefficiencies in transportation, communication, and travel as areas that slow down and discourage collaboration between sub-Saharan Africa, China and India. They noted that this makes collaboration increasingly difficult as operations, communication, and manufacturing can become unpredictable and therefore unattractive to potential collaborators from China and India.

In contrast to firms in Nigeria and Kenya, South African firms cited China and India’s poor infrastructure as a challenge to collaboration. South African firms cited concerns with infrastructure in China and India as an impediment to maintaining high standards of quality and practice, thus making potential South African collaborators skeptical of collaborating with Chinese and Indian firms. This highlights the substantial differences between South Africa’s stage of infrastructure capacity and that of other countries in sub-Saharan Africa (Motari, Quach et al., 2004).

4.4.2.2 Limited understanding of collaborators local markets

Indian and Chinese firms that set up collaboration with partners in sub-Saharan Africa often have little experience of the realities and costs of operating in Africa. Consular representatives from
the Chinese Embassy in Kenya highlighted that many Chinese business attempts fail in Kenya because entrepreneurs do not understand the sub-Saharan African markets before they arrive. When asked about the characteristics of successful entrepreneurs, strong English skills and flexibility were identified as being vital. The Indian Counsel General for South Africa emphasized similar challenges facing Indian entrepreneurs, stating “the problem is one of perceptions and lack of information” among Indians looking to collaborate with firms in sub-Saharan Africa. Interestingly, many entrepreneurs in sub-Saharan Africa involved in collaboration saw India as more receptive to the needs of sub-Saharan Africa markets in comparison with China. One entrepreneur noted that “India has been flexible. Say with packaging - African markets need market specific packaging. They are able to develop small volume products to maintain African regulatory requirements which companies elsewhere find hard to do.”

Understanding specific areas such as marketing has proved challenging for many firms, as they do not understand how to reach consumers in these countries, and thus, fail before they are able to gain any market share. One interviewee stated “There are many examples of Indian companies that have tried to open up in South Africa and have failed, or have taken decades and decades to achieve a small market share. That is because of the differences in markets, somebody coming out of India to manage a business in South Africa doesn’t understand the market here as well as South African businesses do.” Firms in sub-Saharan Africa interested in Chinese and Indian markets also cited difficulties, especially in adapting to the intensely competitive business environments in those countries.

Language barriers were stressed as a factor limiting the understanding of African markets and posing special challenges to the collaboration. Many firms felt collaborations with China were hindered by the language barrier they faced in dealing with Chinese firms and institutions. Some firms cited that language barriers lead to misunderstanding of each others’ capabilities, resulting in misalignments within the collaboration. However, interviewees and firms noted that their Chinese collaborators were working hard to minimize the negative impacts and prioritizing training in English.
In comparison, firms in sub-Saharan Africa cited language and culture as an advantage to collaborating with India. One interviewee stated “With India perhaps, we are better because we speak the same language, Nigeria and India were both colonized by the English, so we speak English. With China we usually have problems.” Additionally, the large diaspora communities of Indian ancestry in many parts of sub-Saharan Africa were also cited as reasons that firms felt more confident in their understanding of Indian commerce and culture. Many firms in sub-Saharan Africa had Indian employees and felt they “knew Indians well” and further expressed that they could relate both to their culture and style of doing business because they had personal experience with them.

### 4.4.2.3 Difficulty in identifying reliable collaborators

Though interviewees from firms and key informants agree that South-South collaboration is of key importance going forward, they cite identifying partners as a major challenge. One of the main barriers is that few firms in sub-Saharan Africa know what is happening in India and China. They have little opportunity to gain international exposure and find it difficult to keep tabs on the rapidly changing biotechnology landscapes in both China and India. One firm CEO stated “I know there’s language barrier but we don’t know what they are doing, we don’t really know what’s going on in China.” This presents firms with an immense challenge when looking for partners with complementarities that will aid in developing compounds, technologies, services, or ideas into commercial goods.

Firms also cited trust as a stumbling block in identifying partners. Most firms in sub-Saharan Africa do not have the capacity to do due diligence on potential collaborators, and government bodies, particularly in Kenya and Nigeria, are rarely able to assist them in the process. Performing due diligence can be extremely expensive and though many firms in South Africa described carrying out such a process when identifying collaborators, those in Kenya and Nigeria find doing this financially impractical.
The risk of encountering counterfeit medicine in sub-Saharan Africa markets, for example, drugs that lack active ingredients or have passed their sell-by-date, underscores the importance of identifying reliable collaborators from China and India. Many governments in sub-Saharan Africa lack the regulatory capacity to verify the safety and efficacy of drugs and make sure that substandard drugs do not reach their markets. Consequently sub-Saharan Africa countries have become prominent recipients of substandard products from both China and India. The main challenge firms identified was having counterfeits of their own products undercut them in the marketplace. These counterfeits are sold at lower prices and can subsequently attract huge market shares. The threat of counterfeit products in African markets has also made Indian and Chinese collaborators reluctant to enter into marketing and distribution agreements with firms in sub-Saharan Africa.

4.4.2.4 Corruption and bureaucracy

Firms in sub-Saharan Africa cited that conducting business in an environment where corruption and excessive bureaucracy are common problems poses a huge barrier to collaboration. Respondents stated political favouritism and nepotism often determined business opportunities to collaborate with companies in China and India. Many firms listed an important aspect of this practice being visible in the government tender system and in purchasing agreements arranged by sub-Saharan Africa governments. South African firms also cited the extremely long processes and bureaucracy involved in forging collaborative projects and arrangements, especially with India. A South African policy maker reinforced this idea stating “It is extremely difficult to get permission to do anything. It can actually kill the projects. By the time we get permission to do something you have lost the will to do it. That is one of the major problems we’ve got [with India].”
4.4.2.5 Regulation and counterfeit drugs

As mentioned above, counterfeit drugs arose as a key issue posing a challenge to firm-firm collaboration between sub-Saharan Africa and China and India. Firms in sub-Saharan Africa underscore the challenge in identifying collaborators in China and India that can provide them pure high quality products. Many governments in sub-Saharan Africa lack the regulatory capacity to investigate and approve potential Chinese and Indian firms who may want to collaborate and consequently sub-Saharan Africa countries have become prominent recipients of substandard products from both China and India. The main challenge firms identified was having counterfeits of their own products undercut them in the marketplace. These counterfeits are sold at lower prices and can subsequently steal huge market shares. This weakens collaborations with partners in both China and India as legitimate firm-firm collaborations face invariant transactional costs in the form of licenses, transport, duties, taxes etc. Counterfeit, sub-standard products being brought into the country undercut these collaborative transaction costs and dissuade Indian and Chinese collaborators from working with firms in sub-Saharan Africa who can subsequently no longer maintain high volumes of distribution and sales. Entrepreneurs from sub-Saharan Africa who collaborate with Indian and Chinese firms further cited that counterfeit products reinforce negative stereotypes and make consumers in sub-Saharan Africa markets increasingly skeptical of the quality of Chinese and Indian health products.

Firms also face the challenge of dealing with import and export regulations, constantly changing taxes, tariffs and duties on imported and exported goods. Entrepreneurs cite this as a challenge in collaboration as it adds uncertainties that could potentially weaken collaborative business attempts. Firms in sub-Saharan Africa viewed the regulations in China and India as constant and consistent and voiced frustration with extremely fluid nature of sub-Saharan Africa governmental regulations and procedures.

4.4.2.6 Language and culture

Our interview data supported the notion that firms perceived language and culture as playing a key role in the formation and establishment of their international collaborations. Many firms felt
collaborations with China were hindered by the language barrier they faced in dealing with Chinese firms and institutions. Some firms cited that the language barriers lead to a mutually poor understanding of each others capabilities resulting in misalignments within the collaboration. These misalignments in communication took many forms: poorly understood documents, incorrect translations, poor working knowledge of the languages, and cultural differences. Language was a challenge almost all firm respondents indicated was present when collaborating with China. However, interviewees and firms noted that the Chinese were working hard to minimize the negative impacts this was having on collaborative business by increasing their comfort level with the English language.

Interestingly, firms in sub-Saharan Africa cited language and culture as an advantage to collaborating with India. Firms cited the large English speaking population and firms who conducted business largely in English as key factors to minimizing the language barrier in collaboration with India. One interviewee stated “With India perhaps, we are better because we speak the same language, Nigeria and India were both colonized by the English, so we speak English. With China we usually have problems.” Additionally, the large communities of Indian descent in many parts of sub-Saharan Africa were also cited as reasons that firms felt more confident in their understanding of Indian commerce and culture. Many firms in sub-Saharan Africa had employees of Indian descent and felt they “knew Indians well” and could relate both to their culture and style of doing business because they had personal experience with it. Most firms cited an elevated level of comfort in collaborating with firms in India as opposed to China with regard to issues of language and culture.

4.4.3 Impact of Entrepreneurial Collaboration

Interviewees cited that collaboration with China and India in the field of health biotechnology provides a good mechanism to increase the availability of vaccines, pharmaceuticals and diagnostics to the wider population in sub-Saharan Africa. The impacts of such collaborations have driven down the cost of basic essential medicines and opened up African markets to technology that has historically been too expensive for widespread deployment in low-resource
settings. Examples include the marked drop in the cost of Hepatitis, TB, Malaria and HIV treatments in sub-Saharan Africa available through generics producers in China and India such as Cipla (Mumbai, India), Ranbaxy, and Holly-Cotec (Ford, Calmy, & von Schoen-Angerer, 2007; Park, 2002). Cheap diagnostics, vaccines, and generics jointly developed or simply acquired through collaboration with China and India could thus continue to positively improve access across sub-Saharan Africa.

According to respondents, traditional herbal medicine may hold potential for African firms. Although not many products have yet made the leap in Africa from research to marketplace, our interviewees’ evaluations indicate the impacts of developments in this field may be felt in future. Ongoing research into plant extracts and various natural compounds could help sub-Saharan Africa develop a traditional herbal medicine pipeline and firms in sub-Saharan Africa would stand to gain great benefits from the IP and licensing of traditional knowledge. Technology transfer in this area may also prove fruitful for firms in sub-Saharan Africa, for example Nigerian researchers started a local firm that uses the Neem plant (Text Box 2) and technology transferred from India to produce products locally for the Nigerian market.

Sub-Saharan Africa’s collaboration with China and India has not yet reached its full potential, whereby firms are engaging in local innovation. However, our interviewees feel that learning from China and India’s experience through collaboration can help them leapfrog into forming more innovative partnerships and potentially innovative biotechnology products targeted to the diseases of sub-Saharan Africa. Firms in sub-Saharan Africa cite they are interested in deepening their collaboration with China and India from marketing relations and engaging in joint innovation. They saw their existing collaborations as laying the ground for more innovative partnerships which would have a greater impact on the availability of locally relevant health products and on the development of health biotechnology in Africa.
5 CHAPTER FIVE
Discussion and Conclusion

5.1 Introduction

This final chapter summarizes some of the main findings of this study and puts forward a set of recommendations based on the results of this study. The goal of this study was to understand the role of China and India collaboration with sub-Saharan African countries in health biotechnology development on the African continent. I approached this goal by dividing it into three main objectives.

(1) To examine the extent and patterns of China and India’s health biotechnology collaboration with sub-Saharan Africa by mapping research and entrepreneurial collaborations

(2) To understand why and how sub-Saharan Africa countries collaborate with China and India by carrying out comparative qualitative case study research on the potentials, drivers, challenges and impacts of the health biotechnology collaborations.

(3) To devise recommendations that will enable sub-Saharan Africa countries to leverage benefits from their health biotechnology collaboration with China and India
As discussed in Chapter 3, to fulfil my objectives I performed a scientometric analysis of co-publication data, conducted survey of biotechnology firms, and conducted six bilateral qualitative country case studies. I begin the discussion with a brief summary of the main findings from each part of this study, highlight the gaps in knowledge that this work contributes to, and further discuss the recommendations and main messages stemming from this research. This chapter concludes with a brief discussion of the limitations faced in conducting this study and then highlights potential areas of future research.

5.2 Summary of Findings

Biotechnology is still a newcomer to most of sub-Saharan Africa. African governments have only begun to emphasize the importance of the biotechnology sector recently, but many nations such as Kenya, Nigeria, South Africa, have begun to develop policies to guide its development. Several African nations have also started institution building and some countries now have universities and research organisations doing impressive research in the health biotechnology field along with firms starting to engage in the biotechnology industry. But resources are in short supply and in order to become more active contributors to research and innovation they need to strengthen capacity and infrastructure. This research study gives an indication that sub-Saharan Africa can harness South-South collaboration to gain this capacity and promote development and innovation of health biotechnology solutions appropriate for the African context by promoting South-South collaboration. Historical ties and the conventional flow of research opportunities and funding from the North to the South have lead to Northern domination in collaborative partnerships with Africa. This exclusive focus on collaborating with partners in the North is beginning to change and there is a growing recognition that partnerships with emerging economies have a lot to offer sub-Saharan Africa.
5.2.1 Main Messages

Both China and India are becoming active collaborators with sub-Saharan Africa in the health biotechnology sector and are increasing their presence on the continent in this science-intensive field. Even though our mapping of China and India’s health biotechnology collaboration with sub-Saharan Africa shows only a moderate level of collaboration, in recent years there has been an upsurge of policies promoting collaboration in science and technology, and an increase in the number of co-publications between these nations. Further, health and biotechnology are typically priority areas among these countries bilateral discussions, and with China and India allocating millions of dollars to support bilateral agreements, collaboration in health biotechnology will continue to be put on the agenda. Time will tell if this is solely a part of their strategy to become global powers, win political favours, and access markets in Africa; or if it is an expression of South-South unity. Their ties with Africa are, thus, not confined to resource extraction, which is the frequent topic in Western media, but our research suggests they are increasing their presence within Africa’s health biotechnology sectors. While criticism suggests that China and India’s collaboration with much of Africa has been directed towards natural resources partnerships, our research indicates that steps have been taken towards a broader approach to collaboration, and both Chinese and Indian firms have started to form ties with Africa in science intensive sectors.

China and India play various roles in sub-Saharan Africa’s health biotechnology but are particularly strong in capacity building. Both countries did play various roles in sub-Saharan Africa’s health biotechnology development and both, for instance, had an active role in providing access to scientific infrastructure as well as the provision of relatively affordable health products appropriate to local health needs on the continent. Their roles in training and capacity building were particularly pronounced and are being strengthened by both China and India allocating millions of dollars for scholarships and fellowships in science and technology earmarked for African nationals. Their capacity-building efforts are also being reinforced by
contributions from international initiatives and organisations, and both TWAS and ICGEB, were singled out by our interviewees as having played a considerable role in financially supporting their training and collaboration with China and India and facilitating collaboration by linking potential collaborators. It appears from the research that these organizations have played a larger role in Kenya and Nigeria as compared to South Africa. However, the strong message from both researchers and entrepreneurs was that third party and philanthropic organizations can play a critical role in brokering South-South collaboration of Africa with China and India. This finding has important policy implications for many African countries, and is an important point to consider when building policies that are aimed at helping to support collaboration. Involving these types of third party organizations and leveraging their collective resources and convening power may be a practical option to facilitate stronger collaboration both for entrepreneurs and research institutions.

**Shared health concerns foster sub-Saharan Africa’s collaboration with China and India.**
Both respondents involved in firm and research collaboration cited the need for Southern countries to work together in addressing health concerns commonly neglected by Northern research agendas. Researchers and firms echoed that access to more appropriate technologies and common health concerns were important areas motivating collaboration with China and India. These areas of commonality are particularly visible when looking at joint research publications which heavily focus on areas such as HIV, TB, malaria, and tropical diseases. Our research illustrates that collaboration with China and India has in many cases allowed researchers to orient collaborative work more closely to their local research agendas and has increased their ability to focus on research questions aligned to their local health needs. Respondents further supported this view citing China and India as important Southern players in developing appropriate, low-cost solutions that can contribute to improving of the lives of many Africans.

**Collaboration with China and India in harnessing traditional medicine and local biodiversity is in high demand in sub-Saharan Africa.** There is increasing potential for collaboration between China, India, and sub-Saharan Africa in traditional medicine. Many researchers I interviewed emphasised that they see this as a primary avenue through which to
collaborate with China and India especially on the development, advancement, and commercialization of traditional knowledge. South Africans were particularly interested in understanding management of IP issues regarding traditional medicine and technology transfer, whereas Kenya and Nigeria were more interested in the development process of herbal medicines. It reflects the strength of South Africa’s health biotechnology sector, and highlights that though they are still interested in technology transfer, there is significant scope for South-South learning in how to manage innovation. Collaboration to harness traditional medicine has already begun and can be seen in such examples as in the case of transferring Neem plant technology to Nigeria and South African collaborations with India in the creation of a traditional medicines database. Such collaborations may become a way for Africa to advance its own capacity in the innovation, development, formulation, testing, and marketing of new herbal products while maintaining a focus on bringing affordable, culturally appropriate, health products to their populations. However, as in many cross-border collaborations, issues regarding standardization and regulation remain key challenges.

Drivers for collaboration with China and India are not uniform in sub-Saharan Africa. Our case-study research showed that there are vast difference in the health biotechnology sectors in Kenya and Nigeria versus South Africa that result in differences in their collaboration with China and India. While Kenya and Nigeria collaborate from a resource poor position, South Africa collaborates with these two emerging economies from a more equitable position. South Africa does not need to gain access to standard technologies and equipment in health biotechnology through collaboration with China as the country already has considerable strengths in this field. Kenya and Nigeria, however, need to collaborate in order to build up human capacity in this field and to gain access to scientific infrastructure needed to complete research projects. South Africa is also in the position to receive graduate students and fellows from China and India for specialised training in health biotechnology. It is still noteworthy that despite its strengths in health biotechnology, South African firms and researchers still consider China and India vital partners.
5.3 Recommendations

Here I present the main recommendations that have stemmed from this research study. These recommendations are grounded in the case study data and have been formulated with the support of other data sources including scientometric analysis, literature, and policy documents.

**Create an African policy environment that can engage China and India.** Harnessing the impact China and India’s South-South collaboration with sub-Saharan Africa effectively rests with African governments, their institutions, and the wider African policy making community (regional communities, AU, NEPAD). China and India have made great strides in formalizing their trade policy and establishing a framework for cooperation with sub-Saharan Africa however sub-Saharan Africa countries have yet to devise a formal approach or policy framework that would allow them to engage more systematically with India and China. This is a critical step for nations in sub-Saharan Africa if they hope to leverage the full benefit of collaboration. Focused but fluid policies need to be pursued so as to protect African interests, enable negotiation based on African terms, help the benefits of collaboration fall where they are most needed, provide a framework to ensure collaborative benefits have receptors within Africa, and create a base on which subsequent relations can be built. It will be important for African governments to take a bottom up approach, to accurately identify challenges facing collaboration on the ground and form policies that help firms and researchers to overcome the challenges outlined in this study. Strengthening regional collaboration may better position firms in sub-Saharan Africa to leverage the size of common African markets and increase their bargaining powers when engaging economic giants like China and India. A comprehensive African policy to engage China and India in science and technology collaboration is needed, and would result in a more structured equitable engagement, thus, creating a platform for mutually beneficial collaboration.

It is clear that China and India will continue to court African governments, but they will begin to face increasing competition from both each other, and also from countries/regions that stand to be excluded (United States and Europe). Africans must decide how they plan to orient themselves on the issue of collaboration with India and China. Collaboration in health biotechnology with China and India holds promise but without a clear path forward and a vision
of what it should accomplish. Africans must decide what is best for Africa, and the government’s prioritization of health biotechnology has been an important step forward in the right direction. As I have illustrated with our research findings, science and technology along with South-South collaboration, may be important vehicles for African development. However, it will be within the context of a grounded, well developed policy that they stand to have the greatest impact.

**Promote scientific exchange and opportunities for cultural understanding.** Governments in sub-Saharan Africa must take notice of South-South collaboration and take the current political will and put it into practice. Promoting trade missions composed of not only those in government but in the private sector is critical in catalyzing linkages between the countries, keeping up to date on current advancements, and encouraging trust-building between firms in the different countries. These types of exchanges, as mentioned above, can be facilitated by third party organizations but an increased role of national governments is needed to increase ownership and promote sustainability. Promoting these linkages allows for a better understanding of the business and research environments in each respective region, the markets, and the business and research cultures each country has to offer. This understanding will help researchers and entrepreneurs see the potential opportunities and anticipate the challenges when working in each others environments. Exposure of African scientists and entrepreneurs to the Indian and Chinese environment will help them benchmark their countries, help them move towards common regulatory standards, and increase the ease with which products can move between markets. Trade missions should be encouraged that include local entrepreneurs, they should not be restricted to the political realm but focus on linking entrepreneurs and encouraging business and investment in Africa and its firms. Researchers must also continue to be supported to attend international conferences, engage in joint research, be provided fellowships, and African institutions should encourage cross appointments and visiting professorships.

**Develop policy instruments to support collaboration in traditional medicine.** The World Health Organization estimates that up to 80% of the population in Asia and Africa depend on traditional medicine to meet their primary healthcare needs (WHO, 2002). Sub-Saharan Africa’s
rich history of traditional knowledge and its wealth of biodiversity represent a niche area where its firms and researchers stand to build a competitive advantage. Our research supports the commercial potential that exists in sub-Saharan Africa with respect to traditional medicine and has highlighted the important role South-South collaboration has played in building capacity. For example the Nigerian Institute for Pharmaceutical Research and Development (Abuja, Nigeria) developed a drug for sickle cell anemia based on traditional medicinal knowledge and has, for instance, collaborations with a number of institutions in India and China including the Council of Scientific and Industrial Research (New Delhi, India), the University of Lucknow (Lucknow, India), and Zhejiang University (Huangzou, China). Many of our interviewees cited that this was a primary area where collaboration between sub-Saharan Africa and China/India could be leveraged to develop local health products and economic prosperity. However, our case study data also supported that though there was great interest in collaborating within this area, there was a dearth of policy and political will to support it.

A few nations in sub-Saharan Africa have established research and training institutes in this traditional medicine, including institutions in South Africa, Nigeria, Rwanda, Mali, and Uganda (Al-Bader, Masum et al., 2010; Van Wyk, 2008) But there is a need for policy makers to continue to support research efforts and further scope for them to develop policy instruments that encourage collaboration between researchers and entrepreneurs in sub-Saharan Africa, and those in China and India. In general we saw a demand for the experience that China and India have in specialized technical knowledge for harnessing biotechnologies, but also a demand from their collaborators for knowledge on how to manage the development process, how to protect the intellectual property rights embedded in the traditional knowledge or local biodiversity, and how to regulate the development of health products based on this type of knowledge/resources. Directing policy to address these needs would position nations in Africa to build capacity that could be translated into developing practical knowledge and commercial industries. Further, political support for the development of traditional medicinal knowledge would encourage the establishment of supply and extraction enterprises and could create a culture of both South-South as well as regional collaboration among scientists, traditional practitioners, and entrepreneurs.
Prioritize collaborations that build capacity. Capacity in health biotechnology is highly varied both within and between the study countries (Kenya, Nigeria, and South African) and China/India. China and India have research and innovation capacity that is now approaching what can be found in many developed countries and because of their context have developed capacity that is contextually relevant to the African setting. The importance of this dimension was a common theme throughout our interviews and many respondents stressed the importance of South-South collaboration in contributing towards capacity building in their countries. It was stressed that the South-South collaboration allowed for a more appropriate level of technology than collaboration with Northern countries that often included the use of less applicable, more expensive, and highly technical technologies.

As was mentioned earlier in Chapter 2, the traditional view of China and India’s partnerships with Africa have tended to focus on the exploitation of commodities. While trade in raw materials has important economic benefits for African economies more focus needs to be paid to capacity building when sub-Saharan African nations are engaging China and India or they risk the benefits being one-sided. The need to prioritize capacity building efforts has been alluded to many times, however it is important to formalize this recommendation here to emphasize its importance.

Increase financial resources to support collaboration. Researchers and entrepreneurs in Kenya, Nigeria, and South Africa all agreed that in order to strengthen South-South collaboration more financial resources were needed. Several collaborations we explored had been jeopardized or halted due to a lack of resources. There was a sense that governments needed to back up verbal commitments with financial resources funding South-South collaboration. Despite economic growth in many of the emerging economies they have made inadequate efforts to establish funds that could support health biotechnology research and developmental efforts. Scientific and technological cooperation agreements were typically stressed as being important as a first step and developing countries needed to sign more agreements with each other, but financial resources needed to follow.
As discussed in Chapter 2, North-South funding schemes can sometimes lead to ownership and the research agenda residing in the developed world. Some interviewees highlighted the emerging importance of South-South-North collaboration where developing countries governments and donor organizations from the North work together to promote South-South collaboration. This arrangement draws funding from philanthropic organizations or Northern donors and leverages it to facilitate knowledge sharing and capacity building between developing countries. However, governments in developing countries need to carefully evaluate if co-funding schemes with Northern governments are the best way for them to use their limited resources. An alternative would be to devise a comparable co-funding scheme with Southern funding sources. Southern governments could contribute to a funding scheme that could be developed and utilized to specifically fund South-South collaboration. If governments such as China and India are to move beyond agreements towards impacts they need provide financial incentives and remove the financial burden from individual collaborators.

5.4 Contribution to Gaps in Knowledge

As discussed in Chapter 1, despite South-South collaboration in science and technology being high on the agenda of many developing nations for the past decade there has been little evidence that examines how and why South-South collaboration is taking place. This study has made a purposeful contribution to this area of the literature contributing qualitative and quantitative evidence towards the understanding of South-South collaboration between China/India and sub-Saharan Africa in a science intensive field, health biotechnology. Specifically, this work aimed to contribute knowledge to three main gaps in understanding China and India’s collaboration with sub-Saharan Africa; it aimed to examine who in the field of health biotechnology was collaborating, why they were doing it, and identify factors that create an atmosphere conducive to successful collaboration. I will discuss below how the mapping and case study research conducted as part of this study on China and India’s health biotechnology collaboration with Kenya, Nigeria, and South Africa, has specifically addressed these three major gaps in the literature.
Firstly, this work has provided empirical research on the extent and patterns of China and India’s entrepreneurial and research collaboration in health biotechnology. Previous to this study there has only been limited, knowledge about the collaborations between China/India and sub-Saharan Africa in health biotechnology field. The scientometric analysis of joint health biotechnology publications and the survey of health biotechnology firms carried out as part of this work has made a contribution to understanding the landscape of collaboration that currently exists with respect to China/India and sub-Saharan Africa. It quantifies the levels of collaboration occurring between these regions in health biotechnology as measured by co-publication in international peer-reviewed journals, and therefore provides a baseline for future research to look at changes over time.

Secondly, little is known about the role that China and India are playing with respect to health biotechnology collaboration in sub-Saharan African countries. In particular, there is limited empirical research examining specifically how and why countries in sub-Saharan Africa are collaborating in this field. Research is also lacking on the factors and conditions that encourage collaboration as well as those that hinder it. The 63 interviews conducted with key informants in Kenya, Nigeria, and South Africa as part of this study investigated the potential and reasons for collaboration, the challenges faced, and the impacts realized thus far. Conducting these qualitative case studies has allowed this study to make a novel contribution to identifying the motivations, challenges, benefits, and barriers of engaging in such South-South collaboration.

Finally, there has been a limited understanding of the various factors influencing South-South collaboration between sub-Saharan Africa, China, and India and no evidence based strategies that could be used to strengthening it. This research has contributed to an improved understanding of China/India's collaboration with sub-Saharan Africa and how they can be strengthened and leveraged to have greater impacts in sub-Saharan Africa. Examining the suggestions, thoughts, and experiences of African scientists, entrepreneurs, and policy makers, allowed for a deep understanding of what key factors need to be addressed in order to improve
the impacts of collaboration. Based on this analysis policy recommendations have been put forward that may be used to guide policy development in African nations or within international organizations. The main findings and recommendations stemming from this work will make a contribution towards how South-South collaboration can best be used to improve the impacts on innovation and how African nations can best promote successful South-South collaborations with China and India in health biotechnology.

In addition, as discussed in Chapter 1 of this thesis, resource interests, trade, and politics between these regions has featured boldly in both the media and literature. Much less attention has been paid to collaboration in science intensive sectors such as health biotechnology, and although this is not a geo-political study, this work also contributes the discourse on China and India’s exploitative behaviour in Africa. It provides empirical evidence of the capacity building efforts being undertaken by China and India in health biotechnology, and provides support to the notion that these countries play a more varied role in sub-Saharan Africa in contrast to the traditional resource exploitation role commonly depicted in the literature.

5.5 Limitations of Study

Despite the benefits of the work there are several limitations that must be kept in mind when interpreting the results. I have outlined five of the main limitations to this work below, they include: limitations to the scope of this study, limitations of Scientometric and survey data, critical observer bias, social desirability bias, and the generalizability of this studies results.

5.5.1 Study Scope

This study sets a foundation for the understanding of the role China and India play in health biotechnology development on the African continent. This study solely focuses on the health
biotechnology sector and does not look at collaboration in other pertinent areas that I know has strong collaboration such as: Information communication technologies and agriculture. Though the scope of the study includes research, entrepreneurial, and wider institutional perspectives it is solely focused on the experience of those in sub-Saharan Africa and their perceptions about the collaboration with India and China. However we also interviewed many informants from embassies, and additionally, several individuals we interviewed were of Chinese or Indian descent. This study has focused on the African viewpoint, and while it does not include the specific views of Indian or Chinese researchers and firms in China and India, it does express the views of many informed about the discourse within those nations. Thus one must be cognisant of this when interpreting the results. In some instances this was mitigated by interviewees who were established residents of Kenya, Nigeria, or South Africa but who were also of Indian or Chinese descent; these unique cases were often well informed about both perspectives and offered valuable contributions to this research. In addition, our definition of biotechnology did not include agricultural biotechnology or its related products. Though this is a limitation of the study there is not clear demarcation between health and agriculture, and given that this study focuses solely on health biotechnology, I felt it appropriate to be exclude research, technologies, or biotechnology services that did not have a direct application to human health.

5.5.2 Survey and Scientometric Analysis

As detailed in the methods chapter, measuring collaboration through co-authorship levels is also not without its limitations. It can both overlook important collaborations that do not result in the publication of a research paper, and inflate collaboration when researchers author papers for which they have made minimal contributions. Using this type of analysis within its limits still can provide valuable insights, and can be especially useful to looking at changes and trends that occur over time. Further, this method was used as a proxy for collaboration, it was not used to asses scientific output or to give a complete picture of all collaborative linkages. In addition, the survey data used to examine firm collaboration also has limitations. For logistical reasons, the data collection did not include all developing countries in this study and it is a limitation that this study did not survey Kenyan and Nigerian biotechnology firms. Furthermore, though the response rate was high information from every firm active in health biotechnology in these
countries was not obtained. Some firms may also not have reported the full extent and characteristics of all their South-South collaborations. However, because of the relatively small size of the biotechnology industries in sub-Saharan African countries, it is likely that by conducting additional research and snowballing in the field, I were able to capture a majority of the entrepreneurial collaboration occurring in each country.

5.5.3 Critical Observer Bias

Critical observer bias occurs when the researcher who is collecting and analyzing the data impacts the results with their own opinions and perceptions; thus, including them as part of the results. According to Morse (Morse & Field, 1995) and others (Creswell, 2009; Strauss & Corbin, 1990) this limitation cannot be eliminated from qualitative research but should be accounted for or anticipated (Morse & Field, 1995). To account for this type of bias a majority of the semi-structured interviews conducted for this study were done so by two investigators. Further the analysis of this data was done in collaboration with my supervisor, thus ensuring the data collection and analysis did not reflect the idiosyncrasies or values of one investigator.

5.5.4 Social Desirability Bias

Social desirability bias is a when research participants have a tendency to reply in a manner that will be viewed favorably by the investigators (or others) (Taylor & Bogdan, 1998). This often leads to over reporting of good behavior and underreporting of bad behavior. Interviewees may have been influenced in their responses either by what they felt the investigators wanted to hear, by what their research institutions, governments, or companies supported. For example, policy makers may have overstated or understated the realities in their country based on what they felt was the most politically correct response at the time. Firms may also have underreported collaboration if they felt proprietary knowledge or some competitive advantage might be lost. Further, they may have reported answers that they though shareholders, potential investors, or others wanted to hear with respect to the image of their company and its perceived global integration. This challenge is not easily perceived and thus is hard to completely eliminate in qualitative research. However, when interviewing respondents the investigators made it clear that
the participants would benefit from participating in the study, emphasizing that our research group was solely academic in its nature, had no political affiliation, and was not visiting as with the intention of funding research or development activities. Further our consent form assured them complete anonymity and I verbally assured them they would not be quoted or identified without their permission.

5.5.5 Generalizability

This study aimed to understand health biotechnology collaboration between sub-Saharan Africa - China/India. However due to logistical, financial and time constraints I narrowed the exploration of sub-Saharan African nations to Kenya, Nigeria, and South Africa. This study collectively refers to these countries as representative of sub-Saharan Africa. This is of course limiting, there are 47 wholly unique countries in sub-Saharan Africa and it is a common but misplaced generalization that Africa exhibits the uniformity of a single country. Thus inferring the same challenges, motivations, and impacts that I saw in Kenya, Nigeria and South Africa to the other nations on the continent is not easily done.

The results and analysis of this study may not be generalizable to the health biotechnology sectors of all countries in sub-Saharan Africa; however, generalizability is not the goal of qualitative research (Strauss & Corbin, 1990). The lessons learned and the implications for policy and practice may be helpful to a wide variety of biotechnology companies, research institutions, government policy makers, as well as non-governmental and philanthropic organizations in sub-Saharan Africa, China and India. However, this study includes high income African nations such as South Africa as well as middle to low income African nations such as Nigeria and Kenya respectively. These countries present a spectrum of development and represent a sample of Africa’s heterogeneity. African nations, even those that are considered low income nations on the continent, can benefit from the results of this study as the lessons learned from the three diverse study countries capture major themes, impacts, and knowledge about how South-South collaboration can be strengthened.
5.6 Future Directions

Further research looking into the perspectives of researchers, entrepreneurs and wider actors in both India and China would be extremely useful in deepening the understanding of their role in health biotechnology collaboration with sub-Saharan Africa. It would be of interest to see if an investigation of the Chinese and Indian perspective would yield similar results. Conducting a similar study in China and India would greatly add to the understanding of China and India’s role in collaboration with sub-Saharan Africa. It would be of further interest to expand this study into other science intensive sectors such as the Information communication technology, manufacturing, environmental sciences, or agriculture. It was apparent while conducting this study that China and India have significant collaboration with other science intensive sectors in sub-Saharan Africa. Examining collaboration in these overlapping sectors may provide interesting contributions to the current understanding of the drivers, challenges, and impacts seen in health biotechnology collaboration; thus providing rich additional information useful for policy formulation.

A similar study of sub-Saharan Africa’s collaboration with Brazil would also be a fruitful area of future research. The scientometric analysis conducted as part of this study, and many of the studies respondents, indicated a growing number of ties between Latin America and Africa, particularly with Brazil. It thus appears that Brazil may also be making important contributions to the African continent through collaboration in health biotechnology. This may be especially true with Portuguese speaking nations in sub-Saharan Africa such as Angola, Mozambique, and to a lesser extent Cape Verde, Guiné-Bissau, São Tomé e Príncipe. Further, it will be important to conduct this type of study again in a few years to note the changing levels and patterns of collaborations and compare the resulting drivers, challenges, and impacts of China and India’s collaboration with the African continent. Studies are also needed to examine regional collaboration within Africa. Our study indicated surprisingly low levels of collaboration among African countries (with the exception of South Africa). Compare the challenges facing South-South collaboration within Africa with the results of this study could yield an interesting comparison.
5.7 Conclusion

Many African nations are betting on biotechnology as a tool to improve their public health and bring economic development. The case study research on India and China’s health biotechnology collaborations with sub-Saharan Africa has identified several findings that underscore how South-South collaboration can be used as a tool for sub-Saharan African nations to build local capacity and commercialize biotechnology products. Although this research is focused on sub-Saharan Africa, China and India, it is relevant to both other developing countries and emerging economies as it gives an indication of the potential South-South collaboration has in the development and innovation of health biotechnology. These findings may be useful to firms considering expansion to developing markets, research groups considering collaboration with developing nations, government policymakers who can influence innovation, and foreign affairs policy makers in both underdeveloped and emerging economies. Continued collaboration between China, India, and sub-Saharan Africa is inevitable, however, countries in sub-Saharan Africa must cultivate these linkages and leverage them with a strong South-South policy to help them realize their full potential. If harnessed, this South-South flow of capacity, knowledge, goods and services, could make a significant contributions towards improving the public health of many African nations and contribute towards their economic development.
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Appendix 1 – Project Summary
Appendix 2 – Invitation to participate in study
Appendix 4 – Interview Guide: Researchers

INTERVIEW GUIDE FOR RESEARCHERS

The texts in italics are recommended follow up questions if needed

Name of Interviewee:                Organisation:                Date:

BACKGROUND

1. Can you give me a brief overview of your institution?
   - What are your institute’s main focus/capabilities?
   - Please include a little about your institution’s background and previous experiences in the health biotechnology field.

2. Approximately what proportion of your research projects do you carry out in international research collaboration?

3. Who are the main partners that you collaborate with?
   - From which countries?
   - From what types of organisations do they come public research institutions, hospital, universities,

COLLABORATION

4. What are the main reasons for you to do this work in collaboration with [name of a particular partner]?
   - Do the same reasons apply for your other collaborations?
- Would you be able to complete these research projects without this collaboration?

5. How would you describe your contributions to this international collaborative project?
   - What did your partners contribute to the project?

6. How did you become interested in the research area of this collaborative project?
   - Did you or your collaborators suggest it?
   - What are your main sources of innovative ideas for the joint research?

7. How did you get to know your collaborators?

8. Where did you get the funding to carry this project out (e.g. governmental agency, angels, financial institutions, VCs, NGOs, etc.)? Please provide the names.
   - Do you and your partners apply for funding jointly or separately?
   - Has funding been easily available and sufficient?

9. Is this collaboration arranged between institutions or between individuals?
   - Is it formal or informal in nature?

10. Do you consider this collaboration to be successful?
    - What are your criteria for a successful collaboration?
    - If successful, what contributed to the success of the collaboration?
    - How successful was it compared to your other collaborations?

11. How many publications have resulted from this collaboration team?
    - In which journals?
    - Is it fairly straightforward to decide who should be first author?
12. Have you encountered any problems with this collaboration?
   - If yes, what were these problems and how did you address them?
   - Are you satisfied with the outcome?
   - How about your other collaborations, did you encounter problems with them?

13. Did any ethical or moral concerns influence the collaboration?
   - Did your collaborator in any way push for you to carry out the research in a way that you felt didn’t totally fit the norms and cultures in your country?
   - Did you feel that your collaborator was in any way pushing for too much influence on the project, or to get more than a fair share of the project’s benefits?
   - If yes, what were these concerns and how did you address them?
   - Are you satisfied with the outcome?
   - How about your other collaborations, did you encounter ethical concerns with them?

OUTPUTS/IMPACTS OF COLLABORATIONS

14. Are the findings of this collaborative research likely to have practical applications?
   - If yes, what are these applications, new products, clinical practices etc?
   - Do the findings of the project have relevance for addressing local health needs in your country/your partner’s country (ex: medicines, vaccines, diagnostics for developing countries)?
   - Are these products/services aimed at the health needs of poor people in your countries?
   - If so how likely is it that they will have access to the products/services?
   - Are the findings also relevant for health needs of developed countries?

15. How can the potential practical applications be realized?
   - Are you and your partners working to take this project further? If so, how?
   - If not, why are you not working to realize these practical applications?
   - From whom do you seek support to take the project further?
   - Is there somebody in your country I could approach to ask questions on how the findings of this research could be implemented?

16. Has any IP/patent been generated from this collaborative project?
- If so, what is the agreement on IP/patent sharing?

17. What were some factors that encouraged the project?
   - Did you take advantage of any special policies/programmes?
   - Did being part of an international collaboration make it easier to have access to incentives?

18. What were the barriers the project faced?
   - How did you address them?
   - Was being part of an international collaboration useful in overcoming barriers?

POLICIES/PLANS

19. What are the key organisations in the health biotechnology sector in your country/partner country that have influenced this project (e.g. government, public research institutions, universities, NGOs, user groups, funding agencies, private firms, international organisations, regulatory agencies, laws)?
   - How have they influenced the project?
   - Do you consider the influences/linkages with these organisations to have been beneficial?
   - What were some of the challenges in establishing and maintaining linkages with these organisations?

20. How do you think this collaboration could be strengthened to encourage innovation?

21. How do you think this collaboration could be strengthened to contribute towards improvements in global health?

22. What could the government in your country do to promote effective collaboration with your partner country?
23. How do you view the prospects of collaborating with developing countries organisations in general?
   - Both public or private?
   - Do you plan to continue to collaborate with this team?

24. Does your institute place a larger emphasis on north-south collaborations rather than south-south collaborations?
   - If so, why? How do they differ?

25. Is there anything else you would like to discuss that you feel is relevant to this topic?
**Appendix 3 – Interview Guide: Entrepreneurs**

**INTERVIEW GUIDE FOR ENTREPRENEURIAL COLLABORATION**

*The texts in italics are recommended follow up questions if needed*

Name of Interviewee:  
Organisation:  
Date:

**COLLABORATION**

1. **How** was the alliance between your institute/organisation and [name of firm] formed?
   - *Who initiated the collaboration?*

2. What were the **reasons** for choosing to do this work in partnership with [name of firm]?
   - *Would your firm have been able to do the work without international collaboration?*
   - *Would your partner have been able to do the work without international collaboration?*

3. How would you describe your main **contributions** to this international collaboration?
   - *What did your partners contribute to the project?*
   - *When you were setting up the collaboration, how did you evaluate the different partners’ potential contributions to the collaboration?*

4. What are your main **sources of innovative** ideas for research and development in the collaboration project?
5. Do you consider this to be a **successful** collaboration?
   - What are your criteria for a successful collaboration?
   - If successful, what contributed to the success of the collaboration?
   - How successful was it compared to your other collaborations?

6. Did you encounter any **problems** with the collaboration?
   - If yes, what were these problems and how did you address them?
   - Are you satisfied with the outcome?
   - How about your other collaborations, did you encounter problems with them?

7. Did any **ethical or moral concerns** influence the collaboration?
   - Did you collaborator in any way push for you to carry out the work in a way that you felt didn’t totally fit the norms and cultures in your country?
   - Did you feel that your collaborator was in any way pushing for too much influence on the project, or to get more than a fair share of the project’s benefits?
   - If yes, what were these concerns and how did you address them?
   - Are you satisfied with the outcome?
   - How about your other collaborations, did you encounter ethical concerns with them?

**PROJECT**

8. What types of **formal arrangements** have you established with [name of firm]?

9. What are the main **outputs** from this collaborative project?
   - Does the project have practical applications? If yes, what are these applications?
   - Does it have relevance for addressing local health needs in your country/partners country?)
   - Is the project also relevant for other low and middle income nations?
10. What are your future plans for this project?

11. What are institution’s/firm’s manufacturing capabilities?
   - What are your arrangements for bringing products through development/clinical trials?

12. What are your sources of funding for the collaborative project (e.g. governmental agency, angels, financial institutions, VCs, NGOs, etc.)? Please provide the names.
   - Did you and your partner apply for funding jointly or separately?
   - Has funding been easily available and sufficient?

13. Has any IP/patent been generated from the collaborative project?
   - If so, what is the agreement on IP/patent sharing?

14. Have you sought regulatory approval for a product resulting from this collaboration?
   - If so, in which countries did you seek regulatory approval?
   - From which regulatory bodies?

15. What are the target markets for the product resulting from this collaboration?
   - What is your pricing scheme?
   - What is the agreement for splitting of revenues for the two collaborating organisations?

16. What were barriers the project faced?
   - How did you address these issues?
   - Was being part of an international collaboration useful in overcoming barriers?
LINKAGES/IMPACTS

17. What are the **key organisations** in the health biotechnology sector in your country/partner country that have **influenced** this project (e.g. government, public research institutions, universities, NGOs, user groups, funding agencies, private firms, international organisations, regulatory agencies, laws)?
   - *How have they influenced the project?*
   - *Do you consider the influences/linkages with these organisations to have been beneficial?*
   - *What were some of the challenges in establishing and maintaining linkages with these organisations?*

18. What were some factors that **encouraged** the project?
   - *Did you take advantage of any special policies/programmes?*
   - *Did being part of an international collaboration make it easier to have access to incentives?*

19. How does your collaboration with firms/organisations in low and middle income countries **compare** to collaboration with high income countries in general terms?

20. What **measures** do you think governments and international organisations could make to strengthen south-to-south collaboration?
   - *What do you think can be done to help firms/organisations to initiate collaboration?*

21. How do you think this collaboration could be **strengthened** to encourage innovation?

22. How do you think this collaboration could be strengthened to contribute towards improvements in **global health**?

23. Is there anything else you would like to discuss that you feel is relevant to this topic?
Appendix 5 – Interview Guide: Innovation System Actors

INTERVIEW GUIDE FOR INNOVATION SYSTEMS’ ACTORS

The texts in italics are recommended follow up questions if needed

Name of Interviewee: Organisation: Date:

BACKGROUND

1. Can you give me a brief overview of your organisation’s work?
   - What is its main focus/capabilities? Please include a little about its background and previous experiences in the health biotechnology field.
   - How do you choose which areas/projects to work on?

2. Approximately what proportion of research projects in your country would you say are carried out in collaboration with parties from other developing countries?

3. Who are the main partners that you collaborate with?
   - From which countries?
   - From what types of organisations do they come public research institutions, hospital, universities,

COLLABORATION
4. What do you feel are the main reasons for South-to-South collaboration with other countries (e.g. human resource training, economic impacts, bilateral relations, etc.)?

5. How would you describe the contributions of your country to international collaborative projects?

6. How did you become interested in the research area of this collaborative project?
   - Did you or your collaborators suggest it?
   - What are your main sources of innovative ideas for the joint research?

7. How did you get to know your collaborators?

8. Where did you get the funding to carry out South-to-South collaboration projects (e.g. governmental agency, angels, financial institutions, VCs, NGOs, etc.)? Please provide the names.
   - Do you and your partners apply for funding jointly or separately?
   - Has funding been easily available and sufficient?

9. How do collaborations tend to be arranged between institutions or individuals?
   - Are they formal or informal in nature?

10. Do you consider your country’s health biotechnology collaborations to be successful?
    - What are your criteria for a successful collaboration?
    - If successful, what contributed to the success of the collaboration?
    - How successful was it compared to your other collaborations?
    - Can you give some examples of successes?

11. Do you know of any problems with collaborations?
- If yes, what were these problems and were they addressed? If so, how?
- Are you satisfied with the outcome?

13. Did any **ethical or moral concerns** influence the collaboration?
   - If yes, what were these concerns and were they addressed? If so, how?
   - Are you satisfied with the outcome?

**OUTPUTS/IMPACTS OF COLLABORATIONS**

14. Do you see collaborations with your country as having **relevance** for addressing your local health needs (e.g. developing or producing medicines, diagnostics, or vaccines for the developing world)?
   - If yes, what are these applications, new products, clinical practices etc?
   - Are the findings also relevant for health needs of developed countries?

15. How can the potential practical applications be **realized**?
   - Are you and your partners working to take this project further? If so, how?
   - If not, why are you not working to realize these practical applications?
   - From whom do you seek support to take the project further?
   - Is there somebody in your country I could approach to ask questions on how the findings of this research could be implemented?

16. Have any **IPs/patents** been generated from your collaborations?
   - If so, what is the agreement on IP/patent sharing?

17. What were some factors that **encourage** collaborative projects?
   - Did you take advantage of any special policies/programmes?
   - Did being part of an international collaboration make it easier to have access to incentives?

18. What were the **barriers** the project faced?
- How did you address them?
- Was being part of an international collaboration useful in overcoming barriers?

POLICIES/PLANS

19. What are the key organisations in the health biotechnology sector in your country/partner country that have influenced this project (e.g. government, public research institutions, universities, NGOs, user groups, funding agencies, private firms, international organisations, regulatory agencies, laws)?
   - How have they influenced the project?
   - Do you consider the influences/linkages with these organisations to have been beneficial?
   - What were some of the challenges in establishing and maintaining linkages with these organisations?

20. How do you think this collaboration could be strengthened to encourage innovation?

21. How do you think this collaboration could be strengthened to contribute towards improvements in global health?

22. What could the government in your country do to promote effective collaboration with your partner country?
   - How about the government in your partner country?

23. How do you view the prospects of collaborating with developing countries organisations in general?
   - Both public or private?
   - Do you plan to continue to collaborate with this team?
24. Does your institute place a larger emphasis on **north-south** collaborations rather than **south-south** collaborations?
   - *If so, why? How do they differ?*

25. Is there anything else you would like to discuss that you feel is relevant to this topic?
Appendix 6 – Status of biotechnology and bio-safety policies in Africa
<table>
<thead>
<tr>
<th>Member Country &amp; Population</th>
<th>Biotechnology/Biosafety Policy</th>
<th>Biosafety Regulatory Regime</th>
<th>Aspects on Commercial planting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burundi 8.5 Million</td>
<td>Draft Biotechnology Policy</td>
<td>Sectoral legislation with ref. to biotech Draft Biosafety Bill 2006</td>
<td>Draft Bill provides for risk assessment and management measures to deal with potential impacts of GMO on biodiversity.</td>
</tr>
<tr>
<td>Comoros 0.8 Million</td>
<td>Draft Policy on Biotechnology issue</td>
<td>No specific Biosafety law.</td>
<td>Reference made to policy and a precautionary approach to production, transit, importation, and dissemination of GMOs or products thereof without express permission.</td>
</tr>
<tr>
<td>DR Congo 62.6 Million</td>
<td>Draft National Biosafety Policy</td>
<td>Draft Biosafety Bill.</td>
<td>No reference made to preventive measures to manage potential risks associated with modern biotechnology.</td>
</tr>
<tr>
<td>Djibouti 0.8 Million</td>
<td>No stand alone Biotech Policy. References to biotech issues implicit in Policy on Environment.</td>
<td>No specific Biosafety law.</td>
<td>Regulatory gap - No legislation of GMOs and their transboundary movement.</td>
</tr>
<tr>
<td>Egypt 75 Million</td>
<td>No stand alone Biotech Policy. Various government policies on biotech and biosafety issues.</td>
<td>Regulations governing GMOs through Ministerial Decree. No specific biosafety law.</td>
<td>Reference made to guidelines on modalities of use, handling, transfer and testing of GMOs; Commercial planting of Bt maize approved in 2008.</td>
</tr>
<tr>
<td>Eritrea 4.8 Million</td>
<td>Draft National Biosafety Policy.</td>
<td>Sectoral legislation with ref. to biotech Draft Biosafety Law and Guidelines.</td>
<td>Draft Policy makes reference to adoption of a precautionary approach and mentions some measures—case-by-case screening for demonstrated risks and scientific uncertainties, tighter rules for screening for GM seeds and comprehensive labelling.</td>
</tr>
<tr>
<td>Ethiopia 83 Million</td>
<td>No stand alone Biotech Policy. References to biotech issues made in other sectoral policies e.g. Policy on Environment.</td>
<td>Draft Biosafety Proclamation and Six Ministerial Directives.</td>
<td>Highly precautionary and reference made for a new law to strictly govern movement of GMOs.</td>
</tr>
<tr>
<td>Kenya 37 Million</td>
<td>Has stand-alone National Biotechnology Development Policy.</td>
<td>Biosafety Act 2009</td>
<td>A number of trials taking place under existing regulations. Biosafety Act 2009 makes provision for developing regulations on environmental releases. Reference made to regional biotech initiatives and need for regional cooperation.</td>
</tr>
<tr>
<td>Libya 6 Million</td>
<td>Draft National Biosafety Policy.</td>
<td>No specific biosafety law.</td>
<td>Makes reference to guidelines dealing with specific aspects of biotechnology under Law No.15/2003. Covers handling, transport, packaging, and identification of LMOs for use as food or feed or for processing.</td>
</tr>
<tr>
<td>Madagascar 19 Million</td>
<td>National Biosafety Policy.</td>
<td>Draft Biosafety Bill.</td>
<td>Reference made on a participatory decision-making mechanism in the course of use of GMOs.</td>
</tr>
<tr>
<td>Mauritius 1.2 Million</td>
<td>No stand alone Biotech Policy.</td>
<td>GMO Act 2003.</td>
<td>Reference made to risk assessment and considers both direct and indirect effects on the environment, human and animal health and socio-economic effects; Act also reliant on usage of notices prior to action even where permission has been granted. Act uses a permit system of regulation for use, market, produce, release into the environment, transit, import or export of GMOs.</td>
</tr>
<tr>
<td>Rwanda 9.7 Million</td>
<td>National Biosafety Policy developed during NBF project.</td>
<td>Draft Biosafety Bill, Draft biosafety guidelines.</td>
<td>Reference made to establishment of ad hoc committees by Cabinet to assist NBC in identifying, assessing, analysing or reviewing information on GMOs.</td>
</tr>
<tr>
<td>Seychelles 0.086 Million</td>
<td>No stand alone Biotech Policy. References to biotech issues made in other sectoral policies.</td>
<td>No specific biosafety law, Sectoral legislation with references to biotech.</td>
<td>Reference made to participatory risk assessment and risk management procedures but also highly precautionary to introduction of GMOs due to high vulnerability (small island).</td>
</tr>
<tr>
<td>Sudan 38 Million</td>
<td>National Biosafety Policy included in NBF.</td>
<td>Draft Biological Safety Bill.</td>
<td>Reference made for risk assessment and management measures before environmental release of GMOs.</td>
</tr>
<tr>
<td>Swaziland 1.1 Million</td>
<td>Draft national Biotech Policy.</td>
<td>Sectoral legislation with ref. to biotech Draft biosafety law.</td>
<td>Legal framework cover confined field trials, pre and commercial releases of GM materials and live imports; acknowledges low technical capacity and emphasizes post-market surveillance.</td>
</tr>
<tr>
<td>Uganda 50 Million</td>
<td>National Biotechnology and Biosafety Policy 2008.</td>
<td>Sectoral legislation with ref. to biotech Draft Biosafety Bill.</td>
<td>Reference made for an enabling environment to utilise biotechnology safely as a tool for sustainable development in the context of poverty eradication action plan and MDGs. Institutional framework exists for policy and legislation implementation.</td>
</tr>
<tr>
<td>Zambia 11.9 Million</td>
<td>Biotechnology &amp; Biosafety Policy 2003.</td>
<td>Draft Biosafety Bill.</td>
<td>Precautionary stance - policy states approval for transfer, use and release of GMOs shall not be given where there is reason to believe that harm or damage may result. Release of GMOs is highly restricted and subjects products intended for direct use as food or feed to the same application procedures as notification for release into the environment.</td>
</tr>
<tr>
<td>Zimbabwe 13.3 Million</td>
<td>Has stand-alone National Policy on Biotechnology.</td>
<td>National Biotechnology Authority Act Research (Biosafety) Regulations of 2000 to be replaced soon.</td>
<td>Reference made to the wide scope of the Biosafety Act- regulates all biotechnology processes, products and applications from research, import, export and contained use.</td>
</tr>
<tr>
<td>Trade in GM products</td>
<td>Food aid with GM content</td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------------</td>
<td>--------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Draft Bill covers exports of GMOs or products derived from GMOs. Current trade guidelines according to EAC.</td>
<td>Biosafety Law contains notification and authorization procedures prior to an intentional transboundary movement of GMOs intended for food or processing. Subscribes to CODEX</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reference made to sectoral laws relating to movement of LMOs but developed prior to ratification of the CBD.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Draft Policy provides for exemptions and procedures for importation of GMOs and their products for human consumption.</td>
<td>Sectoral laws provide for inspection and control of food products imported into the country for human consumption.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not specific to GMOs — piecemeal legislation for requirements on importation of plants and animal products and standards to be met. Decision-making procedure unclear.</td>
<td>Information not available but subscribes to CODEX.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not Available</td>
<td>Not Available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Procedures for importation of GM crops have been prepared.</td>
<td>Subscribes to CODEX</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acknowledges high probability of transboundary movement of GMOs and from importation.</td>
<td>Subscribes to CODEX</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Draft Biosafety proclamation has been prepared to regulate import, export, transit, handling, transport and placing on the market of GMOs.</td>
<td>Subscribes to CODEX and has been a major recipient of food aid. National standards apply.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schedule in Biosafety Law make provision for import, export, placement on the market and handling of GMOs in transit. Current trade guidelines according to EAC.</td>
<td>Subscribes to CODEX and EU accepted GMOs acceptance levels.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Law 15/2003 covers transboundary movement (import/export).</td>
<td>Subscribes to CODEX</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not available.</td>
<td>Subscribes to CODEX</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current trade guidelines according to SADC.</td>
<td>Guidelines developed during the serious food crisis of 2002. Subscribes to CODEX.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trade Guidelines according to SADC BUT also provides for mandatory labelling and identification of GMOs and their derivatives.</td>
<td>A restrictive approach that exceeds provisions of the Biosafety Protocol. Subscribes to CODEX.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current trade guidelines according to EAC.</td>
<td>Subscribes to CODEX.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trade guidelines according to SADC but puts emphasis on strict regulation for transportation of GMOs transited in the country.</td>
<td>Member of WHO and FAO. Recognizes application of CODEX.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Policy—covers trade in transboundary movement of GMOs.</td>
<td>Working policy makes reference to food and feed aid involving GMOs. Subscribes to CODEX.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trade guidelines according to SADC.</td>
<td>Policy on biosafety states that food aid with GM content should be milled prior to distribution. Subscribes to CODEX.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recognises transboundary movement as inevitable and emphasises need for harmonisation; Current trade guidelines according to EAC.</td>
<td>Subscribes to CODEX.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trade guidelines according to SADC and acknowledges transboundary movement inevitable thus makes provisions, but remains highly precautionary of GMOs and their products with some degree of departure from CPB.</td>
<td>Policy subjects GMOs intended for food, feed or processing to Advance Informed Agreement (AIA) - A restrictive approach that exceeds provisions of the Biosafety Protocol. Subscribes to CODEX.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reference made to a National Biotechnology Fund to promote marketing and production of GMOs.</td>
<td>Subscribes to CODEX.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Biotechnology (AAB).

African Regional Programme and Research Network for Biotechnology, Biosafety and Biotechnology Policy Development (BIO-EARN) and Africa Agency of Great Lakes Countries (CEPGL) East African Community (EAC), and are involved in other biotechnology/biosafety regional initiatives such as the East

Conclusion:

Most institutional frameworks include implementation agencies taking different forms such as biosafety inspectors

Note:

Public participation prior to the decision making

Interdisciplinary consultation in the form of a Biosafety Advisory Committee

Applications for biotechnology use or entry subjected to a government agency or office mandated with decision making task.

More than one NCA, each with sectoral responsibilities and a single or multiple windows for receipt of applications for GMOs;

A single National Competent Authority (NCA) referenced differently in each country e.g. National Biosafety Authority (NBA);

Applications for biotechnology use or entry subjected to a government agency or office mandated with decision making task.

The institutional structures for most COMESA countries take either of the following forms:

A single National Competent Authority (NCA) referenced differently in each country e.g. National Biosafety Authority (NBA);

More than one NCA, each with sectoral responsibilities and a single or multiple windows for receipt of applications for GMOs;

Applications for biotechnology use or entry subjected to a government agency or office mandated with decision making task.

Interdisciplinary consultation in the form of a Biosafety Advisory Committee

Public participation prior to the decision making

Note: Most institutional frameworks include implementation agencies taking different forms such as biosafety inspectors

Reference to International Instruments


Note: Most COMESA countries also belong to other regional blocs such as the Southern African Development Community (SADC), Economic Community of Great Lakes Countries (CEPGL), East African Community (EAC), and are involved in other biotechnology/biosafety regional initiatives such as the East African Regional Programme and Research Network for Biotechnology, Biosafety and Biotechnology Policy Development (BIO-EARN) and Africa Agency of Biotechnology (AAB).

Conclusion:

By early 2009, 89% of COMESA member countries had developed their national biosafety frameworks based on UNEP-GEF guidance and framework. While regional cooperation had been acknowledged as fundamental in guiding the process, this did not happen and the frameworks were thus developed within a national contexts. This lack of coordination resulted in overlaps and protracted processes overriding the regional goal of resources optimization – fiscal, human and infrastructural with respect to biotechnology and biosafety development. The situation is compounded by the existence of several regional initiatives and multiple membership in regional trading blocks, some with conflicting trade requirements. Given the observed substantive developments in biotechnology in a number of member countries and heightened political goodwill, there is real opportunity for RABESA II to impact positively on the regionalization process. A good starting point would be to advocate for sharing of existing biotechnology policy documents and legislative frameworks with a view to identifying commonalities that would guide development of minimum and acceptable procedures and guidelines for adoption by individual member countries.

Objectives of the Biotech/Biosafety Frameworks

The fundamental objectives are similar and address three main principles:

- To promote research and development in biotechnology for alleviating poverty and achieve sustainable development;
- To build capacities to develop and safely apply biotechnology in agriculture, health, mining, industry and other areas e.g. biofuels;
- To ensure policies are science-based and promote food security and economic growth.

The frameworks are thus developed in the context of the three main elements that constitute sustainable development namely:

- Environmental protection
- Economic development
- Social development

National Biotechnology Policies

The effectiveness or otherwise of the biosafety regulatory frameworks of the COMESA countries will thus be determined by their capacity to adopt the use of biotechnology to bring about sustainable development at national and regional levels. Although the countries are at different stages in terms of biotechnology activities, their policies, whether approved or in draft form, lay emphasis on different aspects of biotechnology. Countries such as Kenya and Uganda focus on facilitating biotechnology research through capacity building and infrastructure development. The policies anticipate commercialization of GMOs and seek to regulate it. On the other hand, the policies of Malawi and Zambia seem to indicate a cautious approach to GMOs.

The findings of the assessment placed the countries into three categories as summarized in Table 2:

Table 2 - Status of National Biotechnology Policies

<table>
<thead>
<tr>
<th>Category Status</th>
<th>COMESA Country/countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comprehensive National Biotech and biosafety policies</td>
<td>Kenya, Madagascar, Malawi, Rwanda, Sudan, Uganda, Zambia and Zimbabwe</td>
</tr>
<tr>
<td>Draft Biotech policies</td>
<td>Burundi, Comoros, DR Congo, Eritrea, Libya and Swaziland</td>
</tr>
<tr>
<td>Sectoral policies with reference to biotech and biosafety</td>
<td>Ethiopia, Djibouti, Egypt, Mauritius and Seychelles</td>
</tr>
</tbody>
</table>

Institutional arrangements

All COMESA countries have put in place institutional frameworks to govern biotechnology. The majority take the form of National Biosafety Committees (NBCs) which fall under different Ministries, key among them - Higher Education, Science and Technology (Kenya and Zambia), Agriculture and Lands Reclamation (Egypt), Ministry of Environment and Natural Resources (Malawi, Seychelles, Rwanda, Uganda, Swaziland and Libya), Ministry of Tourism, Environment and Communication (Swaziland), and, Inter-Ministerial (Burundi, Ethiopia and Madagascar).

Institutional Structures for Biotechnology and Biosafety

The institutional structures for most COMESA countries take either of the following forms:

- A single National Competent Authority (NCA) referenced differently in each country e.g. National Biosafety Authority (NBA);
- More than one NCA, each with sectoral responsibilities and a single or multiple windows for receipt of applications for GMOs;
- Applications for biotechnology use or entry subjected to a government agency or office mandated with decision making task.
- Interdisciplinary consultation in the form of a Biosafety Advisory Committee
- Public participation prior to the decision making

Note: Most institutional frameworks include implementation agencies taking different forms such as biosafety inspectors

<table>
<thead>
<tr>
<th>Category Status</th>
<th>COMESA Country/Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Status</td>
<td></td>
</tr>
<tr>
<td>Approved Biotech/Biosafety Policy and Biosafety Law</td>
<td>Kenya, Malawi, Zambia and Zimbabwe</td>
</tr>
<tr>
<td>Approved Biotech/Biosafety Policy and Draft Biosafety Law</td>
<td>Madagascar and Uganda</td>
</tr>
<tr>
<td>Approved Biosafety Law but no stand alone policy on biotechnology or biosafety</td>
<td>Mauritius</td>
</tr>
<tr>
<td>Working Biotech/Biosafety Policy and Draft Biosafety Law</td>
<td>Sudan and Rwanda</td>
</tr>
<tr>
<td>Draft Biotech/Biosafety Policy and Draft Biosafety Law</td>
<td>Burundi, DR Congo, Eritrea, Swaziland and Comoros</td>
</tr>
<tr>
<td>No stand alone policy but references to biotechnology and biosafety in other government policy documents</td>
<td>Djibouti, Egypt, Ethiopia, Libya and Seychelles</td>
</tr>
</tbody>
</table>
Appendix 7 – Consent Form
SOUTH AFRICA’S HEALTH BIOTECHNOLOGY COLLABORATION WITH CHINA & INDIA:
CONSENT FORM

The purpose of the study is to identify the factors that have encouraged successful collaborative initiatives between South Africa and China/India in the field of health biotechnology. This is part of a wider study on collaboration in health biotechnology between emerging economies and developing countries. This research is carried out by the University of Toronto’s McLaughlin-Rotman Centre for Global Health, and is supported by a grant from the Canadian Institutes of Health Research (CIHR).

I, ____________________________ , on behalf of ____________________________
(Name of Person) (Name of Institution/Firm)

agree to participate in a study that is investigating the role of international collaboration between South Africa and China/India in the production of knowledge, health products and health services.

By signing this form, I indicate that I:

1. Have read and understand the Letter of Invitation, including the project rationale, description and methodology as described therein.

2. Understand that the process involves open-ended face-to-face interviews with the study investigators and that the interviews will be digitally recorded and transcribed.

3. Understand that my quotes or opinions provided during this consultation may only be used in academic publications and public presentations after obtaining my permission.

4. Understand if there are any questions I refrain from answering I am welcome to do so.

5. Understand that there are no risks associated with participation in this study.

6. Understand that I will not benefit from participating. The primary benefit of this study will be its contribution to knowledge as to how international collaboration can address global health needs.

7. Understand that I can withdraw from the study at any time without explanation.

8. Have not waived any of the legal rights that I have as a participant in this research study after signing this form.
9. Have free access to publications or other research reports based on this research.

10. Have been given a copy of this consent form.

SIGNED:

________________________________________  ______________
PARTICIPANT'S SIGNATURE              DATE

________________________________________
PARTICIPANT'S PRINTED NAME

________________________________________  ______________
INVESTIGATOR'S SIGNATURE              DATE

Halla Thorsteinsdóttir

INVESTIGATOR'S PRINTED NAME

Should you have any questions, please contact Dr. Halla Thorsteinsdóttir by email or phone.

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