

Doctoral Thesis

**Fostering knowledge space actor interactions in an
emerging place-based innovation ecosystem:
The case of Kigali Innovation City**

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The following work of the author is partially integrated in this thesis. All this work was undertaken throughout the time the author was registered at UCL working towards the completion of this thesis.

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Abstract

National Innovation Systems (NIS) are important for societal development, and how these systems play out is a function not only of who the actors in the system are, but also of how these actors interact at multiple levels. The critical question of ‘why’ weak actor interactions persists as a fundamental factor underpinning perpetual dysfunctionality of NIS in developing countries, has been widely debated in numerous science, technology and innovation (ST&I) policy studies, and a range of reasons have been unearthed. This thesis wades into these debates deploying the triple helix and innovation ecosystems frameworks to undertake a critical, real-time study of actor interactions using Rwanda as a case study country.

Taking a Critical Realist approach, this thesis examines Kigali Innovation City (KIC), a place-based innovation ecosystem within Rwanda’s broader NIS, to investigate three interrelated research questions: *How do academic and research organisations located in KIC and in its proximity interact with other actors for research, innovation and learning (RIL)? To what extent do these interactions contribute (or not) to KIC’s development? And What are the possible pathways for fostering these interactions?*

Given the complex nature of KIC, as an evolving national ST&I policy flagship intervention in a peri-urban setting, this study takes a two-phased research approach to explore the research questions. Drawing on data collected from semi-structured interviews and desk research, and based on thematic analysis, this thesis identifies the KIC Knowledge Space actors and their interactions for RIL. It interrogates the suitability of the mainstream conceptual frameworks, such as NIS and triple helix system, originating in the global North for Rwandan context – particularly in relation to KIC’s local embeddedness – despite their central role in shaping the national ST&I policy. The thesis thus develops a context-specific, integrated conceptual framework – undergirded by an innovation ecosystems approach – offering fresh insights into pathways for understanding and fostering actor interactions in emerging place-based innovation ecosystems, taking a nuanced approach involving ST&I policy, urban context, and science diplomacy dimensions. The thesis argues empirically and conceptually that institutional and functional (dis) connectedness often exhibited by Rwanda’s NIS are deeply rooted in actor agency, collaboration, coevolution, and contestation.

Impact Statement

This thesis addresses different stakeholders in academic and policy spaces, including researchers, policymakers, bureaucrats, and funding agencies with interests in ST&I ecosystems and development in a developing country context.

Academic impact: This study's impact spans four dimensions - methodological, conceptual, empirical, and educational. Methodologically, this research has already made an impact. Unlike the mainstream research approaches with participants' role being solely to provide empirical data through interviews, this study's participants were actively engaged throughout the pilot phase, work-in-progress seminar, and post-pilot phase. Deliberate engagement of participants in research design ascertains knowledge co-creation, relevance, rigour, and transparency in qualitative research, and potential uptake. Moreover, this thesis extends the relevance of Critical Realism – as a philosophical foundation for knowledge creation at the interface of constructivism and positivism – by adding localism, highlighting virtual research in an online context.

Conceptually, this study offers a significant contribution towards framing the actor interactions as structured research problem. This research draws on an empirically rich case study to develop conceptual frameworks that would guide future studies of actor interactions on micro- (actor), meso- (ecosystem), and macro- (national system) scales in low-income country (LIC) contexts. For instance, after interrogating the mainstream triple helix system (THS) framework, this thesis proposes a contextualised THS framework with funding forming the fourth functional space, emphasising hybrid actors' influence in innovation ecosystem development. Moreover, this thesis proposes an integrated conceptual framework to study actor interactions for RIL in an emerging place-based innovation ecosystem in complex socio-technical settings.

Empirically and educationally, this work has already contributed to literature through one published journal paper and several conference papers. This thesis offers fresh insights into pathways of fostering actor interactions in innovation ecosystems, taking a nuanced approach involving ST&I policy, urban innovation, and science and innovation diplomacy perspectives. It broadens the understanding of multiple roles and capabilities of universities in shaping the place-based innovation ecosystems, and understanding how the COVID-19 pandemic has exposed these capabilities in LIC

and state-led ST&I settings. Moreover, this research was presented and discussed ten times with students from different MPA routes at STEaPP, UCL, over the period of four years.

Policy impact: With KIC being an evolving policy intervention at the interface of public policy and public administration dimensions of Rwanda's ST&I policy cycle, and considering its spatial dimension in a peri-urban region of City of Kigali, this thesis makes a systemic impact at different levels. For example, at a macro-level, this thesis develops a framework based on Technology Readiness Level (TRL) and R&D-based innovation theory, to reconcile two funding mechanisms for RIL for greater policy outcomes. Presently managed by two separate public entities, these instruments are institutionally and operationally disconnected and lack specific funding calls targeting KIC.

Moreover, this thesis maps the Rwanda ST&I and Foreign Policy nexus, revealing the Rwandan science and innovation diaspora's potential in fostering KIC Knowledge Space actor interactions for RIL, and strengthening the NIS.

From a spatial dimension of KIC as an urban smart city initiative, this thesis reveals KIC's institutional connection with central government while being detached from City of Kigali. The thesis thus recommends local authorities to draw on national development policies to incorporate KIC into City of Kigali's strategies. It also recommends KIC actors to engage with local authorities and adjacent communities thereby shaping KIC into an inclusive, sustainable, and locally embedded and relevant knowledge-based innovation ecosystem.

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Acronyms and abbreviations

ACE	African Centres of Excellence
AFD	French Agency for Development
AfDB	African Development Bank
Afretec	African Engineering and Technology Network
AIMS-Rwanda	African Institute of Mathematical Sciences, Rwanda Campus
ALU	African Leadership University
ANR	French National Research Agency
BERA	British Educational Research Association
BRICS	Brazil, Russia, India, China, and South Africa
CEBE	Centre of Excellence in Biomedical Engineering
CIRED	Centre for International Research, Education, and Development
CMU-Africa	Carnegie Meron University in Africa
DUI	Doing Using and Interacting
EDP	Entrepreneurial Discovery Process Engineering
GCR	Grand Challenges Rwanda, NCST
GIH	Grid Innovation and Incubation Hub, ACE-ESD, UR
GIZ	German Development Agency
GoR	Government of Rwanda
GoSA	Government of South Africa
HEC	Higher Education Council
HICs	High Income Countries
HLIs	Higher Learning Institutions [Organisations], Rwanda
ICTP-EAIFR	International Centre for Theoretical Physics, East African Institute of Fundamental Research
IE	Innovation Ecosystem
IGC	International Growth Centre
IIL	Industry Innovation Lab, CMU-Africa
INGSA	International Network for Government Science Advice
IPRC	Integrated Polytechnic Regional Centre, Rwanda Polytechnic
JADF	Joint Action Development Forum
JICA	Japan International Cooperation Agency
Kb-RD	Knowledge-based Regional Development Theory

KCRC	Kigali Collaborative Research Centre
KfW	German Development Bank
KIC	Kigali Innovation City, Rwanda
KOICA	Korea International Cooperation Agency
KSEZ	Kigali Special Economic Zone
KSI	Knowledge Systems Innovation
KTH	Royal Institute of Technology, Sweden
LICs	Low-Income Countries
LMICs	Low- and Medium-Income Countries
MINAFFET	Ministry of Foreign Affairs and International Cooperation, Rwanda
MINECOFIN	Ministry of Finance and Economic Planning, Rwanda
MINEDUC	Ministry of Education, Rwanda
MINICOM	Ministry of Trade and Industry, Rwanda
MINICT	Ministry of ICT and Innovation, Rwanda
MINIYOUTH	Ministry of Youth, Rwanda
MLP-STs	Multi-Level Perspectives and Socio-Technical Systems
MoH	Ministry of Health, Rwanda
MoU	Memorandum of Understanding
NCST	National Council for Science and Technology, Rwanda
NGOs	Non-governmental Organisations
NIH	National Institute of Health, USA
NIRDA	National Industrial Research and Development Agency, Rwanda
NIS	National Innovation System
NSF	National Science Foundation, USA
NUC	National Umushyikirano Council, Rwanda
NUR	National University of Rwanda
OECD	Organisation for Economic Co-operation and Development of Fundamental Research
PE	Political Economy
PPP	Public Private Partnership
RAB	Rwanda Agriculture and Animal Resources Board
RCA	Rwandan Community Abroad
RDB	Rwanda Development Board
RIC	Rwanda Innovation Challenge, NCST

RIF	Rwanda Innovation Fund
RIL	Research, Innovation and Learning
RISA	Rwanda Information Society Authority
RP	Rwanda Polytechnic
Rwanda FDA	Rwanda Food and Drugs Authority
S3	Smart Specialisation Strategies
SGCI	Science Granting Councils Initiative in Sub-Saharan Africa
SGCs	Science Granting Councils
Sida	Swedish International Development Agency
SMART	Strategic Mobilisation of African Resources for Transformational
SRMP	Smart Rwanda Master Plan
SSA	Sub-Saharan Africa
ST&I	Science, Technology, and Innovation
STeAPP	Science, Technology, Engineering and Public Policy Department, UCL
STEM	Science, Technology, Engineering, and Mathematics
STRINGS	Steering Science, Technology, and Innovation towards the Sustainable Development Goals Project
THS	Triple Helix Systems
TIP	Transformative Innovation Policy framework
TRL	Technology Readiness Levels
TVET	Technical and Vocational Education and Training
UCL	University College London
UCL REC	UCL's Research Ethics Committee
UCL SLREC	UCL STeAPP Local Research Ethics Committee
UKRI	UK Research Innovation
ULK	Kigali Independent University (French: Université Libre de Kigali)
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UR	University of Rwanda

Glossary of key terms

Agency: The capacity of individuals or organisations aka actors to act independently, and make their own free choices (Kopp, 2021).

Capability: ‘The resources available to individuals, organisations, and the wider system as a whole, that are required to fulfil a particular task’ (Kopp, 2021, p. 345).

Capacity: ‘The set of skills and resources – or competences and capabilities – necessary to perform policy functions’ (Wu et al., 2015, p. 166).

Cognitive Proximity: ‘The similarities of the knowledge bases of actors’ (Zhao et al., 2022, p. 4).

Coordination: ‘The instruments and mechanisms that aim to enhance the voluntary or forced alignment of tasks and efforts of organisations within the public sector. These mechanism[s] are used in order to create a greater coherence, and to reduce redundancy, lacunae, and contradictions within and between policies, implementation, or management’ (Kopp, 2021, p. 345).

Developmental University: A university committed to contributing to societal sustainable development through education, research and engagement with community and civil society. It produces, disseminates, and uses knowledge taking into consideration social values. Moreover, development universities cooperate with public policies aimed at inclusive development (Arocena, Göransson & Sutz, 2017).

Ecosystem: A dynamic framework consisting of a set of actors, including start-ups, hubs, investors, academic institutions, public institutions, corporations, who interact and engage with each other to seize new opportunities, support innovation and strengthen the overall business environment for entities at different stages, sectors, and geographical locations’ (Washbourne et al., 2021, p. 3).

Entrepreneurial University: Central to Triple Helix System (THS), entrepreneurial university integrates economic development into its core mission, alongside education and research, by fostering innovation, entrepreneurship, and commercialisation of research outcomes (Feola et al., 2021).

Flagship programmes/policy interventions of a government: The main programmes that tackle significant national issues in areas such as health, education,

environment, irrigation, urban and rural development, employment, and other sectors (Das, 2023). A flagship programme comprises four policy characteristics: innovative, distinctive, uniqueness, and self-defined (Birrell, 2009).

Geographical Proximity: Physical ‘co-location of the actors (...) a means of creating trust’ (Mattes, 2012, p. 11).

Innovation City: A geographic concentration of diverse and specialised innovation clusters, such as industrial and knowledge clusters, aiming to facilitate the development strategy of a city, region, or country. (Mugwagwa et al., 2021).

Innovation cluster: ‘A concentration of interconnected and competing firms and organisations, producing similar or related products and/or services, in specific geographical location. These actors form an innovation cluster when they cooperate to allow the flow of knowledge and/or technology through formal or informal interactions at individual or organisational level’ (Washbourne et al., 2021, p. 3)

Innovation Ecosystem (IE): ‘The evolving set of actors, activities, and artefacts, and the institutions and relations (...) that are important for the innovative performance of an actor or a population of actors’ (Mugwagwa et al., 2021, p. 4).

Innovation Incubation Centre: A facility designed to support the development and growth of new and innovative ideas into viable businesses. These centres provide resources such as office space, laboratories, seed funding, mentorship, and technical support to start ups and entrepreneurs. The goal of innovation incubation centres is to nurture early-stage companies through the critical phases of development until they can operate independently and sustainably (Chandra et al., 2003; Kulkarni and Mandhare, 2021).

Innovation: Viewed through the National Innovation System (NIS) lens, innovation is defined as ‘an interactive learning process. It starts with a good idea, but necessarily includes the creation of new products, tools or processes that are tested and taken up and used by their targeted audiences’ (Washbourne et al., 2021, p. 5).

Institutional proximity: ‘Coherence in regard to laws, [policies], and values’ (Mattes, 2012, P. 10)

Interactions: The dynamic exchanges and relationships among diverse actors within the innovation (eco) system, which facilitate the flow of knowledge, resources, and capabilities necessary for innovation.

National Innovation System (NIS): ‘The elements [actors] and relationships which interact in the production, diffusion [dissemination], and use of new, and economically useful knowledge, (...) and are either located within or rooted inside the borders of a nation state’ (Lundvall, 2010, p. 2).

Organisational proximity: ‘The extent to which relations are shared in an organisational arrangement’ (Mattes, 2012, p. 9).

Policy cycle: A framework used to understand the process of policy-making. Policy cycle typically include several stages or phases, namely, ‘problem definition, policy development, implementation, enforcement, and evaluation, or agenda-setting, analysis, formulation, implementation, monitoring [through learning for termination or renewal]’ (Edelmann and Albrecht, 2023, p. 4).

Policy design: ‘The deliberate and conscious attempt to define policy goals and to connect them to instruments or tools expected to realise those objectives’ (Kopp, 2021, p. 346).

Policy instruments: Tools, techniques, or mechanisms that governments use to implement policies and attain their desired goals (Werdiningtyas et al., 2020; Capano and Howlett, 2020).

Public administration: ‘The formal procedural and organisational arrangements under which public employees serve a government, by implementing and advising on policy, and managing resources’ (Johnston, 2001, pp. 2–3).

Public Policy: ‘A tool used by societies to allocate communal resources, solve problems, and improve conditions. Public policies are particularly useful when individuals are unable to resolve specific conflicts on their own, but do agree on a political process for collective decision-making’ (Golden and Moreland-Russell, 2016, p. 18).

Seed funding: The initial capital provided to support the early-stage development of innovation projects and startups, often aimed at fostering research and entrepreneurial activities within academic institutions (Ayoub et al., 2017).

Social Proximity: 'A result of shared personality characteristics, personal interaction, and a sense of familiarity between individual actors' (Mattes, 2012, P. 10-11).

Socio-technical system: 'The configuration of elements (technologies, markets, policies, user practices, cultural meanings, manufacturing) that underpin the fulfilment of societal functions such as mobility, heating, shelter, and sustenance' (Kopp, 2021, p. 347).

System: 'A set of elements or parts that is coherently organised and interconnected in a pattern or structure that produces a characteristic set of behaviours, often classified as its function or purpose' (Meadows, 2008, p. 188).

Triple Helix Systems (THS): 'An analytical construct that synthesises the key features of university-industry-government (Triple Helix) interactions into an "innovation system" format, defined according to systems theory as a set of components [actors], relationships, and functions' (Ranga and Etzkowitz, 2013, p. 237).

PART I. INTRODUCTION, BACKGROUND, LITERATURE REVIEW, AND RESEARCH METHODS

Chapter 1. Introduction: Actor interactions, a policy problem in place-based innovation ecosystems

1.1 Introduction

Tools from science play a vital role in shaping society and these contributions are often realised through a range of dimensions including, *inter alia*, advancing knowledge and understanding through research and innovation (R&I) and capacity building (Mormina, 2019), enhancing healthcare systems and processes (Watanabe and Matsuda, 2023), driving economic development through technology and innovation (UNCTAD, 2019), and protecting the environment (Taylor et al., 2003). Science, technology and innovation (ST&I) also play a critical role in generating evidence to solve or shape global challenges such as climate change (Hughes et al., 2020), access to health and energy (Mulugetta et al., 2019), as well as food and sustainability challenges (Pigford et al., 2018). These contributions are not uncontested, and science alone cannot achieve these goals. Robust social, political, and economic structures are essential to support technologies and innovation (Mormina, 2019). Moreover, strong systems of innovation and collaborations among diverse actors, including policymakers, academia, industry, and civil society, are crucial for ST&I to effectively address societal challenges (Adenle et al., 2023).

Over the last few decades scholars developed scientific theories and concepts that underpinned the formation and evaluation of policy and governance systems and structures relevant to high-income countries (HICs) (Pinto, 2017; Zmiyak et al., 2020), middle income countries (Chaves Vilela et al., 2015; Albuquerque et al., 2015; Kruss, 2018; Persada et al., 2019; Nascimento et al., 2022), and low-income countries (LICs) (Chataway et al., 2014; Mugwagwa et al., 2014; Chataway et al., 2017; Hanlin and Tigabu, 2017; Chataway et al., 2019; Yongabo, 2021a; Kruss et al., 2021; Daniels et al., 2022) or all contexts (M. Ranga and Etzkowitz, 2013; Mensah and Enu-Kwesi, 2018; Schot and Steinmueller, 2018). Scholarly studies on the contribution of ST&I to society have often adopted the systems approach to determine the contribution of system actors - government, industry, university, civil society, and communities - to determine the roles of these actors and their interactions for knowledge and innovation creation, use, and dissemination (Guercini and Runfola, 2015; Yao et al., 2018; Nkusi et al., 2020; George, 2020) at multiple scales. Furthermore, scholarly studies of the

relationships amongst system actors, notably the university, industry, and government entities have been predominantly conceptualised through the lenses of both National Innovation System (NIS) and Triple Helix System (THS) frameworks. Both concepts are grounded in systems theory: actors, elements, components; relationships, interactions, and functions (Meadows, 2008; Saad et al., 2008; Ranga and Etzkowitz, 2013; Galvao et al., 2019), for knowledge creation, dissemination, and use (Saad et al., 2008; Ranga and Etzkowitz, 2013; Galvao et al., 2019). The NIS concept focuses on technological innovation, with the firm as central actor (Freeman, 1987), and NIS considers innovation as a learning process through the flow of economically useful knowledge for growth (Lundvall, 1992; Nelson, 1993). Lundvall (2010) stresses the importance of embracing the concept of innovation in its widest dimension: ST&I-based, and Doing, Using and Interacting (DUI)-based.

As a developed-country-centric concept, NIS has made significant contributions in informing ST&I policies over the last four decades. NIS ideas have also informed ST&I policy in various Asian countries – known as Asian Tigers (Hong Kong, Taiwan, Singapore, and South Korea) (Kim, 1998; Watkins et al., 2015; Khondker, 2021; Stockton and Yeh, 2022) leading to their successful catch-up with, and leap-frog over some leading global North countries, followed by the recently emerging economies forming the BRICS (Brazil, Russia, India, China, and South Africa) (Sarkar, 2014; Daniels et al., 2017b; Iqbal, 2022). Many of these countries have adopted similar systems approaches to create knowledge-based ST&I ecosystems for regional (or place-based) development within the NIS boundaries, through a range of concepts such as ‘industrial parks or districts’, ‘research or science and technology parks’ (Wdowiarz-Bilska, 2019; Krishna, 2019; van Winden and Carvalho, 2016), ‘special economic zones’ (Zeng, 2011; Zeng, 2012; Zeng, 2015) and ‘innovation districts’ (Katz and Wagner, 2014), ‘innovation hubs’ (Dosso et al., 2021) or ‘innovation cities’ (Inkinen, 2015; Washbourne et al., 2021), or else ‘smart cities’ (Appio et al., 2019; Bulkeley et al., 2019), where such ecosystems were and are experimented on and/or developed explicitly through the lenses of urban development policy innovation (Nilssen, 2019a).

Several African governments, the government of Rwanda (GoR) included, have followed pace in adapting and experimenting with the above-mentioned concepts to underpin their ST&I policies and knowledge-based development agendas and

aspirations driven by technology, specifically digital technologies, in order to respond to the contemporary and future development challenges of social, economic, and environmental dimensions (Daniels et al., 2017b; GoR, 2020b; Twiringiyimana et al., 2021). Nonetheless, scientific literature on the aforementioned concepts and their relationship with innovation and development in the African context remains scarce. Moreover, notwithstanding the achievements and indeed the downsides of the above-stated concepts elsewhere, the question as to whether these frameworks are suited to developing country contexts has increasingly been the subject of much debate among scholars, policymakers, and practitioners. The reasons for this hesitancy include that developing country economies are primarily driven by non-R&D performing companies, an 'informal sector' (Albuquerque et al., 2015; Arocena et al., 2017), and indigenous/local communities, who more often than not engage in modest, incremental innovations that remain 'below the radar' of NIS standards (Chataway et al., 2014; Papaioannou, 2014). This has led to the emergence and development of the concepts of 'inclusive innovation' (Chataway et al., 2014; Mavhunga, 2017; Levidow and Papaioannou, 2018), or 'innovation for inclusive development' (Daniels et al., 2017a; Gastrow et al., 2017), in relation to Sub-Saharan Africa (SSA) and other global South regions alike (Arocena et al., 2017; Yao et al., 2018). Furthermore, the quest to include a range of actors into innovation systems and the desire to examine the extent of these actors' roles in influencing ST&I policies and strategies has been an interesting subject for scientific inquiries in the past few decades. This has thus led to the development of a range of further theoretical concepts (or conceptual frameworks) useful to enable the making and governance of ST&I policies and strategies in HIC or LIC settings or both, on international, national, regional (or place-based, including urban), and organisational scales. The contextual and conceptual dimensions underpinning these frameworks with respect to actor interactions are critically analysed in chapter six of this thesis.

In SSA, Non-Governmental Organisations (NGOs), that is, civil society, including benevolent actors, play a key role in driving inclusive innovation, and governments and academia have been urged to give due attention to and further engage with these actors (Chataway et al., 2014). Similar advocacy has also been made for BRICS to include civil society actors into ST&I policy and governance framing if these countries want to transmute into economies capable of addressing the perceived real social and

economic development problems facing the population in the global South, failing which BRICS will be seen as 'representing the narrow business interests of a southern elite' (Sarkar, 2014). In an effort to measure the impact of innovation beyond product and process development for commercial gains, the Organisation for Economic Co-operation and Development (OECD) revised their innovation measurement method by including both commercial and non-commercial innovation indicators, as part of the 2018 revised Oslo Manual, to reflect the context of indicators from low- and middle-income countries (LMICs) (Lizuka and Hollanders, 2020). Nevertheless, the reality of non-existent or weak interactions between actors, limited scientific and technological capacities and capabilities, as well as poor institutional structures and governance were found to be at the core of the numerous unhealthy or dysfunctional NISs identified in the global South (Arocena et al., 2017), particularly in Africa (Kruss and Visser, 2017). Although these factors continue to impede the performance of national science and innovation systems in developing countries, they remain under-researched, particularly with regard to the dynamics of innovation ecosystems development in place-based (regional) settings within the NIS boundaries. For this reason, the present study aimed to investigate the nature and causes of the failure of NIS in a developing country setting, with Rwanda as the chosen case study.

1.2 Problem statement

1.2.1 What is the problem?

The contribution of NISs is important for societal development, and how this nexus plays out is a function not only of who the actors in the system are, but also of how they interact at multiple levels. There is lack of understanding of how the university system (academia), as the main source of formal knowledge generation, interacts with other actors for research, innovation and learning (RIL), particularly in LICs. Among the abundant research into the flow of knowledge, technology, innovation, and related capabilities in Rwanda's NIS, recent studies have highlighted numerous issues underpinning their underperformance. These include, *inter alia*: the failure to build scientific, technological, and innovation capabilities and skills, at both individual and organisational levels, specifically in the areas of information and communication technologies (ICTs) amongst Rwanda's NIS actors; the absence of growth in knowledge and technology output; and the deficiency in strengthening the science,

technology, and fostering innovation ecosystem, including in contriving conditions to enhance actor interactions for RIL (Nkusi et al., 2020; Yongabo and Göransson, 2020; GoR, 2020b; Twiringiyimana et al., 2021). These issues must be addressed if Rwanda is to meet her ambitious targets of transitioning from her present LIC status as stated by the World Bank (WB) (WB, 2018c), to that of knowledge-based upper middle-income (UMIC) nation by 2035, and further evolving into a HIC by 2050 (GoR, 2020h).

The critical question as to **‘why’** such an underperformance in developing countries persists to this day has been widely debated in numerous studies within science and technology policy research, and a range of answers explored. The evidence from these studies suggests several significant plausible reasons: knowledge-generating organisations such as universities remain overwhelmed with the task of teaching at the expense of conducting research and accomplishing innovation. This was in turn found partly to have resulted from a swift and disproportionate upsurge in higher education enrolments in relation to the funding available over the past few decades (Chataway et al., 2019). Universities’ strategy has therefore been to strive for narrowly-defined, output-based research excellence metrics, at the expense of societal relevance (Tijssen and Kraemer-Mbula, 2018). Previous research has established that this phenomenon might be underpinned by three main factors: (i) lack of conceptualisation of policies and policy instruments – leading to ineffective coordination, governance, and monitoring at micro-, meso- and macro-organisational scales (UNCTAD, 2017); (ii) an industry dominated by trans-national corporations – particularly in the areas of ICTs – with no (or meagre) interest in performing R&D and no (or few) developmental objectives, hampering the potential for developing capabilities in and adoption of technology and innovation (Diyamett et al., 2011; Lemarchand and Tash, 2015); and (iii) weak or non-existent interactions amongst key actors such as academia, government, and industry, and a lack of synergies to stimulate the flow of knowledge and innovation through organisational and institutional frameworks (Yongabo and Göransson, 2020) – including any strategic territorial or place-based development flagship projects/programmes. Earlier research showed that the third failure mentioned above hindered or delayed knowledge base development, and hampered the performance and competitiveness of national science and innovation systems at large (Sawyerr, 2004). Yet, the dynamics of science

and innovation ecosystems development in place-based settings within the broad system remain largely unresearched.

Drawing on the insights gained from the studies referred to in the previous paragraph, particularly those of Yongabo and Göransson (2020), this work focused its attention on establishing the inner structures of NIS to develop an understanding of '*how*' the university system (academia) – as the main source of formal knowledge generation – interacts with other actors for RIL, within and beyond the Knowledge Space of place-based THS in a developing country context. In so doing, this research took the case of Rwanda's Kigali Innovation City (KIC) to explore and interrogate the deployment of the ecosystem's approach in a low-income country (LIC) setting. Given the complex nature of KIC as an 'ST&I policy intervention' at the interface of public administration and public policy spaces, the main research problem – actor interactions in relation to research, innovation, and learning (RIL) – was considered a 'wicked policy problem' (Head, 2008; Head, 2022). While several definitions have been attributed to the concept of 'wicked policy problem', this research adopted Head's definitions referring to wicked problems as a social 'complex, open-ended, and intractable' phenomena (Head, 2008, p. 2). Elsewhere, Head also defines a wicked problem as 'the kind of poorly-structured, intractable policy problem with unknown solutions with which policy-makers, unfortunately, must engage on a frequent basis'. (Head, 2008, p. 2). From a methodological point of view, this research adopted a two-phased (pilot- and post-pilot) method, combined with a critical transdisciplinary approach for greater involvement of and knowledge co-creation with research participants – senior officials and administrators perceived as policymakers – in the research design process. Notwithstanding the wickedness of research problem, this study drew on (Hisschemöller and Hoppe, 1995), as illustrated in Fig. 1.1 below, to explore the research problem as a structured phenomenon. The aim was to drive the consensus of research stakeholders on values and the certainty on knowledge to the highest possible level.

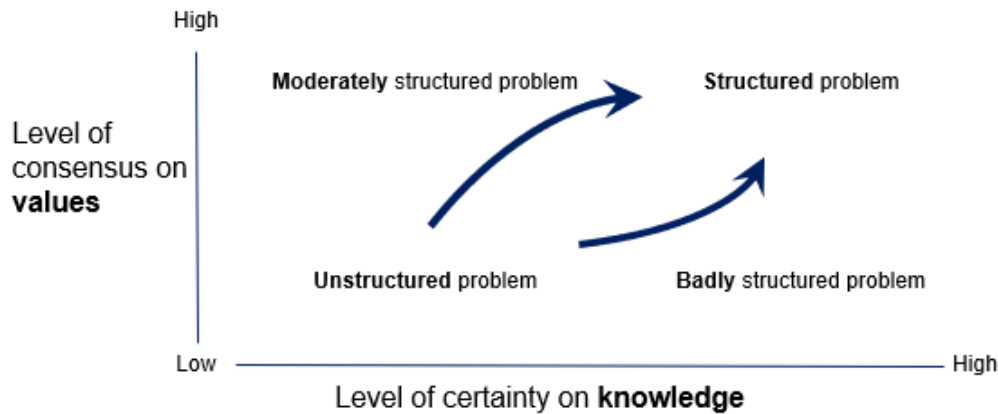


Figure 1.1. Typology of policy research

Source: Adapted from Hisschemoller and Hoppe (1995)

Chapters three and six of this thesis provide a granular exploration of the degrees of wickedness of research problems, and approach their study from methodological, epistemological, ontological, and conceptual perspectives.

1.2.2 Why is Rwanda a case to study?

Recent studies on Rwanda's NIS highlighted that persistent inadequacies in actor interactions are the primary factor contributing to the country's NIS underperformance. These studies recommended further empirical research to gain a deeper understanding of how actors interact within place-based innovation ecosystems, and to examine how these interactions at the ecosystem level influence the performance of the broader NIS. (Yongabo and Göransson, 2020; Twiringiyimana et al., 2021; Yongabo and Göktepe-Hultén, 2021). The small landlocked country of Rwanda is situated in central-eastern Africa. It borders with four countries, namely: Tanzania to the east, the Democratic Republic of Congo to the west, Burundi to the south, and Uganda to the north. It is the second-most densely populated country in Africa with 498.66 inhabitants per square kilometre (WB, 2018a), and a population estimated at 12.30 million, of which 41% are aged under 30 (WB, 2018a; Nkusi et al., 2020). Viewed in a developing country context, where NISs often underperform due weak actor interactions, the author identified seven key factors that make Rwanda an interesting - and in some instances distinctive - case to study:

- (i) **Rwanda is an LIC** with a gross domestic product (GDP) of 801.65 US\$ per capita, and a high poverty rate of 38.2% (WB, 2018a; Twiringiyimana et al., 2021). Recent evidence from the National Institute of Statistics of Rwanda (NISR) suggests that in early 2021, the services sector was the main contributor to GDP at the rate of 46%, followed by the agriculture and manufacturing sectors contributing up to 27% and 20% respectively¹.
- (ii) **Political ambitions and development agenda towards becoming an HIC:** according to Rwanda's vision for 2050, the country has set an ambitious goal of attaining UMIC status by 2035 and HIC status by 2050. As such, Rwanda aspires to build a knowledge-based economy underpinned by ST&I in response to societal and market imperatives (GoR, 2020h; GoR, 2017a).
- (iii) **Presence of a strong policy drive to build an endogenous capacity and capability in science, technology, engineering, and mathematics (STEM), as well as in entrepreneurship:** over the last two decades, Rwanda has extensively invested in developing science and technology capability (Murenzi and Hughes, 2006; Twiringiyimana et al., 2021; Yongabo, 2021b), particularly in ICTs. This policy option was realised partly by deliberately promoting and supporting STEM, including technical and vocation education and training (TVET), across all levels of education. For instance, 43% of higher education students are currently enrolled in STEM programmes, of whom 32.1% are females (GoR, 2019a). This higher education emphasis on STEM enrolment partly stemmed from the government of Rwanda's (GoR) policy decision made in 2015 that saw up to 70% of government scholarships being allocated to students enrolled in STEM programmes (Urama et al., 2015, p. 526). The STEM scholarship share was upgraded to 80% in 2018 with plans to increase it further in subsequent years (Chataway et al., 2019), gradually turning Rwanda's higher education sector into a STEM prevalent setting. Additionally, Rwanda's higher education sector is embracing an entrepreneurial nature and culture, meaning that all universities and institutes are introducing all their students to entrepreneurship courses – with University of Rwanda (UR) already making it compulsory for all undergraduate students – irrespective of whether or not they are enrolled in STEM fields (Nkusi et al., 2020). In her broad political aspirations

¹ <https://www.statist&lcs.gov.rw/publication/1695> [Accessed:24.11.2021]

to position herself as a regional hub for knowledge, technology and innovation, Rwanda has strategically sought out the globally and regionally leading universities and research centres in STEM, with a particular focus on advanced digital technologies. The aim was in part to train African talents in Africa and generate highly skilled graduates capable of contributing to the societal and industrial transformation in Africa in general and Rwanda in particular. The combination of the local public and private universities and institutes with the strategic foreign universities and research entities operating in Rwanda, forms a complex and differentiated higher education system. Previous research has established that the contribution of this complex higher education system to Rwanda's science and innovation systems merits in-depth investigation on micro, meso, and macro scales (Twiringiyimana et al., 2021).

- (iv) **Creation of Kigali Innovation City (KIC) as a place-based and knowledge-based ST&I ecosystem for domestic regional industrial development:** as stated in Rwanda's national strategy for transformation (NST1 2017-2024) and the National ICT Hub Strategy 2024, the GoR created KIC as a consolidated geographical area to house the international and local universities and research organisations to train and yield highly skilled engineers, researchers, and scientists in the priority sectors of national development. Strategically located adjacent to the Kigali Special Economic Zone (KSEZ), the aim of KIC was also to act as an ecosystem to facilitate and accelerate knowledge exchange among academics, entrepreneurs and industry, as well as co-create innovative and transformative technologies and research output in response social and economic demands (GoR, 2017a; GoR, 2019c; GoR, 2020b). KIC is also in line with Rwanda's policymaking option of positioning itself as 'evidence of innovation hubs' for Africa². KIC is thus expected to be an environment underpinning and conducive to generating an open flow of entrepreneurs and innovators, skilled personnel, as well as start-ups and large both domestic and transnational corporations. Establishing how the academic and research organisations located in KIC mutually interact for RIL, and to what extent these interactions contribute (or not) to KIC development, was part of the aims of this study.

² <https://www.minict.gov.rw/news-detail/minister-ingabire-and-mr-hafez-ghanem-the-world-bank-vp-visited-klab-and-fablab> [Accessed: 07.11.2021]

- (v) **Formalisation of an informal economy:** a recent study suggested that the informal sector represents about 70% of African employment and is considered as the ‘engine of innovation’ in Africa (UKaid, 2020). Some SSA countries have adopted policy options and set up policy instruments to nurture and harness innovation activities from that essential sector. The same study however revealed a peculiar situation for Rwanda’s State-led innovation system in relation to the informal sector: the study argued that, unlike other SSA countries, Rwanda’s policy and systematic regulatory top-down approach were geared towards formalising the informal sector, which might adversely impact on the growth of informal innovation activities, and hence curtail the potential for innovation ecosystem development (UKaid, 2020). Drawing on Chataway et al. (2014), this thesis assumes that such conditions may also exacerbate the exclusion of informal sector actors, and hence push them further below the radar of the NIS standards promoted by Rwanda’s ST&I policy (GoR, 2020b).
- (vi) **An emerging, yet weak and fragmented innovation system:** recent studies have revealed Rwanda’s efforts in generating ST&I policy-making options, governance, and conceptualisation of ST&I policy to enhance the likelihood of effective coordination, and in creating R&I funding mechanisms aka policy instruments, to position Rwanda as an emerging NIS. Several studies however claimed that Rwanda’s NIS remains weak and fragmented, partly due to scant systemic actor interactions (Yongabo and Göransson, 2020; Twiringiyimana et al., 2021). This thesis aimed to investigate this question in the context of Rwanda’s place-based ST&I flagship policy intervention and urban development policy innovation – Kigali Innovation City (KIC).
- (vii) **Rwanda’s Proof-of-concept strategy:** the notion of proof-of-concept is more often than not associated with scientific enquiries deploying a case-study approach to investigate the behaviour or performance of certain scientific phenomena (Zhou et al., 2023; Aristizabal-Tique et al., 2023; Wisselink et al., 2023) or policy interventions at experimental stages (Sly et al., 2022). Drawing on the scientific significance of the proof-of-concept concept, the GoR has recently adopted same concept as a strategy to underpin the country’s science-technology- and innovation-driven development aspirations. As stated above in this section, Rwanda’s higher education system comprises a mix of public and private institutions including six foreign or domestic private universities designed

according to a public-private partnership (PPP) model. PPP-model universities have deliberately adopted a teaching and research approach aimed at responding to strategic priority areas of national investment policy (GoR, 2017c). Most of these universities form part of the KIC ecosystem with education and research programmes focusing on STEM strands. The policy of creating PPP-model universities focusing on specialist areas of STEM in an identified geographical setting aligns with Rwanda's development agenda, which in turn is underpinned by politically ambitious aspirations of becoming a knowledge, innovation, and technology hub. This same policy furthermore prominently positions the country as a 'Proof-of-concept hub' for Africa³. Firstly, it creates a policy environment open enough to allow a flow of entrepreneurs and innovators as well as of a skilled labour force. Secondly, it creates a conducive environment for both domestic and transnational technology and non-technology start-ups and big firms.

Although there is no specific policy document outlining Rwanda's proof-of-concept strategy yet, the policy narrative has gained recognition in a range of grey literature. A recent study acknowledged Rwanda proof-of-concept strategy's potential for influencing how policy instruments support (or not) technology development, adaptation, adoption, diffusion, and use, particularly in priority sectors at regional (place-based), national, and continental, or global scales (Daniels, 2021). As highlighted in the same study, the hitherto Rwanda ICT and innovation minister stated that 'to allow Rwanda to become an innovation hub, the government is open to free flow of labour and opening up Rwanda as a 'Proof-of-concept hub' (GoR, 2019c; Daniels, 2021, p. 31). The same study maintains that KIC forms a central part of Rwanda's proof-of-concept strategy, and furthermore according to it, KIC is viewed as part of a national capability and skills set or a 'national flagship programme aimed at creating a space for firms, entrepreneurs, global and regional universities, to develop new technologies (...). KIC is a knowledge and talent platform for the digital technology industry, for Rwanda and Africa.' (Daniels, 2021, p. 49).

³ <https://www.minict.gov.rw/news-detail/minister-ingabire-and-mr-hafez-ghanem-the-world-bank-vp-visited-klab-and-fablab> [Accessed: 07.11.2021]

Section 1.2.3 below provides a comprehensive description of KIC as place-based innovation ecosystem within Rwanda's broad NIS and explains its critical importance for this thesis.

1.2.3 What Rwanda's Kigali Innovation City is, and why it matters

What is Rwanda's Kigali Innovation City, and why is it an interesting case to research?

KIC is an evolving national flagship policy intervention located at the interface of public policy, and public administration spaces of Rwanda's ST&I policy cycle. As can be seen in Fig. 1.2 below, this dual structure and complex nature of KIC makes it a compelling case to explore. A study of Rwanda's ST&I policy review suggested that the creation of KIC had been instigated in 2016 as one of the key flagship ST&I programmes aimed in part at fast-tracking Rwanda's social and economic transformation towards a knowledge-based economy (UNCTAD, 2017).

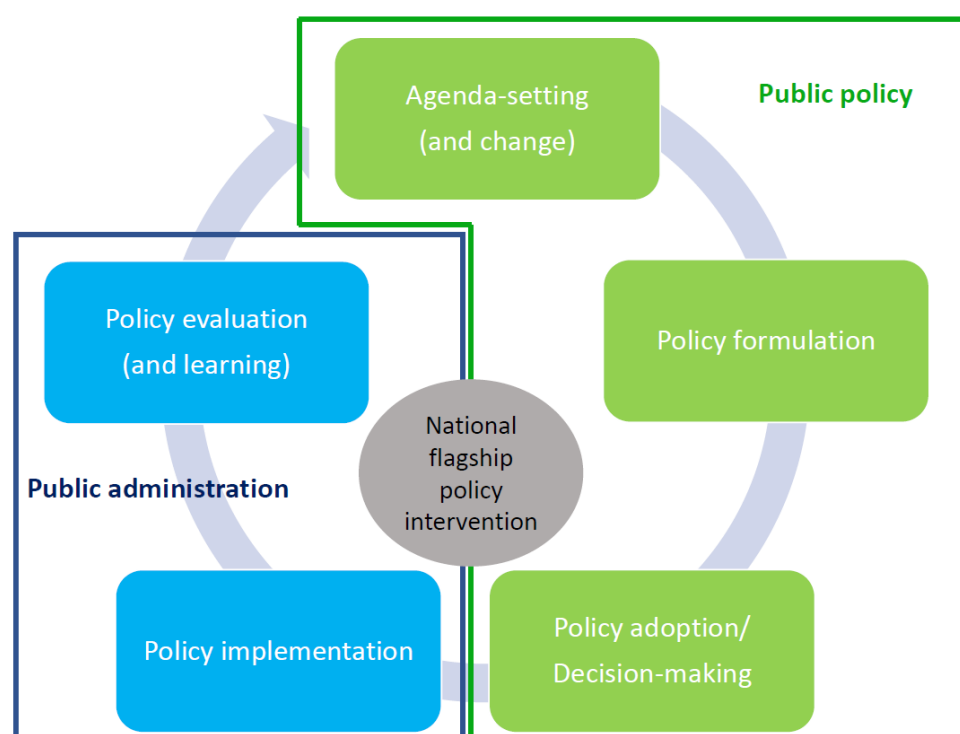


Figure 1.2. KIC locus within the Rwanda national ST&I policy cycle

Sources: Adopted from Jann and Wegrich (2007), Moyson et al. (2017), and Capano and Pritoni (2020).

As part of the emerging KSEZ created in 2013, KIC is physically located in a peri-urban region of Gasabo district, one of three districts constituting Kigali, the capital city

of Rwanda, at about 9.7 miles (15.7 km) distance by road North-East from the city centre, making KIC a peri-urban regional development of Kigali's urban development policy innovation. Formerly named 'Kigali Technopole' (an ICT Park), KIC is being developed as a 'mixed-use, master-planned innovation city', occupying 33% of the entire KSEZ area, hosting up to four [technical] domestic and foreign universities, ICT firms (IGC, 2018, p. 17), bio-tech, agri-tech, and fin-tech firms, office spaces, start-up business incubators, and other ancillary amenities including, *inter alia*, accommodation, retail, and hospitality, making it a 'technology innovation hub'⁴. Fig. 1.3 below shows KIC's peri-urban geographical location in relation to the City of Kigali.

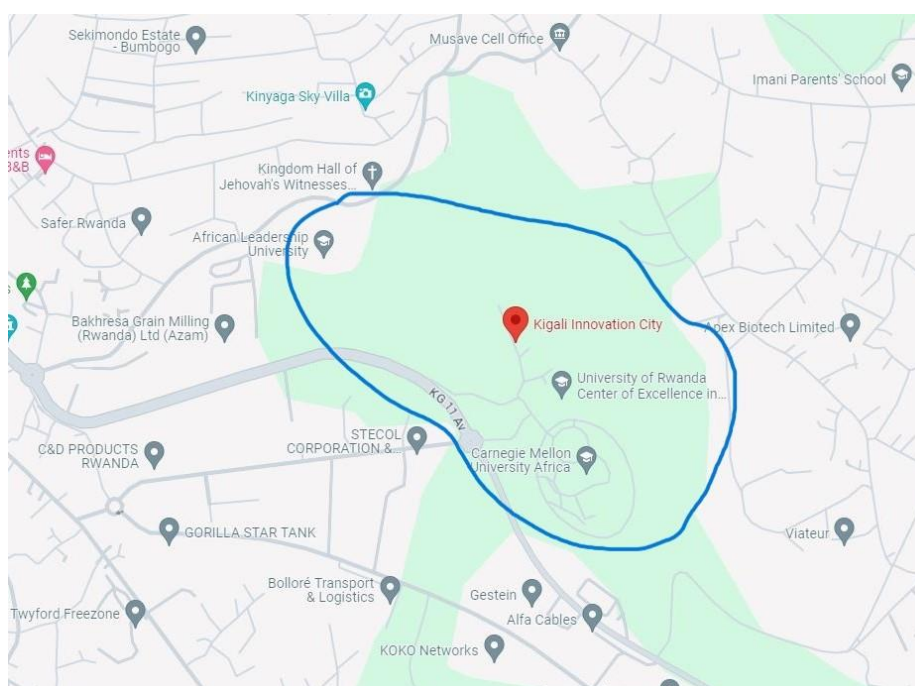


Figure 1.3. Geographical location of KIC within the City of Kigali

Sources: Google maps 2023

This Fig. 1.3 above sheds light on the complex nature of KIC as an emerging place-based innovation ecosystem situated at the interface of urban and rural settings, particularly in relation to its role as a national ST&I policy flagship intervention.

⁴ Kigali Innovation City: <https://www.africa50.com/investing-for-growth/projects-investments/kigali-innovation-city/> [Accessed: 09.09.2021]

The conception of KIC is also metaphorically viewed by some as inspired by America's 'Silicon Valley'⁵. As such, KIC gained and continues to hold an essential position within Rwanda's political and policy discourses and narratives about the country's national development aspirations. For instance, Rwanda's development agenda, aka Vision for 2050, regards KIC as a 'technology and innovation ecosystem' that should further inspire Rwanda's vision of becoming a knowledge hub. According to Rwanda's National Strategy for Transformation (NST1 2017-2024), KIC is being developed to serve as a 'skills ecosystem for attracting local and international talent' in an effort to establish Rwanda as a 'globally competitive knowledge-based economy' (GoR, 2017a, p. 19). In the same vein, Rwanda's ICT Sector Profile 2019 characterised the KIC project as an important component for Rwanda's ambition to become an ICT Hub for the [African] continent. Viewed through the digital technology-enabled urban development strategy *aka* 'Smart city' strategy, KIC was characterised by Smart Rwanda Master Plan as highly important strategic project with a 'must-have' priority (GoR, 2015, pp. 49, 54). The extent to which KIC actors interact for knowledge and innovation generation, acceleration, dissemination, and use, and whether these interactions are (or not) related to KIC's development outcomes, was part of what this research aimed to explore.

1.3 Research scope and objective

1.3.1 Research scope

Drawing on the problem identified in section 1.2 above, this research used Rwanda's KIC to undertake an in-depth investigation of the inner structure of Rwanda's NIS and develop and understanding of how the university system (academia) – as the main source of formal knowledge generation – interacts with other actors for RIL in support of place-based innovation ecosystem development, in an LIC context. Reflecting UCL STEaPP's research philosophy⁶, this study was designed as a transdisciplinary research project aiming to rigorously investigate and further the understanding of factors that facilitate, or hinder as the case may be, interactions between academia and other key factors such as government, industry, and civil society, within an

⁵ <https://nickyverd.medium.com/rwanda-is-building-africas-very-own-silicon-valley-known-as-kigali-innovation-city-kic-d3330975d2ec> [Accessed: 09.09.2021]

⁶ <https://www.ucl.ac.uk/steapp/research-0>

emerging knowledge-based innovation ecosystem. The importance of these interactions among national and place-based science and innovation ecosystems is highlighted in Rwanda national ST&I's policy (GoR, 2020b). In accordance with UCL's doctoral training programme requirements, the research was conducted in two phases – pilot and post-pilot – whose outcomes form the content of this thesis. These two phases are briefly described below:

1.3.1.1 Pilot study purpose and scope

The pilot study formed the initial phase of research focusing on investigating the extent of KIC's Knowledge Space actor interactions for RIL, and whether and how these interactions (i) contributed (or not) to KIC's development, and also (ii) responded to societal challenges. As part of the pilot study, the formation, operation, and growth of KIC – as an emerging knowledge-based innovation ecosystem – was investigated through the THS categories of Knowledge Space, Innovation Space, and Consensus Space (Ranga and Etzkowitz, 2013). Whilst the pilot study focused only on the Knowledge Space actors, it also sought to understand the extent to which current and future interactions between KIC's Knowledge Space actors might have been and may continue to be affected by the COVID-19 pandemic. Fig.1.4 below illustrates KIC's position as a place-based ST&I flagship policy intervention within Rwanda's broader NIS, viewed through the lenses of the national ST&I policy framework. KIC's strategic role of producing capacities and capabilities in science, technology, research, and innovation – In terms of human and infrastructural resources, and R&I outputs – in part contributes to Rwanda's development aspirations of becoming a knowledge-based society as stated in NST1 2017-2024 and Vision 2050 (GoR, 2017a; GoR, 2020h). KIC's specific priority sectors and expectations are broadly reflected in and aligned with the overarching national ST&I policy (GoR, 2020b) goals and objectives, as well as other ST&I related sectoral policies on variable scales. This thesis thus argues that exploring KIC actor interactions at micro- and meso- levels would offer fresh empirically grounded insights that may in part broaden and deepen scholars' understanding of the persistent problem at macro scale. Given that Rwanda's ST&I policy design was underpinned by NIS and THS frameworks, KIC was likewise primarily conceptualised through a THS lens for consistency, focusing on academia aka THS KS actors. Understanding the extent of the above THS KS actor interactions

in achieving the creation, dissemination, and use of knowledge and innovation in relation to KIC's development, and the implications of these interactions for their respective academic endeavours – teaching, research, and innovation – were the ultimate goals of the pilot study phase of the research.

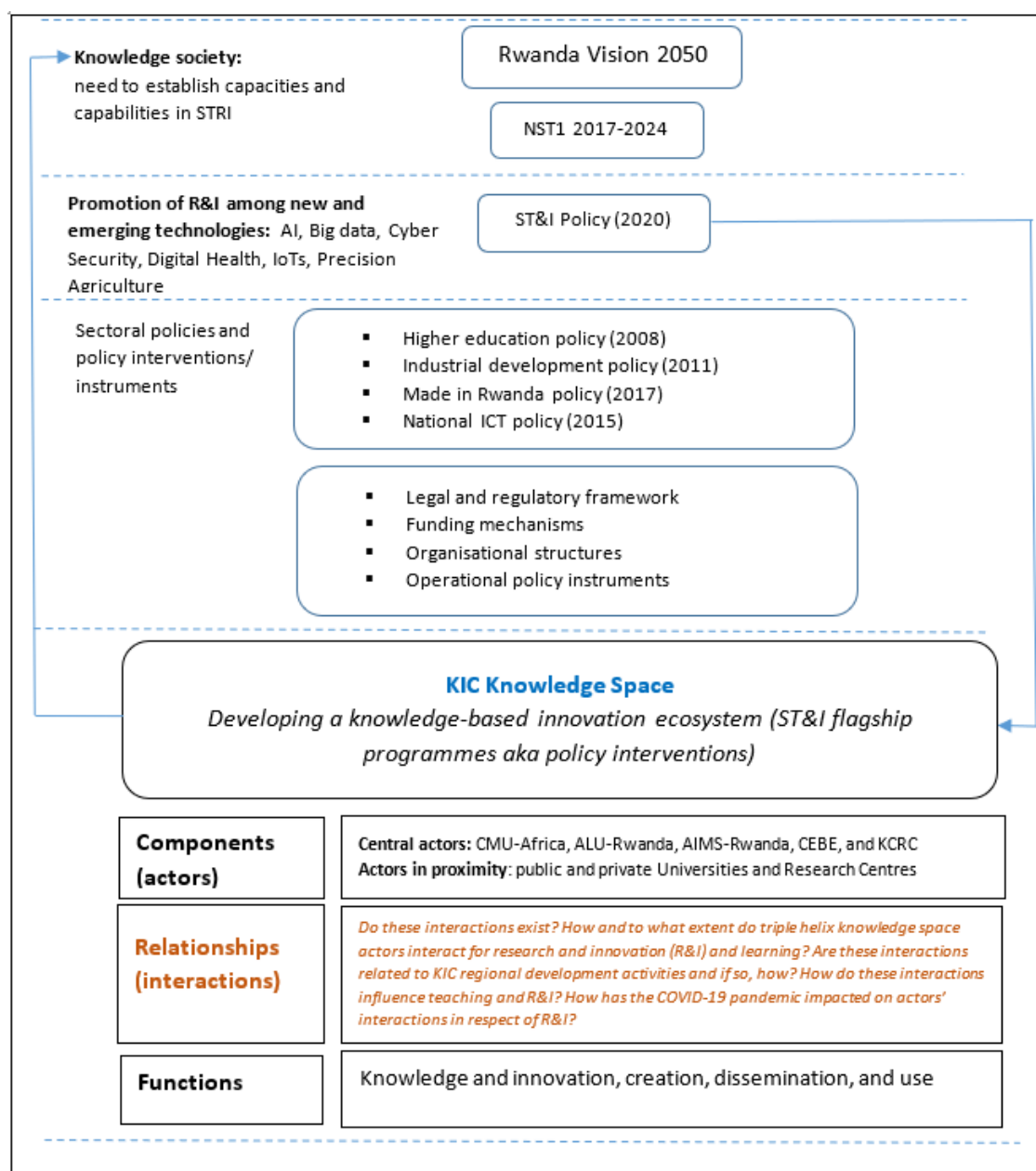


Figure 1.4. Visual contextualisation of KIC as a ST&I flagship policy intervention within Rwanda's broader science and innovation policy landscape

Source: Author's compilation, based on GoR (2020b, p. 3,15); Yongabo and Göransson (2020); Lemarchand and Tash (2015, p. 28); and Ranga and Etzkowitz (2013).

1.3.1.2 Post-pilot study purpose and scope

Drawing on the pilot study's empirical and conceptual insights, the post-pilot study conceptualised KIC through two distinct yet complementary lenses: (i) **KIC as an ST&I policy flagship intervention** – a science and innovation system perspective; and (ii) **KIC as an urban smart city initiative** – an urban innovation perspective. In both dimensions, the research was directed towards gaining a deeper understanding of actor interactions, as well as exploring different pathways towards creating new or fostering existing interactions for the development of an inclusive place-based, knowledge-based innovation ecosystem in a regional setting. The broad conceptualisation of KIC partly offered an avenue for the inclusion of a broad range of actors beyond the KS, including adjacent local communities, local government authorities, and NGOs. This approach thus facilitated analyses of conditions of interactions for inclusive innovation, or innovation for inclusive development (Chataway et al., 2014; Arocena et al., 2017; Mavhunga, 2017; Daniels et al., 2017), to be carried out, although these regrettably fell outside of the THS remit. This research thus not only interrogated the THS conception and proposed complementary lenses, but it also provided fresh insights into and context for specific perspectives for knowledge-based regional development theory (Etzkowitz and Klofsten, 2005; Ranga and Etzkowitz, 2013).

1.3.2 Research aims, main enquiry, and specific questions

Within the scope described above, the research aims were twofold: (i) to expand the knowledge and understanding of systems' theory-based conceptual frameworks and of the conceptualisation of actor interactions in relation to the formation and operation of regional (place-based) knowledge-based and innovation ecosystems, and (ii) to provide an interest in this domain to the policy makers, researchers, and other actors, with evidence for policy innovation options pertaining to place-based development in urban settings in LIC contexts. Both distinct yet complementary components of this study reflect its academic and policy implications, respectively.

Considering the aforementioned research aim, and using Rwanda as a case study, the overarching research enquiry was threefold: *(i) How do academic and research organisations located within KIC and/or in its proximity interact with other science and innovation system actors for research, innovation, and learning (RIL)? (ii) To what*

extent do these interactions contribute (or not) to KIC's development? and (iii) What are the possible pathways for fostering these interactions? As indicated in section 1.3.1 above, the overarching research enquiry was explored in two phases – pilot and post-pilot studies – the first, focusing on investigating four, and the second, three specific questions.

Pilot study research questions:

- 1) Who are the KIC Knowledge Space actors?*
- 2) How do KIC Knowledge Space actors interact for RIL, and do these interactions influence the RIL among these Knowledge Space actors?*
- 3) Are these interactions related to KIC regional (place-based) planning and development activities, and if so, how?*
- 4) How has the COVID-19 pandemic influenced actor interactions in respect of RIL?*

Post-pilot study research questions:

- 5) How do KIC Knowledge Space academic actors interact with industry for RIL?*
- 6) What is the role of government agencies, including foreign offices, in supporting the development of KIC into a knowledge and innovation ecosystem?*
- 7) What specific characteristics define Kigali Innovation City as an urban smart city initiative, and to what extent do Kigali Innovation City Knowledge Space actors interact with adjacent communities in their geographical setting?*

The aforementioned two aims are explored through the research questions, following which research design and conceptualisation are further unpacked in chapter three (research methodology) of the present thesis. It is worth mentioning that the two above objectives and related research questions were respectively explored in the pilot and post-pilot study enquiries as is elucidated in chapters four through ten of this thesis.

1.4 Study implications and relevance - Who will benefit from the research?

Drawing on the interdisciplinary nature of this study, and the case study-based approach used to explore the Research questions taking an in-depth rather than a broad analysis of the science and innovation ecosystem, the study established both academic and policy implications relevant to a broad range of ST&I ecosystem actors,

namely: government (public policy and administration), academia, industry, NGOs, and general public (community) in Rwanda in particular, and in LIC settings in general. The implications might equally be applicable to HIC contexts. The proposed conceptualisation of actor interactions contrived a new approach to studying science and innovation ecosystem development options relevant to actors in academia, policy, and practice domains. The implications of the study for the various actors are particularly elaborated in the concluding chapter of the thesis (conclusions, policy recommendations, and proposed further research).

1.5 Thesis overview

The overall structure of this thesis takes the form of ten chapters that are organised in three parts. The first part (Part I) comprises three chapters, including Introduction, Literature Review, and Research Methodology. The introduction chapter of this thesis problematises the actor interactions for knowledge and innovation generation, dissemination, and utilisation in a place-based innovation ecosystem. It provided an overview of the research problem that contextualises the study both from national and sectoral perspectives. Moreover, the Introduction chapter provides a synopsis of the research scope and purpose. The second chapter presents the review of literature and the knowledge gap in both the theoretical and practical aspects of science and innovation systems, as well as in the science and innovation ecosystems that constitute these broad systems. Chapter three – Research Methodology – presents the design and methodological approach to the study that has guided the empirical and theoretical work in the remaining chapters. It therefore sets the stage for the remainder of the thesis.

The rest of the thesis comprises six empirical chapters, one theory chapter, and one concluding chapter, all structured into two parts, Part II and Part III. Part II comprises three chapters four, five, and six: The empirical chapter four presents the findings of the pilot research, focusing on the understanding of KIC Knowledge Space actors and their interactions for RIL. The empirical chapter five outlines the findings of the pilot research, focusing on the COVID-19 impact on KIC Knowledge Space actor interactions. At a glance, the research question (RQ) on the impact of the COVID-19 pandemic on KIC Knowledge Space actor interactions might ostensibly appear to be outside the scope of the present study. This question was however added to place this

work in its temporal context, with the pilot phase having been carried out during the COVID-19 pandemic. A detailed explanation of the reasons for including a COVID-19 pandemic-related RQ in this study is elaborated in the Methodology chapter – chapter three, and in the empirical chapter five of this thesis. Drawing on the empirical and conceptual gaps identified in the pilot study phase, a theory on the conceptualisation of actor interactions in a place-based and knowledge-based innovation ecosystem was developed and deployed to guide the empirical work in the post-pilot phase of the research, as presented in chapter six. The last part of this thesis (Part III) is composed of three empirical chapters from the post-pilot research phase, namely, chapters seven, eight, and nine, followed by chapter ten that presents final conclusions. Chapter seven outlines KIC's transition from the Knowledge Space to Innovation Space, while chapter eight discusses the conditions required for KIC's development into an inclusive, knowledge-based innovation ecosystem in its spatial dimension as an urban smart city initiative. The penultimate chapter of this thesis, chapter nine, explores opportunities and pitfalls of science diplomacy as the pathway towards fostering KIC actor interactions for RIL in an LIC context. The thesis concludes with the final chapter, chapter ten, presenting the synthesis of the various conclusions, academic and policy implications, and proposed further research. From a research design standpoint, it is crucial to highlight that in the empirical chapters four, five, and seven, this research explores KIC as an ST&I policy flagship intervention within a national science and innovation ecosystem. In chapter eight, the work takes the spatial or place-based dimension of KIC viewed through an urban innovation lens, with empirical chapter nine assessing both ST&I policy and spatial dimensions of KIC through a science diplomacy lens. As indicated above, the organisation of this thesis into three parts reflects the chronological order in which this research was empirically conducted in two phases: pilot and post-pilot.

The next chapter presents a review of previous research relevant to this work.

Chapter 2. Literature review: science and innovation ecosystem – theory, and practice

2.1 Introduction

The Introduction chapter presented the aim and scope of this study. This chapter draws on the Introduction chapter to review the body of literature relevant to this study. It synthesises the earlier and contemporary thinking and research in relation to the overarching research enquiry of this study: *How do academic and research organisations located within Kigali Innovation City (KIC) and/or in its proximity interact with other science and innovation system actors for RIL? And To what extent do these interactions contribute (or not) to KIC's development? and What are the possible pathways for fostering these interactions?*

This chapter particularly focuses on the various scientific studies that deployed a systems-based approach, or systems thinking, to investigate the ways in which the Knowledge Space (KS) actors interact with other actors for knowledge generation, dissemination, and use, in developed countries of the global North and developing countries of the global South. The chapter also highlights the existing knowledge gap with respect to conceptualising actor interactions for place-based development in the developing country contexts. This chapter is composed of five sections: (i) introduction, (ii) review of university systems at global, Sub-Saharan Africa (SSA) regional, and Rwanda national levels; (iii) review of the theoretical dimensions of actor interactions for knowledge and innovation generation, dissemination, and use; and (iv) the existing knowledge gap, and the contribution provided by this research. The chapter ends with a summary in section (v), that provides a transition to the next chapter of the thesis.

2.2 Review of university systems and their interactions with society

2.2.1 Brief overview of the emergence of a global university system

The role and status of universities, as the main sources of knowledge generation, within society has evolved over time in accordance with surrounding social, political, and economic developments. The 'Mediaeval University' *aka* the 'University of faith' emerged in Europe in the eleventh century, whose main mission was to preserve

regional culture and language, and to ensure the preservation of existing knowledge (Chan, 2017, p. 12; Arocena et al., 2017, p. 142). At the onset of the nineteenth century, the role of universities surpassed teaching, to also include research. The former 'University of faith' thus became the 'University of reasoning'. This transformation, known as the first academic revolution, was linked to the creation of the University of Berlin in 1810 (Arocena et al., 2017, p. 143), commonly known as the 'Humboldtian university' model. Whilst some scholars consider this reform as the birth of the modern university, combining education and research (Chan, 2017, p. 12; Meissner et al., 2018), others refute this 'Humboldtian myth', contending that the research conducted within the Humboldtian university had already been introduced into universities from academies in Germany in the seventeenth and eighteenth centuries (Crow and Dabars, 2015, p. 82). This Humboldtian model of German origin was exported to the United States of America (USA) with a new style of teaching and of conducting research in a range of academic fields. This facilitated the transition of science to technological development, heralding the second academic revolution in around the middle of the nineteenth century (UNESCO, 2009; Arocena et al., 2017). The beginning of the twentieth century marked a further extension of the role of universities, to include community engagement in addition to their tasks of teaching and conducting research. This is commonly known as the university's 'third mission', which is often associated with the Latin American University Reform Movement that started in 1918. On the one hand, following the second World War (WW II), universities in the HICs were, by the second half of the twentieth century, enjoying strong financial support from their national governments, and were successfully expanding their knowledge boundaries, leading to formidable inventions and innovations in major areas such as electronics and medicine. Arocena et al. (2017, p. 148) names this academic model the 'University of discovery'. On the other hand, the aftermath of WW II witnessed a flourishing creation of national universities as part of the post-colonisation independence statuses gained by numerous global South countries, including in Africa. Towards the end of the twentieth century, HIC universities underwent a fourth transformation phase, from their 'status quo' teaching and research methods, towards a greater focus on commercialisation, to meet the growing demand for closer links with industry and commerce. Hence, Arocena et al. (2017, p. 151), named this latter redirected model the 'University of calculation'. It has been widely asserted that this new model of 'entrepreneurial University' – that aims to gain financial

capital from knowledge and to bring its knowledge and technology to the marketplace, in addition to teaching and conducting research – originated in the US and has been dominating the higher education sector globally since the transition to the twenty-first century (Meissner et al., 2018; Arocena et al., 2017). Against this view, Willets contended that the notion of ‘university marketisation’ had been developed in England much earlier (Willetts, 2017, p. 278). This ‘university marketisation’ is known as the third academic revolution (UNESCO, 2009).

2.2.2 University systems in Sub-Saharan Africa

As in many other developing countries, the post-colonial period in the mid-twentieth century was marked by the creation of national universities as a prime indicator of independence, by post-colonial governments in SSA, with universities’ core mandate being to form graduate ‘elites’ to help address societal issues such as leadership, public administration, poverty, ignorance, and disease (Arocena et al., 2017; Fonn et al., 2018). However, unlike the situation in developed countries, the rapid expansion of enrolments in higher education curricula in SSA was disproportionate to the pace of creation of new universities. For instance, annual university enrolments in SSA increased by 200 % in the first decade of the 21st century (Fonn et al., 2018), hence the predominance of teaching at the expense of research in that region (Chataway et al., 2019). This rapid expansion was partly associated with desperate entrepreneurial measures adopted by universities to increase their potential in accessing funds from private sources, mainly through student tuition fees, in response to the decline in public funds that followed the economic crisis of the 1980s (Sawyerr, 2004). Scholars thus suggested diverse remedial options to address the funding shortfall, including on the one hand, formulating ‘system-level policy frameworks’ to overhaul the university system in SSA without compromising its ‘public purpose’ (Sawyerr, 2004), and on the other hand, encouraging universities to create entrepreneurial spaces such as ‘incubation centres’ for greater engagement with other actors, including those from industrial and entrepreneurial sectors (Daniels et al., 2021). Nonetheless, the trend of encouraging SSA universities to engage with other actors incurred significant setbacks, not least as a result of their discipline-siloed structures, and hence inadequate interdisciplinary capabilities (Ravjee, 2002; Nkusi et al., 2020; Twiringiyimana et al., 2021). Furthermore, access to higher education still remains poor in Africa to this day, with only about one university per million people, in contrast

to around ten, eight, and six per million population in North America, Europe, and Latin America, respectively (Bezy, 2016a). Besides these trends and challenges, and given the social and economic context in which universities operate, Arocena et al. (2017) suggested that, as the main sources of knowledge generation, universities in LMICs, including those in SSA, should be categorised as ‘developmental’. This view was echoed by other scholars who posited that academic and research personnel should be supported in understanding the need to orientate their teaching and research towards addressing societal problems, starting with those affecting any local communities in their geographical vicinity, and that this should be done in collaboration with other actors such as the beneficiaries of knowledge, fulfilling a role as ‘agents and not patients’, which in turn might contribute to enhancing the societal relevance of universities (Tijssen and Kraemer-Mbula, 2018). A recent study revealed that the notion of ‘developmental university’ and its connection with society proposed by Arocena et al. (2017) was not novel, as it emerged in the 1970s (Ransom, 2023). With regard to research outcome performance, the quality of scientific invention in SSA region remains relatively poor, with only nine African universities – six in South Africa and three in Egypt – feature among the 800 best universities globally according to the 2019 QS world university rankings (QS, 2019). Moreover, Africa’s contribution to the global expenditure on R&D is less than one per cent, compared to three per cent, 27 %, and 37 %, respectively, for Latin America and the Caribbean, Europe, and North America (Fonn et al., 2018).

2.2.3 The University system in Rwanda

Like most other developing countries, Rwanda developed its first university in the post-colonial area – the National University of Rwanda (NUR) was created in 1963, enrolling its first cohort of 16 students (Yongabo, 2021b). According to Lemarchand (2015), the period from 1962 to 1994 saw a slow increase in access to higher education – consisting of one public university and a few private higher education institutions – with fewer than 60 students per 100,000 inhabitants. He went on to demonstrate that access to higher education saw a swift surge from 1994 onwards, with around 750 students per 100,000 inhabitants by 2013 (Lemarchand, 2015, p. 103). Some sources suggested that this rapid growth in access to higher education may have been partly associated with the increase in number of higher education

institutions, that is, the rise from the single university – that reopened in the immediate post-genocide aftermath with around 3,000 students in 1994, to 38 higher education establishments by 2013 – of which 24 were public and 14 private – with 84,448 students in total, of whom 44% were females (GoR, 2014, pp 6, 32). It is worth noting that out of the 24 public higher education organisations, eight were first degree-awarding institutions while 12 offered diplomas – including eight technical and vocational education and training (TVET) colleges.

2.2.3.1 Rwanda's higher education - towards a consolidated system

The first decade of the 21st century marked another evolution of the higher education system in Rwanda. On the one hand, Rwanda's entire education sector saw a shift from French to English as medium of instruction in 2003⁷, while on the other, the eight aforementioned diploma-awarding TVET colleges were created in that first decade, partly to train technicians with hands-on skills ready for immediate employment in industry. Additionally, numerous public degree-awarding institutes specialising in STEM programmes in the hitherto national development priority areas were also created in the same decade (Murenzi and Hughes, 2006).

Rwanda's most recent higher education evolution occurred over the last decade. In 2013, the NUR was merged with seven other public universities and institutes to form a single State university, which was named the University of Rwanda (UR). Likewise, all eight previously autonomous public TVET colleges were merged in 2017 to form a single public TVET higher learning institution named Rwanda Polytechnic (RP). The formation of UR and RP, with campuses across all parts of the country, constituted a significant part the GoR's public policy effort in (i) optimising human and infrastructural resources as well as (ii) providing options for quality teaching, and (iii) fostering research and innovation capacity (Twiringiyimana et al., 2021a; Yongabo, 2021b). While it is too early to determine the impact of such mergers, Rwanda's model of public and private higher education architecture remains unique in Africa. For instance, from its public higher education perspective, on the one hand, UR is the only state-funded research university. This model of a single national public research university has also been applied in Uruguay (Göransson and Brundenius, 2011). On the other hand, RP

⁷ <https://wenr.wes.org/2019/10/education-in-rwanda>

is the umbrella organisation for all regional polytechnic colleges offering TVET programmes.

In addition to UR and RP, Rwanda's higher education system presently comprises 38 higher education institutions, including one independent public Institute of Legal Practice and Development, 28 private local universities and institutes, and nine private TVET colleges. Reliable evidence suggests that by 2019, the total student population amounted to 100,284 including 86,206 enrolled in the 30 general education degree-awarding universities and institutes, of whom 43 % were female, while 14,078 students were attending in TVET institutes, of whom 28 % were female (GoR, 2019a). Rwanda's higher education system experiences a gender divide not only among students but also among staff, with women constituting only 25.6% of the total academic staff (GoR, 2019a).

2.2.3.2 A complex public-private partnership model of Rwanda's university system

Some of the 28 private higher education organisations include six universities, institutes, and research centres operating under the public-private partnership (PPP) model. They include: Carnegie Mellon University in Africa (CMU-Africa), 'the only US research university offering its Master's degrees with a full-time faculty, staff, and operations in Africa'⁸, the African Leadership University, Rwanda Campus (ALU-Rwanda), the African Institute of Mathematical Sciences (AIMS-Rwanda), the University of Global Health Equity (UGHE), the Rwanda Institute for Conservation Agriculture (RICA), the International Centre for Theoretical Physics, and the East African Institute of Fundamental Research (ICTP-EAIFR). Although there is no uniformity in the features and extent of each of these universities' PPP with GoR, the common feature of these six universities and research centres is that they are fully or partly teaching and researching STEM disciplines, most of them being foreign entities. The academic and research programmes offered by these six universities and research centres are strategically aligned with Rwanda's identified priority sectors aimed at enabling Rwanda to attain the political and developmental aspirations of positioning the country as a knowledge, innovation, and technology hub for Africa, in

⁸ Carnegie Mellon University African in Rwanda: <https://www.africa.engineering.cmu.edu/about/index.html>
Accessed 12/08/2020

the context of producing highly skilled and innovative graduates in modern technologies. Additionally to other knowledge producing organisations, Rwanda relies on these six PPP-model universities and institutes to produce high quality R&I for societal and industrial transformation, as stated in the country's development agendas such as Vision 2050, NST1 (2017-2024) and ST&I policy (GoR, 2017a; GoR, 2020b; GoR, 2020h).

2.2.3.3 Rwanda's higher education system from a policy perspective

The higher education policy in Rwanda is under the auspices of the Ministry of Education (MINEDUC), with operational oversight being mandated to the Higher Education Council (HEC), one of the semi-autonomous public agencies affiliated to MINEDUC. Viewed through the lens of academic disciplines, the university system in Rwanda is largely structured according to a traditional, discipline-specific model, namely, the STEM, and Non-STEM model that *inter alia* includes Social Sciences, Arts, Humanities, Economics, Education, and Law. For instance, MINEDUC evidence suggests that 43 % of the total number of students (of which 51.2 % male and 48.8 % female) in tertiary education in 2019 were enrolled in STEM disciplines. The 2018-2024 Education Sector Strategic Plan (ESSP) target for STEM enrolments to reach 51.1 % by 2018/19 was missed (GoR, 2019a, p. 95), although a study revealed that Rwanda had adopted a tertiary education funding model that favoured STEM. According to that model, as Chataway et al. (2019) indicated, at least 80 % of government-sponsored undergraduate students are required to be enrolled in STEM disciplines, which directly support local scientific research and industrialisation'. Most students nationally are enrolled at UR, the only public university offering STEM courses at both under- and post-graduate levels. Since UR's creation in 2013, 55 % of its students have been enrolled on STEM, against 45 % on Non-STEM disciplines (UR, 2020). This establishes UR – the only public research university – as a predominantly STEM course-based higher education organisation.

For the purposes of this work and as presented in the next chapter of this thesis, all participating entities, that is, the KIC's Knowledge Space actor, belong to the STEM university and research centre category. It is noteworthy to point out that STEM programmes nowadays comprise new and emerging technologies – such as artificial intelligence (AI), machine learning, and internet of things (IoT) – which are being

taught and researched by numerous actors who make up Rwanda's university system. In addition to attracting regional and global learning universities and research centres, Rwanda joined in the second phase of the World Bank's (WB) African Centres of Excellence (ACE II) programme in 2017⁹. As part of this programme, Rwanda successfully competed to host four centres including an ACE in Internet of Things, ACE in Data Science, ACE in Energy for Sustainable Development, and ACE in Innovative Teaching and Learning Mathematics and Science, all homed in different colleges and campuses of UR (UNCTAD, 2017, p. 22; UR, 2018). For instance, the UR's College of Science and Technology headquartered in the City of Kigali, hosts the School of Engineering and two of the four ACEs, namely ACE in Internet of Things and ACE-Energy and Sustainable Development. UR College of Science and Technology also hosts the East African regional level research centres including the Centre of Excellence in Biomedical Engineering (CEBE), and the East African Institute of Fundamental Research (EAIFR), a Category II UNESCO Centre supported by the International Institute of Theoretical Physics (ICTP) (UR, 2018, p. 7). ACE in Data Science is hosted at UR College of Business and Economics, while ACE in Innovative Teaching and Learning Mathematics and Science is homed in the College of Education in Kigali. The evidence from UR's report for the period 2013-2020 reveals that the creation of centres of excellence played a key role in fostering UR's research and innovation capacity and capabilities in STEM disciplines. This was partly demonstrated by the significant increase in master's and PhD student enrolments during the period from 2017 to 2020, by comparison to the situation in the previous interval spanning 2013 to 2017 (UNCTAD, 2017, p. 22; UR, 2018). It is thus evident that the centres of excellence programme has been partly contributing to UR's development towards attaining its aim of becoming a research-intensive university with regional, national, and global impacts (UR, 2014; Yongabo, 2021b).

The next section of this chapter presents the review of systems theory-based theoretical and conceptual foundations, underpinning university interactions with other actors for knowledge and innovation generation, dissemination, and use.

⁹ <https://www.worldbank.org/en/results/2020/10/14/building-centers-of-excellence-in-africa-to-address-regional-development-challenges>

2.3 A review of theoretical dimensions of actor interactions

This section draws from the Introduction chapter of this thesis to review the theoretical and conceptual frameworks that are relevant to this work. The common feature of these frameworks is that they are all attuned to a systems approach and to actor interactions for innovation policy and development strategies in global, regional, national, and place-based settings. Drawing on the review of these theoretical frameworks and their application to varied contexts over time, this chapter makes the case as to why the one framework that takes account of the university system as a central actor was selected as the most appropriate and pivotal lens through which to approach this study's research questions.

2.3.1 National, Regional, and Sectoral Innovation Systems

The past four decades have seen increasingly rapid advances in the field of ST&I policy studies. Early studies in this field deployed the NIS to examine the capabilities of countries, regions, and sectors (see details of this background in chapter one). According to Lundvall (2010), an NIS is broadly defined as a system formed by 'the elements and relationships which interact in the production, diffusion, and use of new and economically useful knowledge (...) and [which] are either located within or rooted inside the borders of a nation state' (Lundvall, 2010, p. 2). When referring to NIS, innovation is perceived as 'an interactive learning process' which may be achieved through two methods: – (i) Learning by Doing, Using and Interacting (DUI-Mode of learning), and (ii) Learning by Linking or correlating Science and Technology with Innovation, that is, via science or research-based processes (ST&I-Mode of learning) (Mavhunga, 2017, p. 9). Drawing on the contribution of NIS to economic performance in the global North, the framework has gained an increasing focus in global South academic circles in the past decade, with an over-HIC-centric bias being part of its critics (Arocena, Göransson and Sutz, 2017; Albuquerque, Suzigan, Kruss, et al., 2015). However, Mavhunga (2017) challenges the universality of NIS with respect to African context, claiming that "a broadened, redefined, reconceptualised, or transformed notion of innovation in Africa (...) will help ensure that innovation from formal and informal sources are captured" (Mavhunga, 2017, p. 181). In his quest to contextualise the NIS framework to reflect LICs in general, and the African context in particular, Daniels in Mavhunga (2017) attempts to redefine NIS to reflect inclusivity

with regard to (i) sectoral aspects: informal sectors, indigenous knowledge innovations, and non-technological innovation (incremental versus radical innovation), and (ii) actors: non-corporate and/or non-academic entities such as communities, that is, people with tacit knowledge, NGOs, and civil societies. While government, academia, and industry remain intrinsically essential NSI actors, industry is its central actor (Daniels et al., 2017; Datta et al., 2019; Twiringiyimana et al., 2021). Fig. 2.1 below illustrates Rwanda's emerging, yet still weak and fragmented, NIS, due in part to scant interactions among system actors (Yongabo and Göransson, 2020).

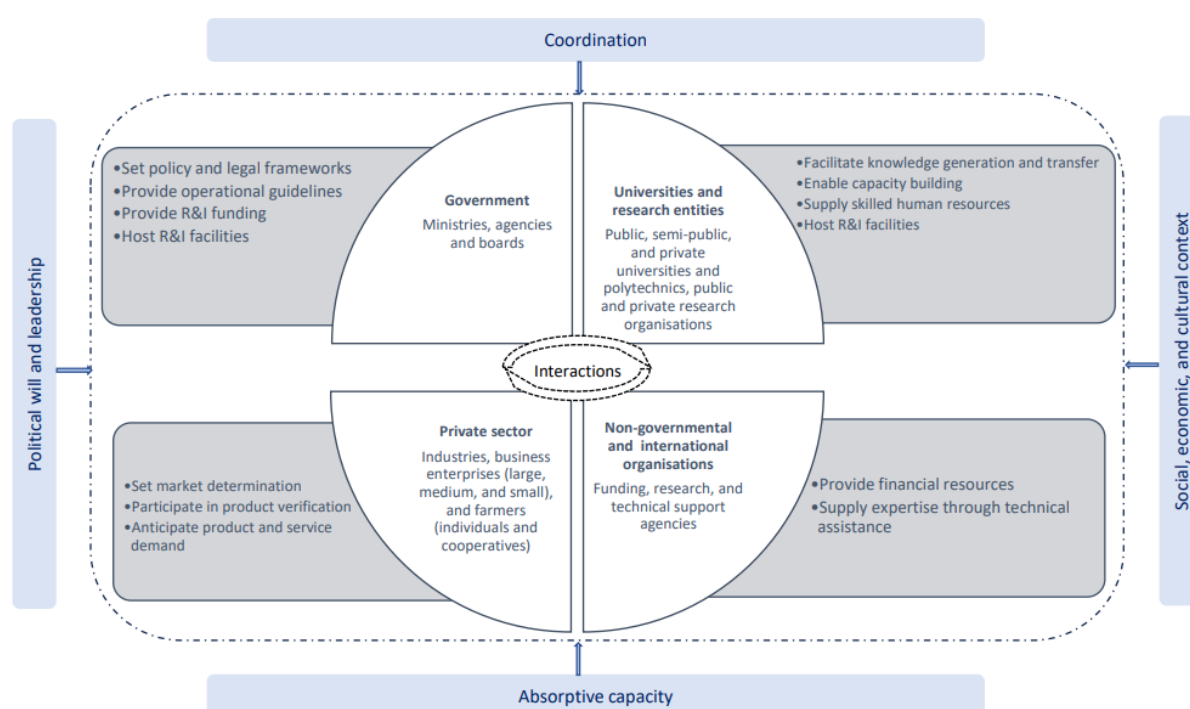


Figure 2.1. General layout of Rwanda's NIS

Source: Adapted from Yongabo and Göransson (2020, p. 13)

This Fig. 2.1 above sheds lights on the institutional and functional disconnectedness of Rwanda's NIS actors in relation to the flow of knowledge and innovation at the national level.

Over the past few decades, researchers and practitioners have drawn on NIS to study innovation policy at regional and sectoral levels, hence the emergence of regional innovation systems (Doloreux and Parto, 2005) and sectoral innovation systems (Reinstaller, 2003). While inclusive RISs may serve as an appropriate conceptual and analytical framework to explore the role of entrepreneurial university systems in LIC

contexts (Yao et al, 2018), a combination of RISs with other relevant analytical frameworks such Smart Specialisation Strategy (S3) are indispensable to explore innovation pathways for development in ‘less innovative regions’ (Asheim, 2019, p. 2).

2.3.2 Smart Specialisation Strategy

According to Daniels et al. (2021), Smart Specialisation is defined as ‘a place-based innovation policy approach that enables territories to construct competitive advantages through a better exploitation of the specific strengths and assets of the given territory’ within an NIS (Daniels et al., 2021, p. 151). With regard to specific territorial idiosyncrasies, the implementation (or adoption) of Smart Specialisation Strategies (S3) is believed to organically facilitate policy implementation and learning in a flexible, incremental, and gradual process. This is thought to be achieved in six steps: ‘(i) localising diagnostics on the basis of quantitative, qualitative, and expert-generated evidence; (ii) prioritising and selecting a few innovation domains in line with business and societal (not *per se* sectorial) challenges; (iii) developing a critical bank of research and innovation activities and human capital; (iv) mobilising the community to engage in decision-making (triple- or quadruple-helix actors); (v) customising innovation policy combinations and instruments to support transformative pilot activities; and (vi) regular impact assessments, monitoring and strategy reviews’ (Dosso et al., 2020; Daniels et al., 2021, p. 293). It is of paramount importance to note that government (national, regional or local) is the central actor for S3 development and implementation. As Dosso et al. (2020, p. 3) posited and as illustrated in Fig. 2.2, a ‘Smart Specialisation process is led and coordinated by a dedicated government structure’ *aka* ‘governance’, with academia or ‘research and education’ being part of the place-based governance structure, overseen by the various Smart Specialisation entrepreneurial discovery groups. The main role of these entrepreneurial discovery groups is to implement the entrepreneurial discovery process (EDP) defined as ‘a participatory process for local decision-making, which ideally brings together business, government, research, and education institutions, as well as civil society/consumer groups (users), to identify new domains for innovation and market opportunities (...)’. These interactive processes are at the core of S3, ultimately leading to selecting and encouraging existing or new entrepreneurial activities with significant potential for delivering local development.’ (Dosso et al., November 14, 2020b, p. 4).

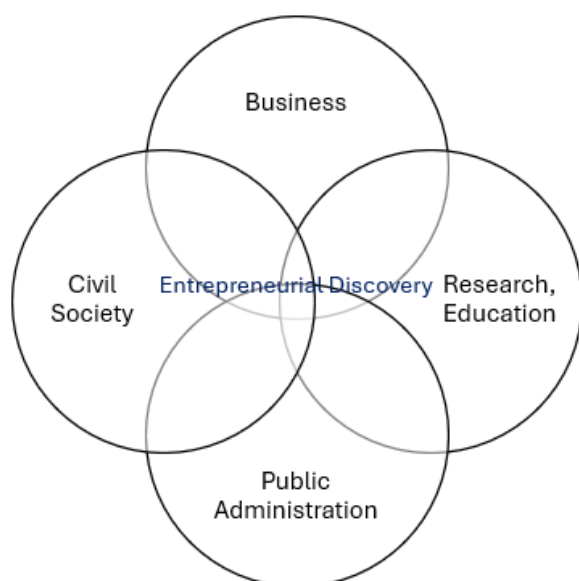


Figure 2.2. Entrepreneurial Discovery Process (EDP) for a Smart Specialisation Strategy (S3)

Source: Adopted from Dosso et al. (2020, p. 4).

Rooted in a HIC context, S3 ‘was promoted under the cohesion policy to reduce the socio-economic disparities between the European Union (EU) regions through greater efficiency in using regional funds for innovation’ (Dosso et al., 2020b). Over the last few years, exploratory efforts to integrate S3 into national ST&I policy frameworks have extended from the EU to include other regions and countries including Oceania (Australia), Latin America and the Caribbean (Mexico), and Africa (Tunisia, Ivory Coast, Nigeria and Rwanda) (Daniels et al., 2021, p. 291). As in the EU region (albeit in a different context), smart specialisation regions were identified in the above-mentioned other parts of the world on the basis of their primary existing economic activities such as agriculture in Ivory Coast (Dosso et al., 2020). In contrast to other pilot countries, preliminary findings from exploratory investigations towards S3 integration into Rwanda’s ST&I policy suggested that S3 may best be successfully applied to the country’s industrial development. This would imply that Rwanda’s industrial zones such as Kigali Special Economic Zone (KSEZ) could to some extent be considered as smart specialisation zones. One scenario unique to Rwanda is the genesis of KSEZ and KIC, an industrial zone that by and large was created as part of Rwanda’s economic development strategy (see details in chapter one). Central to the

KSEZ and KIC creation strategy was Rwanda's development agenda of making Kigali a 'knowledge and tech hub in selected industrial sectors including: fin-tech, edu-tech, energy-tech, agri-tech, big-data management, pharmaceutical, biotech, and cyber-tech' (GoR, 2020h, p. 21). KSEZ resulted from the consolidation of identified land – acquired by government and/or investors through a gentrification approach to City of Kigali's broad urban development strategy –previously occupied by economically-deprived residents of semi-urban areas of Kigali. Such land earmarked for a smart specialisation zone was subject to contextual pre-conditions to ensure it merited the tailored transformative policy investment required. This thesis thus argues that one detrimental consequence of establishing such S3 zones might be the potential for exacerbating privileged exclusivity and socio-economic disparities. Nonetheless, empirical research on place-based or territorial policy interventions constitutes an under-researched area, which is otherwise potential for evidence-based and inclusive dimensions of innovation policy and related strategies in SSA (Dosso et al., 2022).

2.3.3 Transformative Innovation Policy

In response to mounting conceptual and contextual criticism of NIS, the Transformative Innovation Policy (TIP) framework emphasises the mobilisation of innovation to address the challenges facing contemporary society, ranging from inequalities, threats to the natural environment, and unemployment, to economic performance (Schot and Steinmueller, 2018; Daniels et al., 2020; Daniels et al., 2021). Unlike the linear state-led model of innovation (Frame 1) and NIS approaches where innovation is largely underpinned by corporate scientific and technological capabilities (Lundvall, 2010) (Frame 2), the TPI framework (Frame 3) assumes that innovation can stem from any of the various actors: government, academia, industry, civil society, and/or deprived communities, and can take any direction for change within the sociotechnical system (Schot and Steinmueller, 2018; Daniels et al., 2021) (see Fig. 2.3. below).

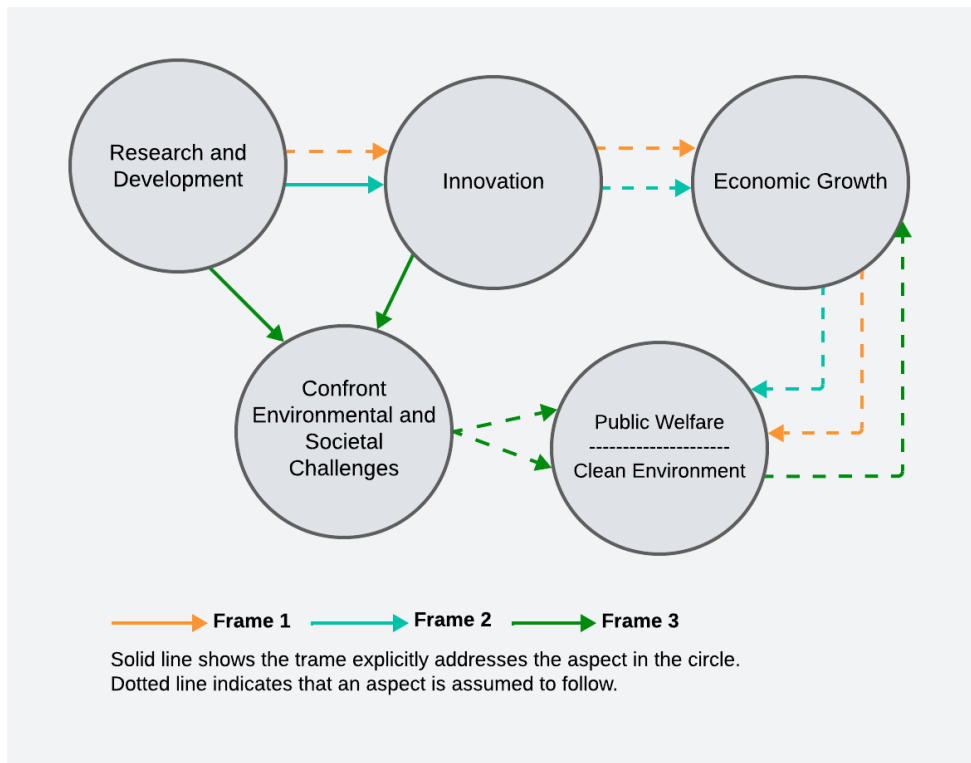


Figure 2.3. Conceptualisation of Transformative Innovation Policy (TIP)

Source: Adapted from Daniels et al. (2021, p.294)

Six criteria for TIP were outlined in Daniels et al. (2021, p. 284): ‘A focus on achieving societal goals through the changing of sociotechnical systems; directionality, that is, ensuring that other trajectories or pathways are explored as part of determining the choice of technology; ensuring that an impact is achieved at system level, that is, over and beyond any individual sectors; a focus on second-order (or more in-depth) learning and reflexivity; inclusiveness of a wide range of actors; and conflict and consensus (ability to encourage conflict, [resolve] it, and reach a consensus in the policy process’. Like that of other actors, the role of academia within a TIP framework is merely implicit.

2.3.4 Multi-level Perspectives and Socio-Technical Systems

A Multi-Level Perspectives (MLP) approach often serves as a valuable lens to investigate the conditions required for successful technological transitions (TT) to occur from niches (micro level) through regimes (meso level) to landscapes (macro level). Through a MLP approach, (technological) niches comprising novel configurations of individual actors shape or influence (or are shaped by) the existing

(meso) socio-technical regimes such as the judicial, regulatory, and techno-scientific body of knowledge available at place-based (regional) or national levels, which may (or may not) subsequently influence the transformation of the socio-technical landscape (macro level beyond national boundaries) (Geels, 2002). The extent of actor interactions at niche level may in part determine (or be determined by) the scope of system dynamics at regime and landscape scales. Although the focus of this research went beyond technological innovation, the nature of MLP served to some degree to mirror the role of innovation ecosystem actor interactions at micro-level, and their implications for meso- and macro-level NIS performances. However, some evidence suggests that the MLP approach lacks explicit insights into actor interactions at micro-, meso-, and macro-levels (Geels, 2002). Fig. 2.4 illustrates the MLP as a nested hierarchy.

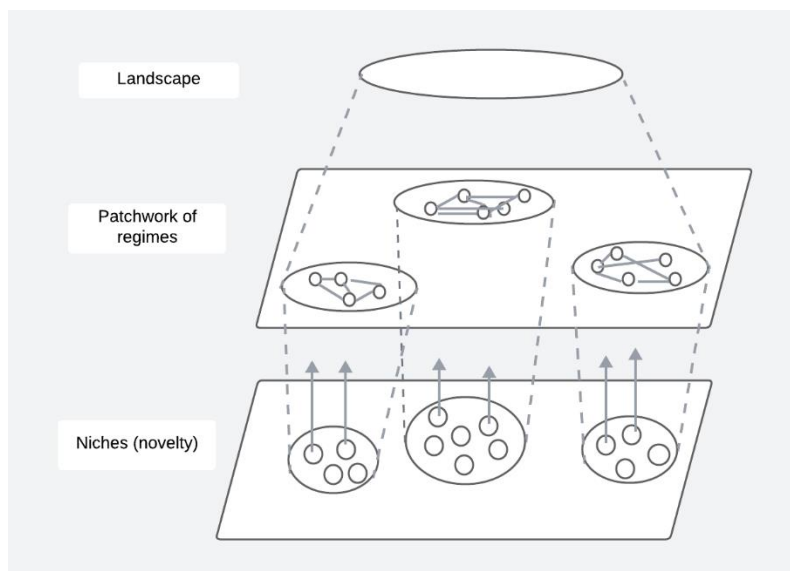


Figure 2.4. MLP levels in a nested hierarchy

Source: Adopted from Geels (2002, p. 1260)

As can be seen in Fig. 2.4 above, the (technological) innovation emerging from actor interactions at niche levels are influenced by socio-technical factors at the regime and landscape levels. Drawing on the experience of the United Kingdom (UK) healthcare system, the National Health Service (NHS), and approaching its enquiry through the lens of MLP and socio-technical and innovation systems, a recent study found that innovation emerged from interactions. When considering the healthcare perspective, the same study also highlighted six main factors that influenced the ways in which an

innovation system operated: (i) skills, capabilities, and leadership, (ii), interactions – relations and networks, (iii), information and evidence environments, (iv) incentives – motivation and accountabilities, including with regard to policy and regulatory frameworks, (v) actors' involvement and engagement with innovation, and (vi) funding, commissioning, and procurement (Marjanovic et al., 2020).

2.3.5 The Knowledge Systems Innovation

As presented in section 2.3.1 above, a body of research has suggested that science and innovation systems-dominated policy framings and related ST&I policy interventions were intended to lead both to scientific excellence (R&D) and economic growth (commercialisation). In contrast, ST&I interventions in the knowledge systems-dominated policy framing were expected to lead to sustainable and equitable development in response to societal needs (UKaid, 2020, p. 11). Confined to the national setting, Knowledge System is defined as a 'network of agents, practices, and institutions that organise the production, transfer, and use of knowledge' (Cornell et al., 2013; UKaid, 2020, p. 6). As can be seen in Fig. 2.5 below, the Knowledge Systems framework involves four distinctive yet inter-related perspectives namely: (i) Innovation systems – for the commercialisation of economically useful knowledge and innovation, (ii) Inclusive innovation – aimed at meeting societal needs, (iii) Sustainable transitions – for sustainability and resilience of the system, and (iv) Transdisciplinary development research – aimed at empowering the disadvantaged.

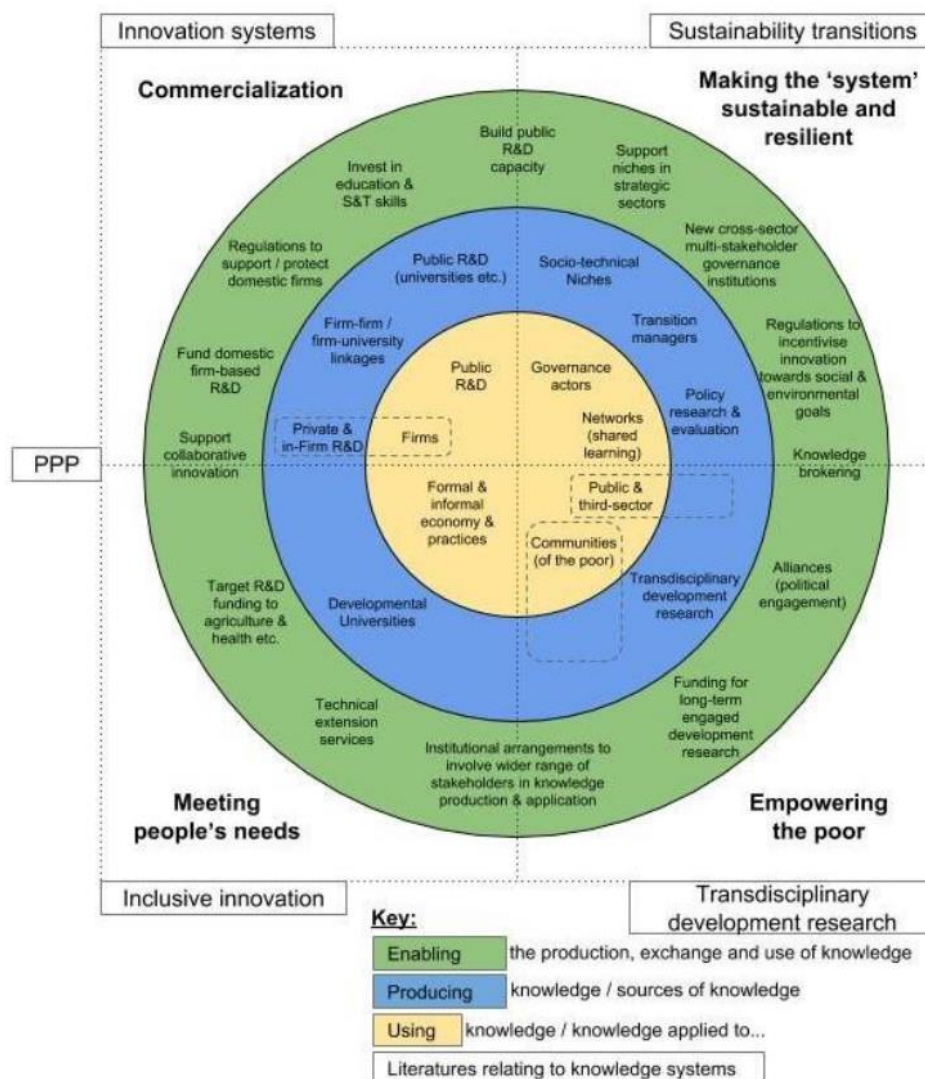


Figure 2.5. Knowledge Systems Innovation perspectives

Source: UKaid (2020, pg. 14)

Drawing on the aforementioned perspectives in Fig. 2.5, the Knowledge Systems Innovation (KSI) seeks to characterise the agents (or actors), practices, and institutions in the 'mainstream and emergent ST&I trajectories, support the mapping of research system, the wider innovation ecosystem, and diverse development outcomes' (UKaid, 2020, p15). Central to the KSI framework, most relevant to this study, is the concept of developmental universities that emerged in 1970's, with universities expected to support the newly independent African countries achieve developmental outcomes (Cloete et al., 2012). As Mkandawire posits, until the 'era of adjustment', the primary role of developmental universities in Africa was to generate socially relevant and economically useful knowledge, that addressed the needs and

interests of local people (Mkandawire, 2014). This perspective contrasts with the contemporary framing of universities as siloed centres for innovation.

2.3.6 Science Diplomacy, Innovation Diplomacy, and Diaspora Theory

Evidence suggests that science diplomacy has been practised by countries for centuries, although its emergence as a scientific concept only dates back to a couple of decades (Turekian, 2018). Scholars have attempted to conceptualise science diplomacy from different angles with the definition of this notion remaining in dispute and inadequately defined. Further to the early introduction of the concept of science diplomacy by the Royal Society and American Association of the Advancement of Science back in 2009, scientists developed conceptual frameworks allowing it to be studied or applied at the interface of science, public policy, international policy, or foreign policy (Flink and Schreiterer, 2010; Griset, 2020). For instance, the early theorisation of science diplomacy explores it through 3 spheres focusing on the role of science in international or foreign policy: Science for diplomacy, Diplomacy for science, and Science in diplomacy (Ruffini, 2017). As shown in Fig. 2.6 below, the theory of science diplomacy suggests that there is interconnectedness between science diplomacy, in all three of its spheres, and internationalisation of research. The degree of excellence of this interconnectedness determines the level of influence of a particular country over other countries. Countries have been using diverse approaches for diplomacy to support their respective national science, technology, and research systems. As Ruffini (2017) revealed, in addition to forming specific offices for science diplomacy in their respective embassies abroad, some countries adopted the model of creating 'networks abroad', coordinated by 'science attachés' *aka* 'science counsellors' within embassies (Ruffini, 2017, pp. 60–61). Furthermore, the roles and focus of these networks differ depending on countries' specific scientific priority. It is worth noting that these networks *aka* 'representative offices' differ from the centres for scientific research collaboration created abroad under the auspices of national science systems (Ruffini, 2017, p. 59).

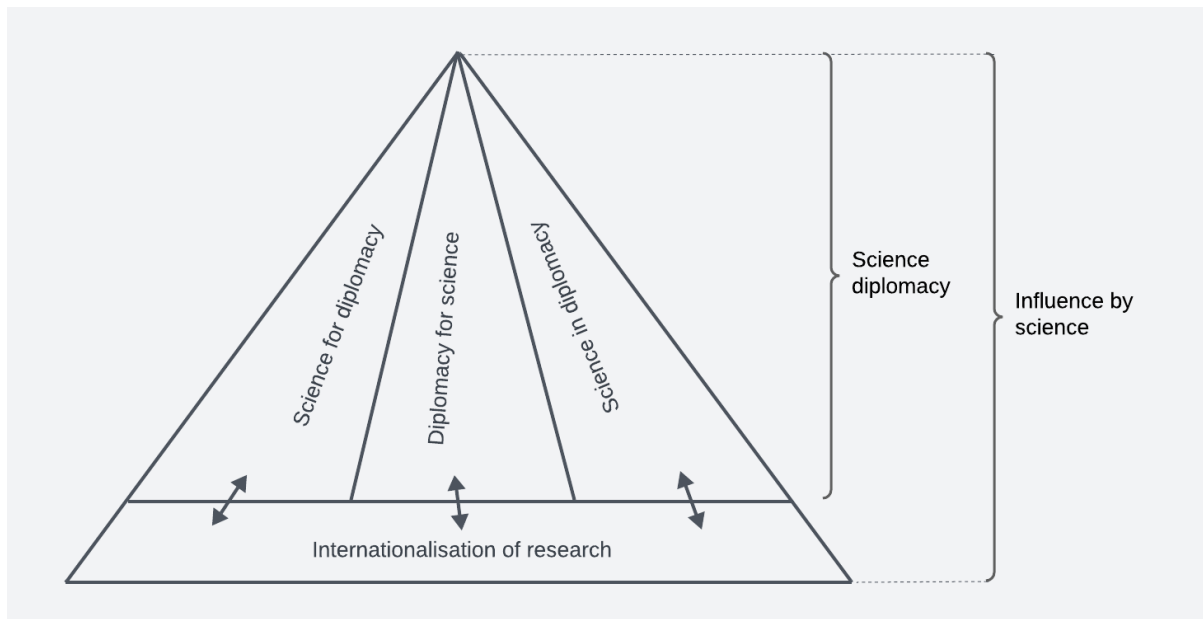


Figure 2.6. Science diplomacy and internationalisation of research in diplomacy of influence

Source: Adapted from Ruffini (2017, p. 28)

Stemming from migration policy, diaspora theory has recently emerged as the second dimension of science diplomacy. This theory provides tools and frameworks through which scientific diaspora leverages the capabilities in the recipient countries while contributing to home countries (Shuval, 2000; Vertovec, 2009; Seguin et al., 2006; Chirvas, 2022). Depending on national differences, regional contexts, and the actors involved in this scientific domain, scholars recently sought to broaden the concept of science diplomacy to encompass a newly emerging notion: innovation diplomacy. The aim was to bridge the existing gap in mainstream science diplomacy concept, particularly focusing on the actors involved. Through innovation diplomacy, the pioneering countries in the global North and global South not only engaged the scientific community abroad, but also the other capabilities ranging from business people, innovators, entrepreneurs, to government ministries and agencies responsible for promoting ST&I. This thus brought innovation diplomacy closer to the functions of systems of innovation at national and/or sectoral scales, in the global North (Kļaviņš, 2021), the global South (Anunciato and Santos, 2020a), or both (Leijten, 2017). According to Gluckman (2016, 2022), the most recent dimension of science diplomacy focused on how science could contribute to creating credible evidence for policy within

national science and innovation systems, and how, through science advice, diplomacy could contribute to advancing countries' interests or agendas (Gluckman, 2016; Gluckman, 2022).

Despite the emergence of science diplomacy and innovation diplomacy in recent literature, recent studies found that capacity development in this discipline at university level had not developed as rapidly as it had in political and public policy discourses. Researchers therefore went on to propose how science diplomacy and science innovation programmes could be taught at university level in different countries, with the aim to build a scientifically sound human workforce to employ as science advisors or scientific diplomats (Mauduit and Gual Soler, 2020; Moomaw, 2018). Given the relevance of this discipline to this work, science diplomacy was used as one of the main lenses through which to explore potential pathways towards fostering KIC's Knowledge Space actor interactions for RIL (see chapter nine for details).

2.3.7 Political Economy

Political economy (PE) is often described as an interdisciplinary specialist sub-discipline of social science that studies how political systems and economic systems interrelate. The concept of policy economy is thought to have been invented by Adam Smith as an economic analytical method aimed at exploring how 'historical and material circumstances change the incentives that the constant human nature faces' (Paganelli, 2020). Over the past few decades, scholars deployed a discursive approach to categorise political economy into the three categories: ideas, interests, and institutions, and to inquire how these categories underpinned (facilitating or hindering) political and economic dynamics in a specific context (Byrne and Mbeva, 2017). Drawing on socio-technical systems case-studies in both HIC and LIC contexts, Byrne and Mbeva (2017) claimed that the extent to which PE was operational was in part contingent on whether and to what extent actors were 'interacting and dynamic rather than isolated and passive' (Byrne and Mbeva, 2017, p. 5). Most recent research work on PE case studies arisen from Science Granting Councils in SSA noted how, based on empirical evidence, the concept had evolved to the point of adding a fourth category, 'structures', as well as shedding light on the scopes of the previously existing categories of 'ideas', 'interests', and 'institutions' (Chataway et al., 2017), to form four co-productive categories of an evolving PE (Daniels, 2020), as

illustrated in Fig 2.7 below. For the purposes of this study, PE was deemed vital as it offered a prominent lens through which to examine how the aforementioned PE categories influenced (or not) the creation and development of a knowledge-based innovation ecosystem.

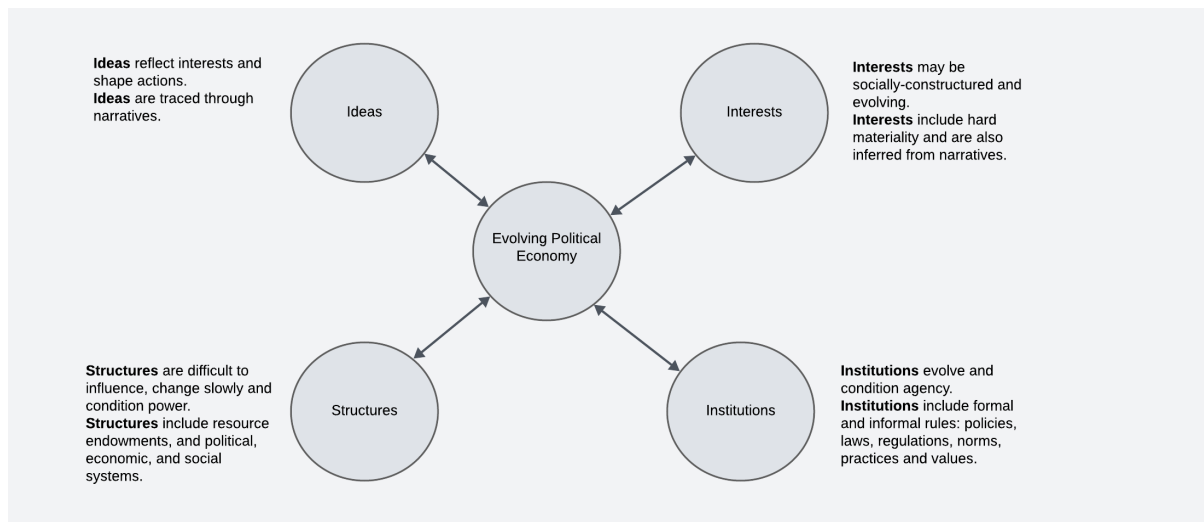


Figure 2.7. Four co-productive categories of an evolving political economy

Source: Adapted from Daniels (2020).

2.3.8 Urban Innovation

The concept of ‘Smart City’ and its relation with innovation in HICs gained an upsurge in the literature of innovation and socio-technical studies over the past few decades (Bulkeley et al., 2019). Considering smart city initiatives as urban innovation, Bulkeley et al. (2019) developed a smart city typology including technological, organisational, collaborative, and experimental dimensions. Based on their empirical research, Bulkeley et al. (2019) went on to posit that a given type of smart city may generate an incremental or radical urban innovation initiative depending on the scope of its innovation activities. Whereas the smart cities underpinned by collaborative (interactive) governance and experimentation tended to be radical, those with a sole technological aim may only have yielded incremental urban development effects, even in instances where the technological innovation itself was radical (Nilssen, 2019a). The case experience of Toronto’s Sidewalk Lab’s smart city testified to how ‘technological solutionism’ *aka* ‘tech-push’ for urban development without prior

community involvement and adequate experimentation may lead to failure (Haggart and Tusikov, 2020). Based on a comparative analysis of 40 European Urban Living Laboratories (ULLs), Bulkeley et al. (2019) drew a typology of smart cities subdivided into the three categories 'Strategic', 'Civic', and 'Organic', with each smart city feature being underpinned by a range of factors including, *inter alia*, situatedness, actors involved, aim or scope, relationship between laboratory and urban setting, priorities, funding models, and timelines. They went on to plot the typology of contingency control relations and/or tension dynamics based on whether the experimentation of a smart city was either configured as a 'trial', 'enclaved', 'demonstration', or 'platform'. Through the Strategic Mobilisation of African Resources for Transformational Advancement (SMART) Africa manifesto 2013, several African governments, including that of Rwanda, followed the pace in adapting and experimenting with the concept of 'Smart City', to underpin their technology-driven and knowledge-based development agenda and aspirations, especially ICTs, to address the contemporary and future urban development challenges in the social, economic, and environmental fields (GoR, 2015; Smart Africa, 2017). Notwithstanding the above, scientific literature about the concept of smart city and its relationship with innovation within the African context remains scanty. Based on the interpretivist study of the emerging concept of smart city, using examples in Ethiopia, Kenya, South Africa, Namibia, and Rwanda, Achieng et al., (2021) proposed a specific conceptualisation of the term to reflect the African context, its relevance, and its values (Achieng et al., 2021).

2.3.9 Innovation Ecosystem

2.3.9.1 *Innovation ecosystems – a theoretical perspective*

The Introduction chapter of this thesis provided an overview of the notion of 'innovation ecosystem' and how this scientific concept had been defined and explored differently in various academic and policy studies. This work followed Washbourne's (2021) definition of *ecosystem* as 'a dynamic framework consisting of a set of stakeholders, including start-ups, hubs, investors, academic institutions, public institutions, corporations, who interact and engage with each other to seize new opportunities, support innovation and strengthen the overall business environment for entities at different stages, sectors, and geographical locations.' (Washbourne et al., 2021, p. 3). As Papaioannou (2009) pointed out, the term 'ecosystem' is a short for 'ecological

system'. The term 'ecology' originates from two Greek words: 'οἶκος' (oikos) or (ecos), meaning 'household' or 'home', and 'λόγος'(logos), meaning 'discourse' or 'study'. Essentially, ecology can be interpreted as the study or discourse of the household of nature. It is a field with biology that focuses on living organisms and their interactions with the environment. These interactions form ecological systems or ecosystems, which 'evolve through adaptation of the living organisms to their environment' (Papaioannou et al., 2009, p. 4). Ecosystems, therefore, do not require external interventions to evolve. Palmberg's (2009) earlier work on the concept of 'innovation ecosystem' revealed that a functioning ecosystem presents the features of a 'complex adaptive system' as illustrated in Fig. 2.8 below.

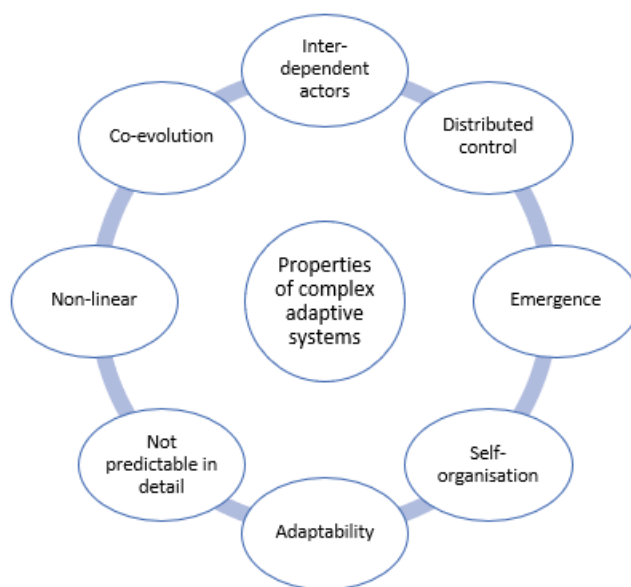


Figure 2.8. Innovation ecosystem as a complex adaptive system

Source: Adapted from Palmberg (2009, p. 485)

From a pragmatic perspective, the relevance of an innovation ecosystem is often manifested through its embeddedness in a broad innovation system at national, place-based, organisational, or sectorial levels. That said, the ability of [actors'] collaborative networks to adapt to a non-linear environment within a particular innovation ecosystem implies that they assume certain features of complex adaptive systems – agility, self-organization, self-governance, and synergy effects (Palmberg, 2009). Moreover, a recent work deployed a neo-functional approach to innovation ecosystem viewing it as 'the evolving set of actors, activities, and artefacts, and the institutions and relations

(...) that are important for the innovative performance of an actor or a population of actors' (Mugwagwa et al., 2021, p. 4). These diverse yet complementary perspectives on innovation ecosystems constituted a conceptual foundation for this work as presented in empirical chapters five, seven, eight, and nine of this thesis. Viewed through a broad systems perspective, evidence from some scholars suggested that an innovation ecosystem that works well is the one that is characterised by three main properties: resilience, self-organisation, and hierarchical systems evolved from the bottom up, with the overall goal of the system reflecting or serving the goals of its actors or subsystems (Meadows, 2008; Washbourne et al., 2021; Mugwagwa et al., 2021). Although the concept of innovation ecosystem elicits the co-evolution of interactions among actors, their innovations, and their environment, several scholars have challenged this interpretation of innovation systems theory and its application in innovation research, arguing that 'it can lead to problems of reductionism and functionalism' (Papaioannou et al., 2009, p. 2).

2.3.9.2 Reviewing the relationship between innovation ecosystems and urban enhancement – a practice perspective

Katz and Wagner's (2014) work on the new geography of innovation investigated the evolution of the conceptualisation of innovation ecosystems and their relationship with cities from a regional or place-based development perspective. This work found that, over time, innovation ecosystems had evolved mainly through three categories: (i) industrial areas/parks, (ii) science or research parks distant from urban settings, and (iii) innovation districts which were often embedded within an urban setting (Katz and Wagner, 2014). Focusing on the latter category, they went on to further classify innovation districts as *aspiring*, *emerging*, and *established*, mainly based on their development status with regard to their facilitation of knowledge and innovation production, dissemination, and use for economic and societal advancement purposes in an urban place-based or geographical setting. Despite sharing similar characteristics, innovation districts were also referred to in literature as innovation clusters or industrial clusters, which concepts had been deployed to understand extensive studies of innovation ecosystems such as Silicon Valley in California, USA (Engel, 2015). As indicated in the Introduction chapter of this thesis, developing countries often attempted to follow HIC development trajectories by adopting ST&I

policy models and narratives for knowledge-based economic development at national, and/or place-based levels, in an effort to catch up with and/or leapfrog more advanced nations. A number of policy studies of contemporary innovation ecosystems in Africa revealed that several SSA countries had adopted the creation of innovation ecosystems in urban areas. Examples of these ecosystems include Nairobi Silicon Savannah in Kenya (Braman, 2017; Shakarian, 2020), Silicon Mountain in Blue in Cameroon (Mugwagwa et al., 2021), Knowledge City (Cité du Savoir) in Diamniadio, Senegal (CIRED, 2018; Société Générale, 2019), and Kigali Innovation City (KIC) in Rwanda (IGC, 2018). Whilst these studies identified the various goals and architectures of the innovation ecosystems, no single empirical study exists which investigated the conditions for the formation of an innovation ecosystem as an ST&I and urban policy instrument in SSA context.

The remaining sections of this chapter review the conceptual framework that was deployed in studying several knowledge-based innovation systems in the global South, and ascertain why it was chosen as the most appropriate lens to guide the pilot phase of this research, notwithstanding the caveat of contextual dichotomy.

2.3.10 The Triple Helix System

As presented in the Introduction chapter of this thesis in general and in previous sections of this chapter in particular, evidence was found to suggest that the majority of systems theory-based concepts such as NIS, S3, SD, UI, and IE were developed from an HIC perspective, and the Triple Helix System (THS) as a model of innovation is no exception (Etzkowitz, 1996). Over the past few decades, scholars embraced the THS concept and its derivatives such as quadruple helix (QdH) and quintuple helix (QiH) to debate, from broad perspectives, the construct of academia, government, and industry innovation relationships, alongside related trans-disciplinary modes of knowledge co-production. These investigative discussions comprehensively explored economically useful knowledge (mode 2) from a THS viewpoint, and socially and environmentally relevant knowledge (mode 3) from a QdH and QiH perspective, in diverse contexts (Gouvea et al., 2013; Baccarne et al., 2016 ; Galvao et al., 2019 ; Carayannis and Campbell, 2009), including Africa in particular (Saad et al., 2008; Daniels et al., 2017). A review of THS configurations (statist, *laissez-faire*, and balanced) models, their derivatives, and the analyses of THS implications for research

and innovation (R&I) policy, governance, and practice in SSA has been discussed elsewhere (Twiringiyimana et al., 2021). While analysing science and innovation systems from a THS derivatives perspective remains relevant within established science and innovation systems, the relevance of sectoral or specialised studies – that *inter alia* take into account civil society, cities, and climate change as key actors (or spheres) – appears in part to be a function of many contextual factors such as political, cultural, social, and economic settings, at national and/or regional levels. For instance, a recent study showed that the new ST&I policies for Rwanda and South Africa had both broadly been conceptualised based on NISs. However, while the construct in the case of Rwanda was based on a THS framework (with government, industry, and academia being the key actors), civil society was added as a fourth main actor for South Africa, resulting in a quadruple helix framework (GoR, 2020b; GoSA, 2019; Twiringiyimana et al., 2021). The study therefore suggested that the THS framework of academia, industry, and government essentially remained an analytical and research tool for emerging and less researched science and innovations systems such as those of Rwanda. However, given the role of external R&I funding agencies (donors, including foreign government entities) in shaping Rwanda's science and innovation system, this thesis' author argues that these actors might form a stand-alone and fourth helical sphere in the case of specialised studies on the aspects of funding and capacity for development in the formation of Rwanda's NIS. Because of their central role in promoting inclusive innovation, NGOs could be included in this fourth sphere of donors as has been posited in earlier research in this area (Chataway et al., 2014).

From a systems theory perspective, evidence from a recent study suggested that THS had been one of the most appropriate frameworks deployed to uncover the inner dynamics of NIS, with both frameworks being often viewed by scholars and practitioners as innovation policy conceptual frameworks (Twiringiyimana et al., 2021). In their conceptual analysis of the two systems, Datta et al. (2019) suggested that both THS and NIS shared considerable similarities in respect of their respective structural makeup of main actors (academia, industry and government) as well as their policies and regulatory tools to facilitate interactions between actors. However, the major difference between THS and NIS is that while the university system is a central actor for the former, the firm entity is a main actor for the latter. THS frameworks consider

university (academia) systems as central actors for knowledge generation, dissemination, and use (Etzkowitz, 1996; Saad et al., 2008; Ranga and Etzkowitz, 2013) by academic researchers and students alike (Etzkowitz, 1996). Therefore, according to Datta et al. (2019), the contribution of university systems to innovation processes is much greater in THS than in NIS. In addition, viewing and tackling the issues investigated in the present research through a THS approach in a LIC context (Rwanda in particular) assisted in understanding how a plausible transition from an NIS (frame 2) innovation policy focused on economic growth, to the emerging TIP (frame 3), which places societal and environmental interests ahead of economic growth (Schot and Steinmueller, 2018), or indeed, a successful combination of the two, could be achieved.

2.3.11 Rationale of Triple Helix Systems and Regional Development Theory as fundamental theoretical framework for this study

Relevant literature has extensively argued that academia explicitly played a central role among main THS actors (Daniels et al., 2017; Schot and Steinmueller, 2018; Twiringiyimana et al., 2021). As indicated in the Introduction chapter of this thesis, the key objective of the latter was largely to develop an understanding of how academic actors – as the prime source of generation of formal knowledge – interacted within the place-based THS Knowledge Space of KIC. The above review of systems theory-based policy and analytical frameworks demonstrated that academia ranked among the relevant essential actors but was not necessarily or explicitly a central actor. For example, on the one hand, just as NIS focused on the production, dissemination, and use of knowledge and technical innovation, the MLP approach likewise placed the emphasis on technological transition, making industry the central actor in both frameworks. On the other hand, the TIP and S3 approaches were largely underpinned by government-led innovation processes. In contrast to the above frameworks, the often highlighted that academia played a pivotal role among THS actors (Daniels et al., 2017; Schot and Steinmueller, 2018; Twiringiyimana et al., 2021). Additionally, the nature of universities allowed them greater potential for innovation compared to other knowledge producing actors such as R&D agencies and knowledge-based firms. As Etzkowitz (2013) states, the ‘university is potentially more innovative than any other type of knowledge institution [organisation], because of one fundamental characteristic

of universities from their inception. That is, the university has the students, which make for a flow of human capital' (Etzkowitz, 2013)¹⁰. From policy and empirical perspectives, THS was deemed the most appropriate and overarching framework, largely on the basis of recent studies on Rwanda's NIS, which recommended embracing a THS model to achieve an in-depth understanding of the issues responsible for the country's NIS failures, namely, the perpetual inadequacy of actor interactions within place-based settings (Yongabo and Göransson, 2020; Twiringiyimana et al., 2021). Viewing KIC as a place-based (or regional) innovation ecosystem with Rwanda's NIS, this study partly aimed at exploring the question: *are KIC universities playing this important role in Rwanda?* This work scrutinised that question by studying the relationships these universities formed for KIC development. With the caveat that THS frameworks had mostly been used in mature and structured science and innovation systems in HICs, this case study was anticipated to be intensive, partly because the framework was going to be applied in a LIC with different contextual underpinnings.

2.3.11.1 The Triple Helix System as a conceptual and analytical framework for knowledge-based development at regional level

Ranga and Etzkowitz (2013) developed a THS framework as an analytical and research tool to further investigate the nature, relationships, and functions of THS components (or actors) in their spheres (academia, industry, and government) in underpinning knowledge creation, dissemination, and use within a given region within the NIS boundaries. It is particularly significant that THS are formed and operate through three functional spaces: knowledge, innovation, and consensus. Fig. 2.9 below illustrates the indicative characteristics of a typical THS.

¹⁰ Henry Etzkowitz's Keynote on the 'Entrepreneurial University Wave', International Institute of Triple Helix (IITH) Conference, Amsterdam, 28th May, 2013
<https://www.youtube.com/watch?v=I5WyTnD-WGE&t=70s> [Accessed: 16.10.2021, minutes 6:03-6:22]

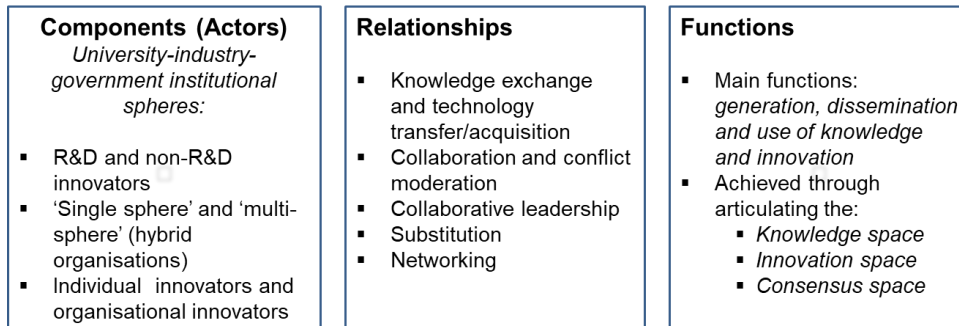


Figure 2.9. Synthetic representation of a Triple Helix System

Source: Adapted from Ranga and Etzkowitz (2013)

According to Ranga and Etzkowitz (2013), balanced configurations of THS have been shown to best promote innovation potential and to stimulate the transition towards a knowledge society. This balanced model, shown in Fig. 2.10 below, enables actors to transcend their specialist boundaries and hence facilitate the flow of people and exchange of knowledge and technologies within and across the various boundaries (spheres). Whether within or across spheres, the flow of knowledge and innovation is more often than not steered by individuals with ground-breaking capabilities, denoted 'innovation organisers' when they are in a managerial or leadership position to influence others, or 'entrepreneurial scientists' in the case of researchers with both academic and business capabilities, that is, those with the ability not only to produce cutting edge knowledge, but also to succeed in generating financial capital from this, for personal or corporate benefit (Ranga and Etzkowitz, 2013).

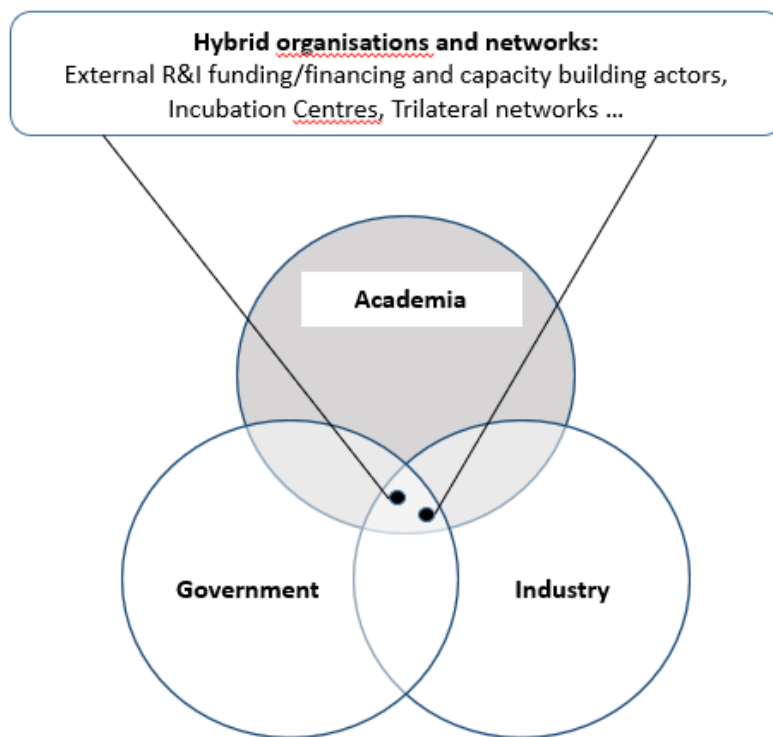


Figure 2.10. Proposed conceptualisation of KIC's Knowledge Space in a balanced Triple Helix configuration

Source: Author's compilation, based on Ranga and Etzkowitz (2013) and Meusburger et al. (2018, p. 301)

In this balanced (THS) model, actors engaged in substitutions to compensate for the weak actors in order to attain the targeted regional development innovation policy objectives. Examples could include: an entrepreneurial university engaged in developing spin-off companies or technology transfer/acquisition facilities, which would otherwise be the responsibility of industry, or an entrepreneurial government engaging in funding R&I and start-up businesses in addition to overseeing policy, regulation, and control, or indeed an industry taking up academic activities such regular academic training or professional short courses at national and/or regional levels within a given NIS setting. It can thus be seen that the role of hybrid organisations is central to this perspective (Etzkowitz, 1996; Ranga and Etzkowitz, 2013). As is the case in most SSA countries, Rwanda's ST&I policy regime is predominantly state-led and 'proactively (...) aimed at developing a knowledge-based economy' (Frost et al., 2019; Mbanda, 2019; UKaid, 2020), with the Government having control over academia and industry, thus making it a 'statist model' of triple

helix innovation (Meusburger et al., 2018). Nonetheless, Rwanda's R&I governance and practice does presents characteristics of a 'balanced THS model'. For instance, its National Council for Science and Technology (NCST) subsidises academia and industry by funding R&I in addition to its remit of managing ST&I regulation and coordination. In addition, the creation of a national Research Coordination Committee (RCC) delineates an element of transition towards the formation of hybrid networks which stimulate the horizontal synergies for academia-industry-government innovation (GoR, 2020b; Twiringiyimana et al. 2020).

2.3.12.2 Formation, transition, and directionality of THS spaces: the experiences of the New England Council, Silicon Valley, and Stockholm's Kista Science City

According to Etzkowitz and Klofsten's (2005) theory of knowledge-based regional development (Kb-RD), regional growth is achieved through a four-stage linear process: genesis, implementation, consolidation and adjustment, and self-sustaining growth and renewal, as illustrated in Fig. 2.11 below. However, the formation and transition of THS spaces is a non-linear process, the directionality and pathways of which are generally subject to diverse factors such as cultural, economic, and political dynamics, as well as societal developmental junctures within any particular regional setting.

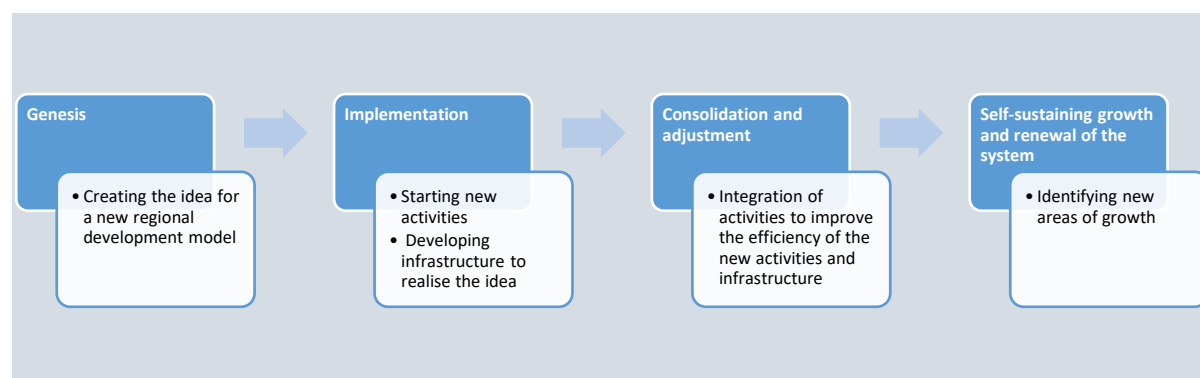


Figure 2.11. Four-stage model of regional growth and renewal

Source: Adapted from Etzkowitz and Klofsten (2005); Ranga and Etzkowitz (2013)

Using Etzkowitz and Klofsten's (2005) proposed theory of Kb-RD, Ranga and Etzkowitz (2013) discussed the diverse creation of THS in the three settings of: the New England Council, USA (1920-1950), Silicon Valley in California, USA (mid-

1950s), and Stockholm's Kista Science City, Sweden (1970s). These were achieved through the non-linear formation, transition, and directionality of THS spaces, namely: Knowledge Space, Innovation Space, and Consensus Space.

The case of the *New England Council* epitomised the significance of both the Consensus Space and Knowledge Space at the genesis stage to influence the formation of an Innovation Space. This case illustrated the transition from Consensus Space to Knowledge Space, and later to Innovation Space. At the turn of the 20th century, New England's economy plummeted, forcing industrial actors (small and medium size industries) to relocate to other affordable places to run their businesses. In turn, the 'Governors' of the six states of New England decided to create a Council to collectively devise a strategy and raise funds to renew the economic development in the region. The aim was to capitalise on the existing knowledge space that comprised two major universities, Massachusetts' Institute of Technology (MIT) and Harvard, and offered the scientific and entrepreneurial potential to advance knowledge and innovation within the hitherto 'newly emerging radio industry' in the 1920s. The Council therefore invented the 'venture capital firm' which focused on supporting start-ups stemming from these two universities. As a result, the start-ups flourished and expanded into forming an Innovation Space (Ranga and Etzkowitz, 2013).

The case of *Silicon Valley* in California, illustrated in Fig. 2.12 below, illustrates the transition from Knowledge Space to Innovation Space, and then to Consensus Space in the final stage of 'self-sustaining growth and renewal of the system' (Ranga and Etzkowitz, 2013). Prior to the economic slump in the last decade of the twentieth century, academia (comprising Stanford University among others) and industry (high-tech firms, including university spin-offs) had already established a Knowledge Space and Innovation Space respectively. However, each sphere was pursuing its own strategy under the '*laissez-faire*' THS model (Etzkowitz, 1996). The high-tech companies had thus developed well-established R&D units and inter-firm clusters for which they could see no value in interacting with university and/or government entities. The economic recession of the mid-1990s instilled in these high-tech firms the importance of collaborating with the academia and local government, as an imperative to renew the economic development of the region. Hence a brand-new organisation named 'Joint Venture Silicon Valley' was created, which adopted a venture capital

approach to support auspicious novel ideas. ‘Computer networking’ was selected as the then-promising emerging technology to afford the region a comparative advantage.

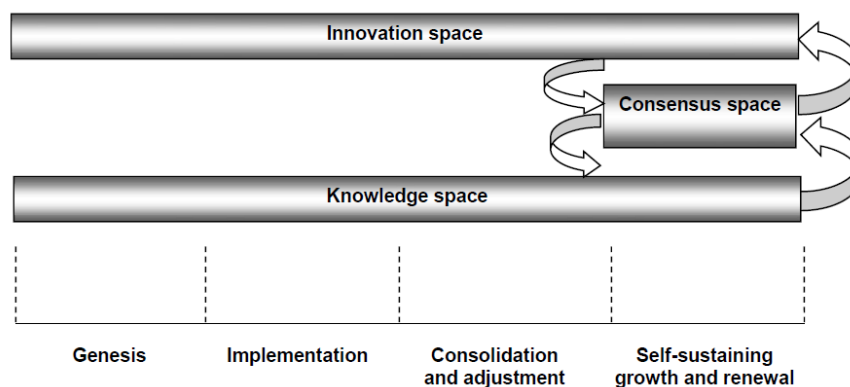


Figure 2.12. Silicon Valley development stages in the mid-1990s

Source: Ranga and Etzkowitz (2013)

The case of *Kista Science City* in Stockholm, Sweden, illustrates how a Consensus Space can successfully strengthen interactions between ‘business-intensive platforms’ aka Innovation Space and ‘knowledge-intensive platforms’ aka Knowledge Space. The Kista Science City originated from the region hosting, first, Ericson and later, IBM departments in the early 1970s. A decade later, the Mayor of Stockholm foresaw the transformation of the region into an ‘electronics centre’ which later matured into an ‘established ICT centre for national and international prestige’, dubbed ‘Sweden’s Silicon Valley’, which attracted numerous R&D-performing organisations (or units) from academic and business spaces in the fields of electronics, computer science, and engineering. The ICT centre became home to the Kista Science City in 2000, a new creation arisen from the joint vision of the regional government, academia, and industry. Two years later, Stockholm University and the Royal Institute of Technology (KTH) created an IT University as a joint venture which stimulated the region’s comparative advantage, particularly in ICT. According to Ranga and Etzkowitz (2013), by 2010 Stockholm’s Kista Science City was host to over 5,000 ICT students and academics, and in excess of 1,500 ICT firms.

The review of the above three case studies revealed the vital role of regional government in establishing a THS as a strategy for regional development. The creation of the New England Council and Silicon Valley arose from economic recovery strategies following downturns in these two regions of the U.S. In both of them,

innovations in the hitherto emerging technologies – radio communication in the former and computer networking in the latter cases – stemmed from interactions between universities and local Small and Medium Enterprises (including university spin-ins and spinouts). Conversely, the formation and growth Stockholm’s Kista Science City mainly emanated from already established big transnational corporations. The US model of THS innovation based on venture capitalism and university spin-offs (or spin-ins) is therefore not the only model fit for purpose and applicable to other countries and regions with diverse political, social, and economic settings. As alluded to in this chapter and as emphasised by Mavhunga (2017), context matters.

2.4 Knowledge gap and contribution of this research

The systems theory-based scientific concepts, theories and frameworks presented in the previous sections of this chapter were deployed to explore the performance of science and innovation systems at national, regional, and or sectoral levels, in developed and developing countries alike. Moreover, several studies in developing countries attributed the persistent underperformance of NIS to weak or non-existent interactions amongst key actors such as academia, government, and industry, and a lack of synergies to stimulate the flow of knowledge and innovation (Yongabo and Göransson, 2020; Twiringiyimana et al., 2021). Earlier studies had demonstrated that the inexistence or lack of actor interactions hampered knowledge-based development, thus impeding the competitiveness of national science and innovation systems (Sawyer, 2004; Albuquerque et al., 2015b; Kruss and Visser, 2017).

Despite the importance of place-based innovation ecosystems in attaining national ST&I policy outcomes within broad NIS, there still remains a paucity of empirical investigations into the dynamics of innovation ecosystems development in place-based settings in developing country contexts. There have furthermore been no empirical studies that assessed the state and nature of actor interactions at place-based science and innovation ecosystems levels, nor the ways in which these interactions influenced the performance of science and innovation systems in a developing country setting. This thesis therefore empirically sought to bridge this knowledge gap by focusing on the inner structures of Rwanda’s NIS with the aim of developing an understanding of **‘how’** the university system (academia) – as the main source of formal knowledge generation – interacted with other actors for RIL, within

and beyond the KIC's Knowledge Space. Moreover, the work explored varied pathways for fostering KIC's Knowledge Space actor interactions for KIC development into an inclusive innovation ecosystem. In doing so, this thesis argued that the perpetual underperformance of national science and innovation systems in SSA largely stemmed from the weakness or absence of actor interactions across science and innovation ecosystems or sub-systems within the NIS boundaries. Understanding and fostering actor interactions at micro- and meso-levels of ecosystems might therefore be conducive to enhancing interactions at macro-level, hence improving the performance of science and innovation systems at national level. It is worth noting that the focus of this work was not to assess the status of KIC's development *per se*, but rather to understand whether, and if so, how and to what extent academia (university system actors), conceptualised through THS as KIC's Knowledge Space actors, interacted within itself to achieve the aforementioned goal of developing KIC as a place-based, knowledge-based innovation ecosystem.

Given the purpose of this study, an in-depth and meticulous *in situ* scrutiny of Rwanda's under-researched NSI, with a focus on academia — the key actors within KIC's Knowledge Space — was conducted in two phases, employing multiple relevant frameworks. The first phase, *aka* the pilot phase, focused on investigating and gaining insights into whether THS was a relevant framework in a LIC context, and whether THS was a useful tool to explore whether universities and the network they formed constituted important actors for place-based development. The second phase, *aka* the post-pilot phase, focused on exploring the pathways for fostering KIC's Knowledge Space actor interactions for RIL, and the conditions for KIC to develop into an inclusive knowledge-based innovation ecosystem both from ST&I policy and urban perspectives.

While THS framework supported understanding the nature and extent of academic actor interactions with other actors in relation to RIL, findings from the pilot phase revealed that THS alone was insufficient as a conceptual lens to fully address the primary research aim. The framework lacked the comprehensiveness required for this study. The systemic, complex, socio-technical, and developmental dynamics of KIC — characterised by its dual role as both a flagship ST&I policy intervention and an urban innovation initiative at the interface of urban and peri-urban settings in an LIC — could not be adequately studied through a single framework. Hence, following a descriptive

analysis of the various frameworks, an integrated, context-specific conceptual framework was developed to guide the post-pilot phase of the research (see details in chapter six).

2.5 Chapter summary

This chapter focused on content review whilst being guided by the aims of this research. Driven by research design, this approach thus facilitated a deep dive to uncover the contemporary research and policy discourse relevant to this work, positioning the research topic within the body of knowledge pertaining to ST&I policy studies. In order to identify the existing knowledge gap and propose knowledge that would contribute to bridging the gap, the review was approached through two main themes: (i) review of university systems at global, regional, and national (Rwanda) levels, and (ii) review of theoretical dimensions of actor interactions for knowledge and innovation generation, dissemination, and use, in the global North and global South alike, and on Rwanda's KIC as a case-study.

Next in this thesis is the Methodology chapter which presents the methods used and the epistemological and ontological foundations adopted to investigate this research problem whilst bridging the aforementioned knowledge gap.

Chapter 3. Research methodology

3.1 Introduction

Alongside presenting the role of science in shaping society, the Introduction and Literature review chapters of this thesis elaborated on how scientific theories, conceptual frameworks, and methods had been deployed to guide, shape, interrogate and/or evaluate the creation and development of place-based, knowledge-based innovation ecosystems within National Innovation Systems (NIS) in high-income country (HIC) and low-income country (LIC) country settings. The previous chapters also highlighted the associated knowledge gap with the absence of empirical evidence as to how Knowledge Space actors interacted with other actors for knowledge creation, use, and dissemination, how these interactions influenced innovation at micro- (organisational), meso- (place-based or regional), and macro- (national) levels in a developing country context. This research primarily aimed at investigating this problem by adopting a two-phased research approach that used Rwanda's Kigali Innovation City (KIC) as a case study. This chapter provides a detailed account of the methodological approach deployed to carry out the research.

3.2 Research design and approach

Why and how was a case study approach chosen as the preferred research methodology? A case study approach has arguably proven to be the most relevant method of empirical research enquiry for knowledge creation from both conceptual and contextual perspectives in the event of a scarcity of research data (Höglund and Linton, 2018; Davidson, 2017; Mugwagwa et al., 2021; Daniels et al., 2022). In policy research, a (multi-country) case study approach is often used to establish *in-situ* a thorough understanding of complex phenomena such as the role of science granting councils (SGCs) in the fields of national science and innovation systems (Mugwagwa et al., 2020b). A case study approach is also often used to generate evidence to inform or support the generation of new theories for science or concepts for policy, such as responsible innovation (Stilgoe et al., 2013), e-incubator based triple helix business models (Persada et al., 2019), entrepreneurial ecosystems (Kshetri, 2014), and innovation district strategies (Bank and Sibanda, 2018). It is also often viewed as a preferred research approach for exploring or testing existing theories or concepts by

examining the extent of relevance of these concepts in diverse contexts. According to Ranga and Etzkowitz (2013), a case study approach was suggested as the best and most appropriate research methodology for the type of investigations similar to this thesis. Building on the existing literature on case-study methods, Ketokivi and Choi (2014) discussed the heterogeneity of methodological approaches in case study research. Depending on the RQ and objectives, a case study approach may aim to generate, test, or expand theory. The above authors furthermore suggest that ‘case research rigour is determined by attention to idiosyncrasy and transparency of reasoning’ (Ketokivi and Choi, 2014, p.232). In light of the present RQ and proposed knowledge contribution, and with reference to existing TH conceptual frameworks and earlier empirical evidence as described earlier in this section, the Ketokivi and Choi (2014) decision tree was adopted to determine whether the case study research approach adopted met the transparency and duality criteria (*situationally grounded* and *generality*) required for the investigation in question (Ketokivi and Choi, 2014).

As illustrated in Fig. 3.1 below, a ‘case research as theory elaboration’ approach was selected for the pilot stage of this study partly with the aim of exploring the relevance of a THS framework in a LICs context. Empirical data from Rwanda were thus used, not only to test the validity of the THS framework, but also to challenge it in relation to the contextual situatedness of the case research. This empirical work thus in part aimed to contribute knowledge creation for evidence-based theory elaboration as ‘most theories are well elaborated, but empirical proof for the described changes, roles, and processes is limited’ (Spruijt et al., 2014, p. 16). Spruijt et al.’s (2024) claim is of particular paramount importance in LIC contexts with a scarcity of data for policy and decision-making, and policy interventions (Heege et al., 2019; Twiringiyimana et al., 2021). These work data were thus used to explore and understand the behaviour of Rwanda’s KIC actors and its academic and policy implications for the creation, use, and dissemination of knowledge and innovation, in a place-based setting as well as within broader NIS (Yongabo and Göransson, 2020).

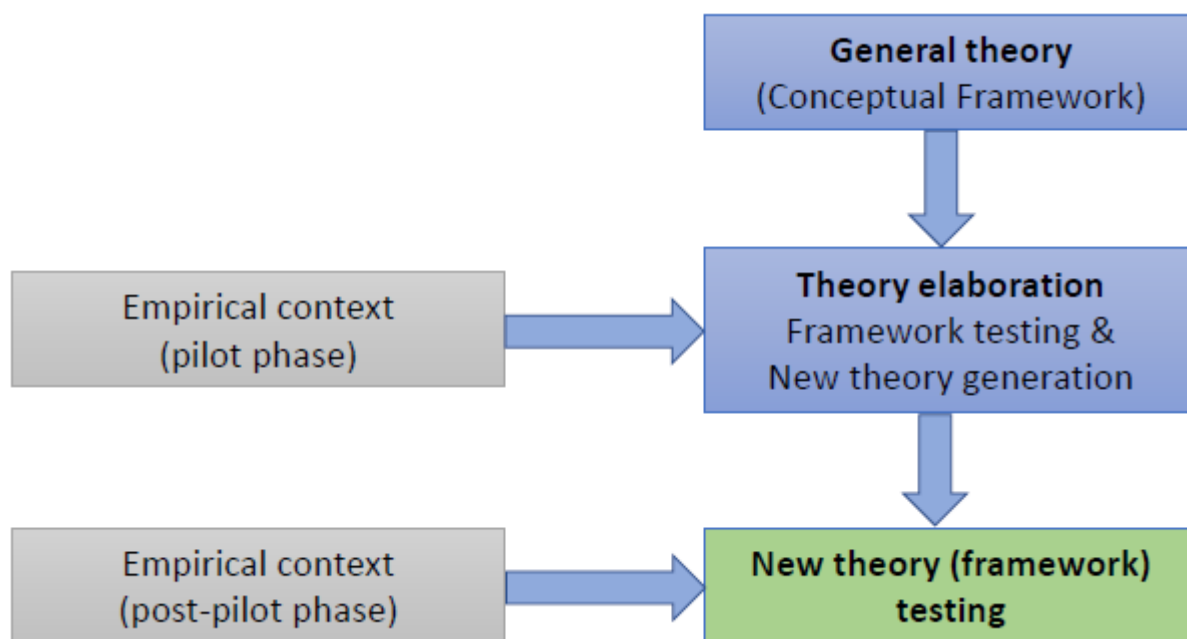


Figure 3.1. Theory (Framework) elaboration, generation, and testing approach to case study-based research

Source: Adapted from Ketokivi and Choi (2014)

Why opt for a pilot and post-pilot research approach? According to University College London's (UCL) doctoral training programme guidelines, doctoral candidates are required to carry out their doctoral research in two phases. In the first phase, normally the first twenty-four months, the student works on the pilot research. On successful completion of this phase, the remaining part, denoted as 'post-pilot' phase in the thesis, is dedicated to conducting further research and thesis writing. Research being presented on this thesis was thus conducted based on a 'two-phased case-study approach', that is, two consecutive yet complementary phases: the pilot study that was undertaken from February 2020 to February 2022, followed by the post-pilot study from July 2022 to July 2023.

What is known about the 'pilot study' concept? From a research methodology perspective, pilot research, *aka* a 'pilot study', is often adopted in case study research methodology. That said, the rationale for using such a 'pilot study' approach often goes unjustified (Kadima et al., 2021). This research had therefore attempted to conceptualise 'pilot research' from a methodological point of view. From an urban

policy innovation perspective, Hughes et al. (2020) maintained that pilot projects serve as one policy implementation option through which a change to complex policy problems is explored on a 'smaller scale before attempting larger changes' (Hughes et al., 2020, p. 6). Attempting to theorise a 'pilot project' concept in relation to how policy interventions move beyond the pilot stage in urban innovation, Hughes et al. went on to suggest that a post-pilot project may take either of two directions, 'scaling up' or 'scaling out' based on the anticipated policy outcomes. Scaling up means 'the widening of the scale of operation', with scaling out meaning 'the expansion geographically of a pilot the city to another jurisdiction, including other cities and other levels of government' (Hughes et al., 2020, pp. 8–9). Viewed through the lenses of public policy and administration spaces constituting a policy process, *aka* 'policy cycle' framework (Capano and Pritoni, 2020), a pilot project approach also often proves to be a preferred methodological strategy for governments in policy experimentation (Bulkeley and Castán Broto, 2013). Chapter six of this thesis discusses the theoretical foundations of public policy cycles from a policy actors' perspective.

As alluded to in the Introduction chapter of this thesis, proof-of-concept is another terminology often used in literature to signify experimentation of a policy intervention, *aka* 'piloting'. A case study approach is often deployed to examine and learn from the proof-of-concept phase for full-scale or upscale implementation in a similar context or elsewhere. (Sly et al., 2022). From a methodology point of view, this research design thus drew from Hughes et al. (2020) to define the post-pilot stage 'scaling up' from the pilot stage. As illustrated in Fig. 3.2 below, the pilot study focused on KIC as an ST&I policy intervention' within Rwanda's NIS. During the pilot phase, the study investigated the different types of interactions amongst the KIC central actors (academia) and how these interactions influenced (or not) the development of KIC into a knowledge-based innovation ecosystem. The pilot study deployed conceptual and methodological approaches, at both micro- (intra-actor) and meso- (place-based inter-actor) levels, to identify the nature and various types of KIC actors and their interactions, and how these interactions influenced (or not) the KIC's Knowledge Space. Chapters four and five of this thesis present in detail the findings of the pilot study. In addition to exploring Research questions (see chapter one), the pilot study also served as a learning opportunity through pre-testing the methodological approach in general, and the data collection instruments as well as data analysis tools in particular.

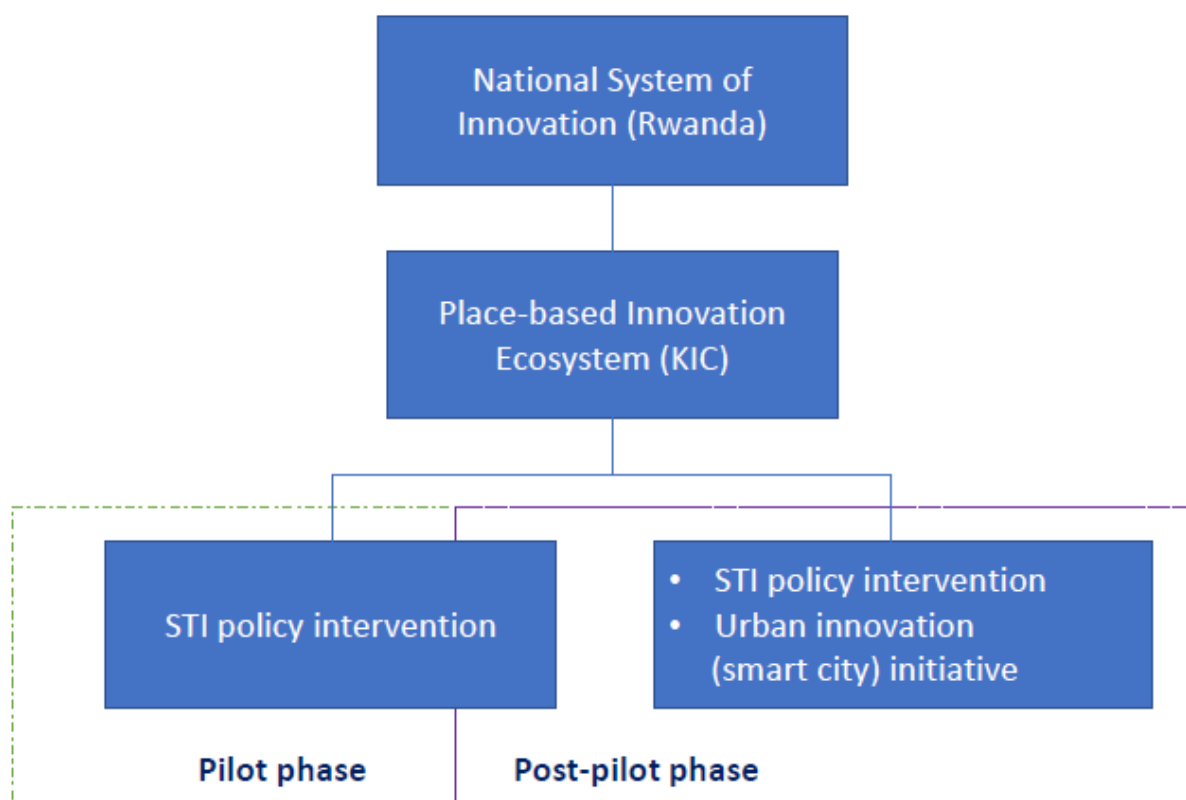


Figure 3.2. Two-phased case study research approach

Source: Author's own compilation

As can be seen in Fig. 3.2 above, the post-pilot research work was conceptually approached through two distinctive yet complementary lenses, namely: (i) KIC as a national ST&I policy flagship intervention in a place-based or regional setting – a science and innovation system perspective, and (ii) KIC as an urban smart city initiative – an urban innovation perspective. In both perspectives, the study was geared towards developing the understanding of actor interactions, as well as exploring different pathways, including science diplomacy, to create new or foster existing interactions for the development of an inclusive and sustainable place-based science and innovation ecosystem in a national setting.

Based on the pilot phase, the research expanded in scope and scale to include other actors, namely: public sector (government), industry, and civil society, to explore the conditions and pathways towards fostering actor interactions for RIL in support of KIC's development. As illustrated in Fig. 3.1 above, after interrogating the mainstream theoretical framework for the pilot study, a new integrated conceptual framework was developed and tested as a lens through which to explore the post-pilot research

questions. Chapter six of this thesis provides a detailed account of the integrated conceptual framework that guided the research process in the post-pilot phase. Viewing KIC from an urban policy innovation perspective, the direction of this study called for exploring the concept of ‘scaling out’ in other cities within Rwanda. The rationale was that this might arguably add value to Rwanda’s secondary city development strategy (see details in chapters eight and 10). To address the research objectives, a qualitative method and semi-structured interview approach were the main modes adopted or both the pilot and post-pilot research phases. These were in turn supplemented by other methods as discussed in section 3.7 below. The sub-section below discusses the philosophical assumptions and requirements that guided this research.

3.3 Epistemological and ontological underpinnings of the research

Every research pursuit is underpinned by ontological beliefs and epistemological assumptions. Chesky and Wolfmeyer (2015) defined ontology as a ‘study of the state of being’, and epistemology as a ‘study of knowledge and scope of knowledge’ (Chesky and Wolfmeyer, 2015, p. 18). They went on to submit that while ontology is a ‘branch of philosophy that is interested in exploring questions of existence, being and reality’, epistemology is a ‘branch of philosophy that is interested in understanding knowledge, how we come to acquire it and whether it is fallible or valid beyond human understanding’ (Chesky and Wolfmeyer, 2015, p. 19). These ontological and epistemological dimensions not only determine researchers’ beliefs about their world, they also ‘influence researchers’ choices about how to produce and verify knowledge statements about the social world, how it is constructed and how it operates’ (Galdos Frisancho, 2022, p. 51). Drawing on a critical review, Galdos Frisancho (2022), developed a brief yet comprehensive overview of how ontological beliefs and epistemological assumptions are deployed for knowledge production through a range of contemporary and competing approaches: positivism, interpretivism, critical realism, and constructivism. Table 3.1 below illustrates the summary of these philosophies along with related methodological approaches.

Table 3.1. Examples of philosophies underpinning social science research

	Positivism	Constructivism	Interpretivism	Critical Realism
Ontology	▪ Independent and objective reality. ▪ Causality is indicated by constant conjunction of empirical events.	▪ Reality is linguistically constructed. ▪ Multiple realities are possible.	▪ Reality is socially constructed. ▪ Multiple realities are possible.	▪ Objective, stratified reality consisting of surface-level events and real entities with particular structures and causal properties.
Epistemology	▪ Knowledge is generated by discovering general laws and relationships that have predictive power. ▪ Particular emphasis on prediction.	▪ Epistemic relativism. ▪ The goal of the knowledge produced is to destabilise or subvert discourse and power.	▪ Knowledge is generated by interpreting subjective meanings and actions of subjects according to their own frame of reference. ▪ Emphasis is on interpretation.	▪ Reproduction is used to create theories about entities, structures and causal mechanisms that combine to generate observable effects. ▪ Emphasis is on explanation.
Method	Quantitative methods, such as experiment, survey, and statistical analysis of secondary data.	Qualitative methods such as ethnography.	Qualitative methods such as ethnography and case study.	▪ No preference for a particular method. ▪ Choices depend upon the research questions and the nature of relevant entities and causal mechanisms.

Source: Adapted from Galdos Frisancho (2022)

Given the complexity of KIC as a ‘ST&I policy intervention and considering the social and wicked nature of the research problem, as discussed in the Introduction chapter of this thesis, Critical Realism (CR) was deemed the most appropriate philosophical approach to the study. In fact, a wicked policy problem refers to ‘the kind of poorly-

structured, intractable policy problem with unknown solutions with which policy-makers, unfortunately, must engage on a frequent basis'. (Head, 2022, p. 2). This research thus took the CR approach as it's [CR] 'search for causation helps researchers to explain social events and suggest practical policy recommendations to address social problems' (Fletcher, 2017, p. 183).

The sub-section below provides an overview of CR and why it was the preferred approach for this research.

3.3.1 Taking a Critical Realist approach

Over the past few years, CR has increasingly become a widely accepted philosophical lens through which to conduct research in social sciences. Some literature suggested that CR stemmed from the 'paradigm wars' between positivism and constructivism in the 1980s (Denzin and Lincoln, 2018). CR employs the features of both constructivist and positivist frameworks to depict the ontological and epistemological standpoints, making it a comprehensive scientific philosophy (Fletcher, 2017). Fig. 3.3 below illustrates CR at the interface of constructivist and positivist perspectives, along with localism. The latter reflects the research that was conducted virtually, in an online context using video and/or audio functions of UCL's Zoom and Teams platforms. For instance, for the localist position, the 'interview process is not a neutral tool to evoke rational response and uncover truth, but rather a situated event in which the interviewer creates the reality of interview situation' (Qu and Dumay, 2011, p. 10).

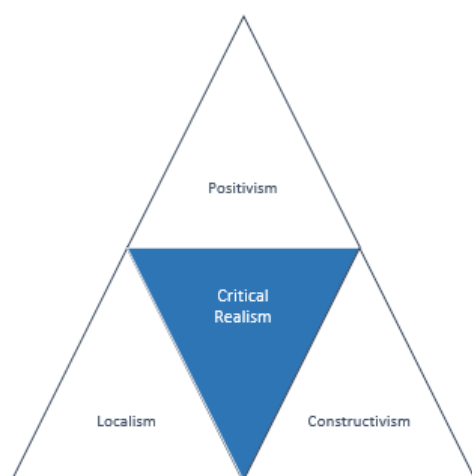


Figure 3.3. Critical Realism as a central philosophical foundation for the research

Source: Author's own compilation

From an ontological perspective of CR, reality comprises three interactive levels of stratification. As demonstrated in the ‘triple-layered’ metaphoric iceberg in Fig. 3.4 hereafter, the *empirical level* is the first one that represents the ‘realm of event’ as experienced and observed by the researcher. The second and middle level comprises the *actual*. At this level, events occur whether or not they are observed or interpreted. These actual or ‘true’ events usually differ from the events experienced or observed at empirical level. The third level consists of the *real*. *Social* structures of ‘causal mechanisms’ existing at real level cause the events that are experienced and observed at empirical level (Fletcher, 2017; Galdos Frisancho, 2022). While the metaphoric iceberg in Fig. 3.4 demonstrates CR’s ontological and epistemological levels of ‘human knowledge of reality’, it also shows the ‘limitation of the [human] epistemic fallacy’ (Fletcher, 2017). This submission adds to Denzin and Lincoln’s (2018) assertion that ‘CR bases the researcher’s emergent ideas on empirical evidence and acknowledges that knowledge is partial, provisional, and historically located’ (Denzin and Lincoln, 2018, p. 415). The relevance of a scientific inquiry is thus contingent upon the extent to which the empirical events facilitate the understanding of related social structures or causal mechanisms.

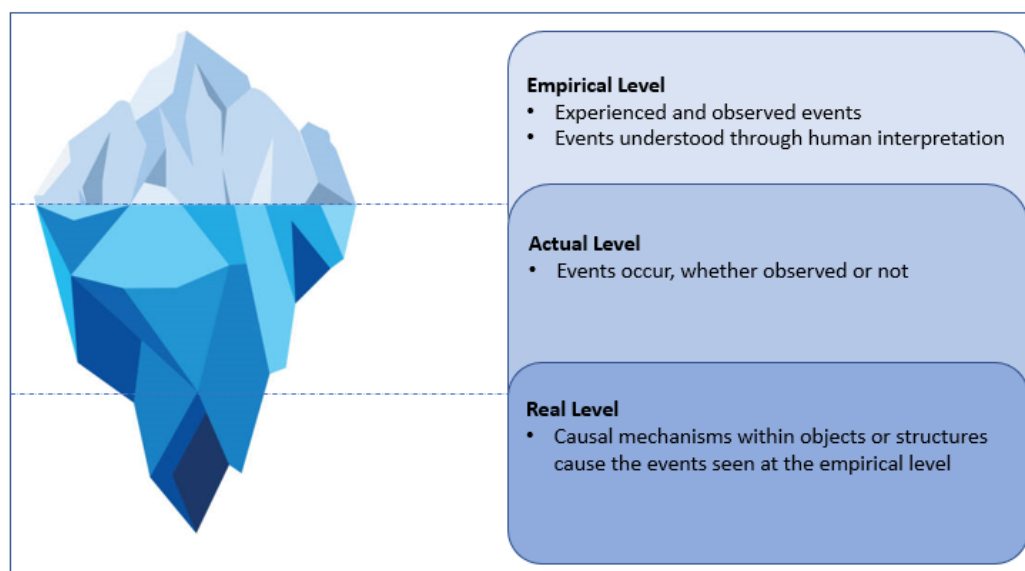


Figure 3.4. The Iceberg metaphor for Critical Realism as a scientific research approach

Source: Adapted from Fletcher (2017) and Galdos Frisancho (2022)

Even though there had been no intention *a priori* to develop a new theory, a CR position was adopted as the epistemological basis in approaching this case study research. Notwithstanding this, when scrutinising the THS concept as a socially constructed phenomenon during the pilot phase, the emphasis was placed on understanding and interpreting the empirical, actual, and present relationships among the actors, rather than seeking to influence the mode of interaction of these actors (Easton, 2010). Easton (2010) suggested that CR is a ‘coherent, rigorous, and novel philosophical position that not only substantiates case research as a research method, but also provides helpful implications for both theoretical development and research process’ (Easton, 2010, p.118). He further suggested that as a new approach for establishing ‘truth’, CR was increasingly being used for case studies in areas such as interdisciplinary science, sociology, information, economics and management, to mention but a few (Easton, 2010). The case research in the present study was intensive in the sense that at the interview stage, it focused on a broad range of actors, from diverse strands of disciplines and with different levels of experience and expertise. It also involved qualitative data analysis at both pilot- and post-pilot stages, from complex intra- and inter-organisational systems. The objective was to create knowledge through interrogating existing theoretical frameworks, developing and testing new frameworks, and thus developing informative theoretical and conceptual conclusions.

3.4 A From interdisciplinarity to critical transdisciplinarity, and co-creation in knowledge creation

The Introduction and Literature Review chapters of this thesis highlighted how actor interactions for RIL were wicked and multifaceted policy problems. Studying such a perpetual problem in an emerging innovation ecosystem environment such as KIC required a nuanced inter and transdisciplinary approach, allowing for the exploration of a broad range of perspectives from both academic and non-academic actors. This thesis attempted to establish the link and contrasts between three main scientific terminologies that often incorrectly tend to be used interchangeably in academic and policy discourse: multi-disciplinarity, inter-disciplinarity, and trans-disciplinarity. These terms were thus defined from a methodological perspective: based on the multi-

coloured Rubik's cube metaphor, Chausson defines multidisciplinary as 'different disciplines working in parallel without integration'; interdisciplinarity as 'Different disciplines crossing different disciplinary boundaries to create new knowledge and theories, as (...) cubes melted together' (Chausson, 2022). Interdisciplinary approaches to knowledge co-creation in academia and practice gained popularity in a broad range of fields in the past few years. Yu et al. (2023) made the case for engineering designing and prototyping to move away from a monodisciplinary to an interdisciplinary approach to create engineering solutions to complex 21st century problems (Yu et al., 2023). In addition to engineering research and production, interdisciplinarity was deployed in engineering teaching (Richter and Paretti, 2009), medical and life sciences (Atienza Casas et al., 2023), systems thinking (Constable, 2021), social and behavioural sciences (Salvato, 2015), and innovation studies (Yu et al., 2020). It is widely accepted that interdisciplinarity in research is beneficial in that it helps research teams deploy different perspectives to understand or shape complex problems (Brown et al., 2023). Such complex problems, *aka* 'wicked problems' would not be fully understood if viewed through a single lens or by applying a monodisciplinary approach. Despite the above-mentioned methodological differences between multidisciplinary and interdisciplinarity, both approaches to knowledge creation share one common aspect when viewed from a system's approach. The disciplines 'working in parallel' in the case of multidisciplinary and those being 'integrated or melted together' in the case of interdisciplinarity are all located within the one and same system actor's sphere, that is, academia.

Transdisciplinarity differs from multi- and interdisciplinarity in that it involves knowledge co-production that transcends the academic actor boundaries to include non-academic actors or practitioners. Chausson defines transdisciplinarity as 'harnessing, sometimes with integration, but not always, multiple knowledge systems beyond academic knowledge' (Chausson, 2022). In the same vein, Maguire (2018) argued that, 'like anthropology, transdisciplinarity is more than the knowing why and the knowing how, [it] is a way of knowing[.] The developing of an attitude to the world which is a contribution to an epistemology of what matters locally and globally' (Maguire, 2018, p. 4). He goes on to submit that transdisciplinarity concerns that which is at once between the disciplines, across the different disciplines, and beyond all

disciplines. Its goal is the understanding of the present world, of which one of the imperatives is the unity of knowledge'. (Maguire, 2018, p. 5).

Weak actor interactions for RIL in a place-based knowledge-based innovation ecosystem is thought to be wicked as it encompasses 'issues which implicate multiple domains of academic inquiry and involve the interplay of academic disciplines and practitioners seeking real world solutions' (Chausson, 2022). Recalling the wickedness of this research's main problem, a transdisciplinary approach was specifically deployed at post-pilot stage to further develop an understanding of the status of interactions between a broad range of actors, and the conditions (or causal mechanisms) underpinning those interactions. In fact, 'transdisciplinarity offers a conceptual framework and an approach to research which begins to provide the conditions to understand how we come to know and to choose what matters at an individual and collective level' (Maguire, 2018, p. 13).

The capacity to understand such a complex problem thus requires a holistic approach to knowledge production that substantially implicates multiple disciplines, sectors, different types of actors and stakeholders with a range of diverse skills-sets, expertise and experiences. As is demonstrated in chapter seven of this thesis, deploying existing theories and engaging with participants' knowledge critically constituted essential considerations raised by CR ontology and epistemology (Fletcher, 2017). With a complex and diverse nature of participants in this research, with diverse levels of understanding, values, interest in, influence to, and needs of KIC, a critical transdisciplinarity served as the most suitable approach as it was 'dialogic, consultative, realistic, values driven, context sensitive, open, enquiring and patient' (Maguire, 2018, p. 12). A critical transdisciplinary approach was all the more essential for a case study research approach in the context of empirical data scarcity. Specifically for the case studied in this research, a transdisciplinarity method was selected to gain knowledge from academic and non-academic actors including policymakers, with a greater understanding of the contextual and practical dynamics of Rwanda's science and innovation system. Considering the state of KIC as a flagship policy intervention in Rwanda's science and innovation policy landscape, this study was thus methodologically undertaken whilst keeping the two key questions below in mind: *How can this research be conducted in such a way that it changes practice*

within and without academia? How can this research enable policymakers to incorporate research evidence into policy making?

A detailed account of the approaches to empirical data collection are presented in the sections below in this chapter. Through these approaches, research participants were not used as tools providing empirical data – as is often the case in mainstream research approaches. They [research participants] rather contributed as active agents in shaping the research design, thus making them likely to consider applying the research findings and recommendations – hence in turn generating greater possibilities for the research impact to reach the participants' society and communities. The tripartite and two-phased research approach of a pilot-phase, work-in-progress seminar, and post-pilot phase represented a significant effort to achieve research openness. This interpretivist approach enabled interactions with actors from epistemic and non-epistemic communities – including key informants who would not otherwise have had the opportunity to bring a greater contribution to the research process (see details in section 3.5.2 below).

3.5 Research purpose and data collection

The Introduction chapter of this thesis offered a granular description of the scope and objective of this work as it was conducted in two consecutive and complementary phases: pilot and post-pilot phases. The purpose and scope of each phase were also presented. By way of a recall, using Rwanda and KIC as a case-study, the main RQ was threefold: *(i) How do the academic and research organisations located in KIC interact with other science and innovation system actors for research, innovation and learning (RIL)? (ii) To what extent do these interactions contribute (or not) to KIC development? and (iii) What are the possible pathways of fostering these interactions?* This triple main RQ was thus investigated in the pilot and post-pilot phases which focused on four and three research questions, respectively.

Pilot phase research questions:

- 1) *Who are the KIC Knowledge Space actors?*
- 2) *How do KIC Knowledge Space actors interact for RIL, and do these interactions influence the teaching and R&I among these Knowledge Space actors?*

- 3) *Are these interactions related to KIC's regional (place-based) planning and development activities, and if so, how?*
- 4) *How has the COVID-19 pandemic influenced actor interactions in respect of R&I?*

Post-pilot phase research questions:

- 5) *How do KIC Knowledge Space academic actors interact with industry for RIL?*
- 6) *What is the role of government agencies including foreign offices in supporting the development of KIC into knowledge and innovation ecosystem?*
- 7) *What specific characteristics define Kigali Innovation City as an urban smart city initiative, and to what extent do the Kigali Innovation City Knowledge Space actors interact with adjacent communities in their geographical setting?*

At each phase of the research process, the framing of the research questions was underpinned by a CR ontological and epistemological foundation and guided by conceptual frameworks described in chapters two and six respectively. While this research was primarily exploratory, it partly aimed at interrogating the relevance of exogenous conceptual frameworks that had largely been developed for and applied in HICs, but not necessarily in LICs contexts. The work also sought to build on these mainstream theoretical frameworks and propose and test an integrated framework appropriate to answering these research questions at post-pilot stage, using Rwanda's KIC as a case study. In so doing, and in addition to contributing knowledge to scholarly literature, this work sought to draw on empirical data to collectively make these concepts useful in enabling the making and governance of ST&I policy at national, regional (place-based), and organisational levels. Chapter six provides a descriptive analysis of conceptual frameworks relevant to this study. Given the caveat of the paucity in data in the public domain, an in-depth and close *in-situ* investigation of existing empirical datasets was imperative in this sense. Having secured research ethical approval, participant identification, data collection, and data organisation processes were conducted from August 2022 to April 2023. The study adopted a two-pronged approach to data collection, with desk research and semi-structured interviews being the main methods of collecting most of the data. Some grey data and information were collected through organised interactions with a range of sources of evidence on key actors including academia, government, industry, and civil society

relevant to the case studied. For the purposes of complementarity of research methods (Ahmed and Othman, 2021), and drawing on the findings from empirical data, a rudimentary scoping review of bibliometric data and content analysis were undertaken to facilitate a further nuanced in-depth analysis. This was a methodological effort to respond to the specific main Research questions as completely as possible. The sub-sections below provide a detailed description of each of the four data collection approaches deployed in work.

3.5.1 Desk research

Desk research played a central role in setting the research in context while responding to research main questions. Data were drawn from relevant sources and progressively stored in and processed through a personal database created with Zotero, a free and open-source reference management software designed to manage bibliometric data and other related research resources from peer-reviewed and grey literature (Trinoskey et al., 2009). Given the context of data scarcity, grey literature was profoundly relied on to gain a solid and in-depth description of the case study. This work thus primarily adopted a widely accepted definition of 'grey literature' as 'a literature which is produced by all levels of government, academics, business [including non-commercial organisations], and industry, but which is not controlled by commercial publishers (...) It includes reports, theses, conference proceedings, and official documents not published commercially' (Davidson, 2017, p. 2). The work also concurred with another related and widely accepted definition that limited grey literature to 'literature protected by intellectual property rights, of sufficient quality to be collected and preserved by library holdings or institutional repositories' (Schöpfel, 2011), or 'a range of documents not controlled by commercial publishing organisations' (Adams et al., 2016). Moreover, given the contemporary advances in technology, and in particular ICTs, with online information being rapidly and arguably more conveniently disseminated via online media channels than paper-based resources, including social media outlets, this work adopted a broad and inclusive definition of grey literature to include data and information presented in written form. Table 3.2 below provides an overview of different aspects of 'grey literature', 'grey data', and 'grey information' with examples (Adams et al., 2016, p. 2).

Table 3.2. Updated defining aspects and examples of ‘grey literature’, ‘grey data’, and ‘grey information’

Term	Definition aspect	Examples
Grey literature	Not controlled by commercial publishing organisations	- Internal reports - Working papers - Newsletters - Dissertations and theses - Conference papers
Grey data	User-generated, web-based	- Tweets - Blogs - Vlogs - Facebook/Instagram/LinkedIn status update
Grey information		- Meeting notes - Emails, - Personal memories

Source: Author’s compilation, adapted from Adams et al. (2016, p. 2) and Paez (2017).

By the time this work was conducted, Zotero featured among the research software packages recommended by UCL library¹¹. As shown in Fig. 3.5 below, the total of 307 sources were consulted and used for the purposes of informing and shaping this work.

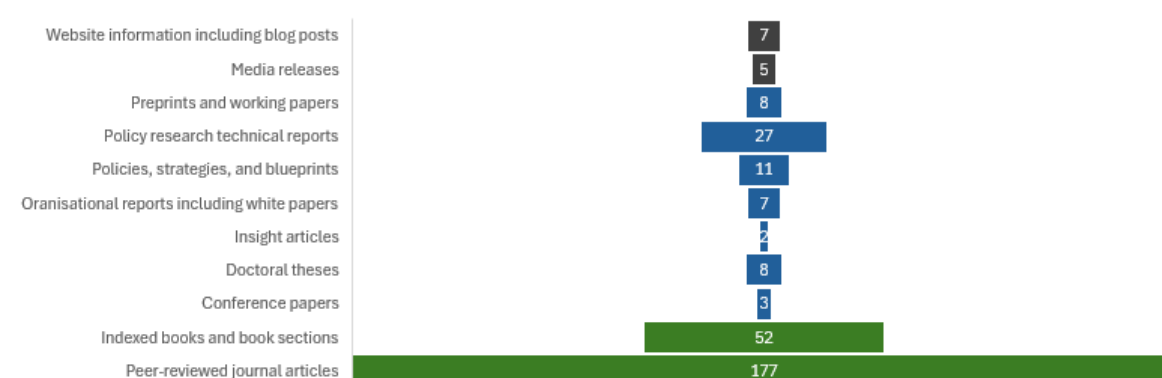


Figure 3.5. Overview of secondary data sources used in this thesis

Source: Author’s compilation based on bibliographic information from Zotero library references.

¹¹ <https://library-guides.ucl.ac.uk/zotero/versions> [Accessed: 05 May 2023]

As illustrated in Fig. 3.5 above, secondary data sources were categorised into three: academic literature highlighted in green, grey literature highlighted in blue, and grey data highlighted in black. The academic literature review constituted the majority of the sources with 229 items, including 177 peer-reviewed journal papers and 52 indexed books and book chapters. The grey literature review comprised 66 items, including three conference papers, eight doctoral thesis, two insight articles, seven organisational reports and white papers, 11 organisational policies, strategies and blueprints, 27 technical reports, and eight preprints and working papers. The grey data was the least sourced with 12 items including five media releases, and seven general website information including blog posts. The 307 sources were selected from 687 reference items from Zotero library, based on three main criteria: (i) relevance to this study, (ii) credibility of the sources, and (iii) publication date (see Appendix_3.15 for details on Zotero library for this research). Drawing on Adams et al. (2016) and Paez (2017), the grey literature and grey data informed the content of this case study research work while setting the study in context. The grey literature and grey data also helped uncover evidence through storytelling and policy narratives, and actor interaction dynamics pertaining to the formation and development of KIC as an emerging public policy intervention, none of which information would have been available through mainstream scholarly literature. In fact, the ‘understanding of (...) factors such as group dynamics and political context are reflected in grey literature’ (Davidson, 2017, p. 2). Moreover, grey literature allows contextual understanding of how and why public interventions are effective (or not) and what this means to the relevant stakeholders (Adams et al., 2016). From a research methodology point of view, in addition to ‘case research’, Paez (2017) emphasised the importance of grey literature in ‘systematic reviews’. Despite doctoral theses and dissertations, and sometimes conference papers, often being subjected to rigorous and meticulous, arguably high-quality reviews, the remaining categories of grey literature as exemplified in Table 3.1 and Table 3.2 above, are not necessarily run through similar levels of scrutiny prior to publication. In addition to grey data circumstantially gathered through online sources, grey information gathering was equally paramount during seminars, conferences, and capacity development sessions relevant to this research. Section 3.8 below provides an in-depth description of the implications of how collecting grey data and information contributed to the research’s openness, pushing the

boundaries of the grey literature method further beyond desk review. Hence, this research did not underestimate the downsides of grey literature including, *inter alia*, the variations in quality, reliability, and different forms of potential bias (Paez, 2017). To overcome these pitfalls associated with grey literature, the selection and utilisation of sources from grey literature were conducted with the utmost precautions and appraisal throughout the study.

3.5.2 Semi-structured interviews and work-in-progress seminar

The research adopted a semi-structured interview approach, with the research questions themes determined by the research objectives. The Interview checklists with detailed research questions for pilot- and post-pilot study phases are presented in Appendix_3.1 and Appendix_3.6 respectively. The semi-structured interview format is arguably the most popular research method due to its flexibility, accessibility, intelligibility, and most importantly its capability to disclose important and often hidden facts of human and organisational behaviour. From a methodological point of view, a 'semi-structured interview involves preparing questions guided by identified themes in a consistent and systematic manner, interspersed with probes designed to elicit more elaborate responses' (Qu and Dumay, 2011, p. 9). The purpose of interview guidance is to ensure that a 'thematic approach is applied during the interview'. (Qu and Dumay, 2011, p. 9). The method thus allows the possibility of altering interview-interviewee conversation style and re-arranging research questions based on the respondent's expertise and their organisational category – whether government, academia, industry, or civil society. This is mainly 'because it has its bases in human conversation, it allows the skilled interviewer to modify the style, pace, and order of questions to evoke the fullest responses from the interviewee (...) It proves to be especially valuable if researchers are to understand the way the interviewees perceive the social world under study' (Qu and Dumay, 2011, p. 9), making it the most realistic and appropriate method of data collection. From an institutional and organisational point of view, 'semi-structured interviews help to develop the understanding of the way in which managers make sense of, and create meanings about, their jobs and their environment' (Qu and Dumay, 2011, p. 9). Moreover, case study and interview approaches have been used to investigate place-based development challenges

associated with university – city relationships in diverse geographical contexts (Bank and Sibanda, 2018).

Drawing on the aforementioned understanding of case study research and interviewing methods, this research deployed an expert interviewing style using semi-structured techniques targeting managers, at least at director level. Unlike the ethnographic approach whereby research aims to learn about the organisational culture from within (Qu and Dumay, 2011), this study took a place-based case study approach to learn from participants' specialist expertise and understanding of Rwanda's ST&I policy, landscape, and KIC ecosystem in which they operate, and how this ecosystem is shaped or influenced by – their respective roles and organisations.

In addition to semi-structured interviews, greater knowledge co-creation was realised mainly through work-in-progress seminars held when the study was transitioning from pilot stage to post-pilot stage. The seminars brought together a range of participants with expertise and experiences transcending the realm of academic disciplines, creating the opportunity for co-creation and co-learning. Moreover, besides engaging research participants through work-in-progress seminars, and following up on semi-structured interviews, this study adopted a persuasive research process to ensure greater participant engagement in research and co-creation of knowledge as part of a de-colonisation of research effort (Kessi, 2017). For instance, a few interviewees were surprised and pleased with the interviewer persuading them to review the transcripts to check and ensure their insights and perspectives were fully and correctly captured. This sense of surprise on the participants' part may arguably have stemmed from their viewing the research approach as unprecedented or unexpected. This process was indeed adopted as an alternative or contrast to the mainstream unidirectional and top-down approach to the research interview process, where participants'/informants' involvement in research was traditionally limited to answering Research questions during the interview period. Although the aforementioned approach created opportunities for participants' greater involvement in the research process – both during and after their interview time – it presented several setbacks. For instance, the process was time-consuming and required great deal of patience from a researcher's point of view. It also demanded a sense of persuasive capability for the researcher to be able to secure participants' post-interview feedback.

3.5.2.1 Participant identification and interviewee selection

Section 3.2 of this chapter provides a detailed account of how this research was designed to be conducted in two phases – pilot and post-pilot. In line with the research objectives, the pilot study focused only on KIC academic entities. According to UCL’s Research Ethics Committee’s (UCL REC) approval, primary data collections for the pilot study were to be carried out among no fewer than nine academic entities – conceptualised as KIC’sKS actors – with the aim of securing a minimum of eighteen respondents, that is, two key respondents per academic entity. Drawing on the United Nations’ Conference on Trade and Development (UNCTAD)’s 2017 review of Rwanda’s ST&I policy, which recommended that not all KIC actors may need to be located within KIC’s geographical space (UNCTAD, 2017, p. xiii), fifteen (15) KIC’s Knowledge Space actors were identified and categorised into two types for the purposes of this study: (i) Central actors – five academic entities who, by the time this study was being conducted were found to be physically co-located within KIC’s geographical boundary (namely, CMU-Africa, KCRC, ALU-Rwanda, UR Centre of Excellence in Biomedical Engineering (CEBE) campus, then under construction, and AIMS – Rwanda, whose space was awaiting construction); (ii) Actors in proximity – ten public and private universities and research establishments located in close proximity (both geographically, and in terms of academic programme relatedness – cognitive proximity) to central actors, in the vicinity of KIC and within the City of Kigali. Fig. 3.6 below illustrates the KIC KS central actors, and actors in proximity, highlighted in yellow and blue colours respectively.

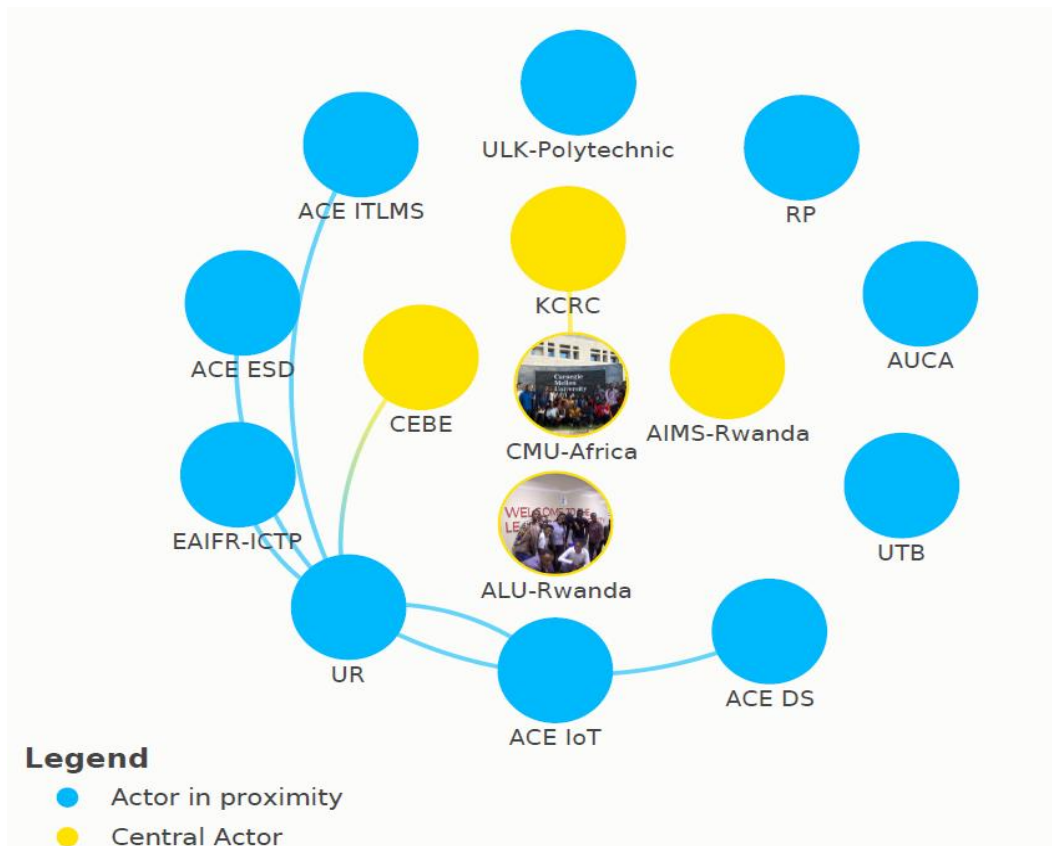


Figure 3.6. Mapping of identified KIC Knowledge Space Actors

Source: Author's design using Kumu Stakeholder Mapping tool¹²

As can be seen in Fig. 3.6 above, the photos of students on two KIC's Knowledge Space central actors, CMU-Africa and ALU-Rwanda, demonstrate the physical presence of the two universities in KIC.

The selection of interviewees for the pilot study was primarily based on sourcing candidates with expert knowledge from the 15 identified academic entities, alongside a degree of 'snowballing' technique. 30 potential participants were identified, approached and invited, of which 16 participants from ten entities were interviewed as illustrated in Table 3.3 and Fig. 3.7 below. The academic profiles of interviewees ranged from professors (4), PhDs (6), and MSc holders (6) including two engineers.

¹² <https://kumu.io/RemyT/kic-knowledge-space#untitled-map>

Table 3.3. Pilot study interview entities and participants

#	Participant's ID	Organisation name	Organisation category	Organisation type	Participant's functional area	Participant's gender
1	Participant_PS01	UR	Public research university	Academia in KIC Proximity	High level academic administrator in the area of R&I	Male
2	Participant_PS02	ACE ESD	WB & Public research centre (ACE)	Academia in KIC Proximity	High level administrator in centre	Male
		UR		Academia in KIC Proximity	Researcher and academic staff	
3	Participant_PS03	AUCA	Private teaching university	Academia in KIC Proximity	High level administrator in university	Male
4	Participant_PS04	ACE IoT	WB & Public research centre (ACE)	Academia in KIC Proximity	High level administrator in centre	Female
		UR		Academia in KIC Proximity	Researcher and academic staff	
5	Participant_PS05	ACE IoT	WB & Public research centre (ACE)	Academia in KIC Proximity	High level administrator in centre	Male
		UR		Academia in KIC Proximity	Researcher and academic staff in	
6	Participant_PS06	IPRC-Kigali, RP	Public polytechnic	Academia in KIC Proximity	High level administrator in college	Male
7	Participant_PS07	ACE ESD	WB & Public research centre (ACE)	Academia in KIC Proximity	High level administrator in centre	Male
		UR		Academia in KIC Proximity	Researcher and academic staff	
8	Participant_PS08	UTB	Private university	Academia in KIC Proximity	High level university administrator in university	Female
9	Participant_PS09	ALU-Rwanda	Private university	Academia in KIC Central	University administrator	Female
10	Participant_PS10	MINEDUC	Public Policy	Academia in KIC Proximity	High level analyst in government	
		ICTP-EAIFR	ICTP & Public research centre (Regional CoE)	Academia in KIC Proximity	High level official in centre leadership	Male
		PASET	WB & Multi-national Programme	Academia in KIC Proximity	High level official in programme leadership	
		ACE	WB Programme	Academia in KIC Proximity	High level official programme leadership	
		KCRC	Rwandan based NGO (research centre)	Academia in KIC Proximity	High level official in centre leadership	
11	Participant_PS11	UR	Public research university	Academia in KIC Proximity	Former high level university administrator	Male
		ACE in Energy for Sustainable Development	WB & Public research centre (ACE)	Academia in KIC Proximity		
		KCRC	Private research centre	Academia in KIC Central	High level official in centre leadership	
12	Participant_PS12	UR	Public research university	Academia in KIC Proximity	Researcher and academic staff	Male
				Academia in KIC Proximity	Academic administrator in area of R&I	
13	Participant_PS13	ULK Polytechnic Institute	Private polytechnic	Academia in KIC Proximity	High level administrator in university	Male
14	Participant_PS14	UR	Public research university	Academia in KIC Proximity	High level academic administrator in university	Male
15	Participant_PS15	UR	Public research university	Academia in KIC Proximity	High level administrator in university	Male
16	Participant_PS16	CMU-Africa	PPP university (AfDB Regional CoE)	Academia in KIC Central	Research and academic staff	Male
		KCRC	Rwandan based NGO (research centre)	Academia in KIC Central	High level administrator in centre	

*Explanation of participant anonymised name codes: PS stands for Pilot Study, and numbers in the code are associated with research participants' first names in alphabetic order.

Source: Author's compilation based on primary data

Table 3.3 above illustrates the actual participants' entities, categories, and gender (see more details of pilot-study participant demographic data in Appendix_3.11). It is worth noting that in Table 3.3 above, participants' functional areas were used instead of job titles. This was essentially to strengthen respondents' encryptions by using respondent coding/characterisation, which removed any possibility of identification while retaining the meaning. The average number of professional academic positions held per pilot study participant was 2. However, as shown in Fig. 3.7 below, one participant presented an odd state (see number 10 in Table 3.3 above) with five multiple senior roles including one government position. Moreover, Fig. 3.7 below shows one

participant holding senior positions in academia and an NGO or was denoted in this research as fulfilling a role in civil society. The one NGO presented in Fig. 3.7 was in fact a not-for-profit research organisation created and hosted by one of the KIC Central Actors.

Drawing on the pilot-study findings, the post-pilot phase explicitly targeted participants from the following categories of actors: (i) Central government ministries; (ii) Local government (City of Kigali); (iii) Academia (KIC'sKS actors, both central and those in proximity), and (iv) Civil Society organisations. In accordance with the approval of UCL's STEaPP Local Research Ethics Committee (SLREC), 18 participants representing 14 entities, including 11 central government ministries and agencies, two local government authorities, four academic entities, and at least one civil society organisation, were targeted for interview. The 11 central government entities represented 45% of government ministries while the two local government entities constitute 100% of the authorities responsible for KIC's geographical location. The four academic entities were selected specifically for further enquiry, based on the pilot study findings. It was intended that this would help achieve balanced reflections and perspectives from participants from different categories of entities. This was also sought to enable triangulation during the data analysis, and thus assist inasmuch as possible in generating valid evidence. In a similar manner to the pilot study and in line with the research objectives, the post-pilot phase targeted experts and senior or mid-level leaders or managers from the participating entities, whose mandates were directly or indirectly related to the development of KIC (see Introduction and background chapters for details on KIC). Participants were primarily identified through staff contact details on the respective participating entities' websites. Support from a local supervisor was also sought and thankfully gained in identifying participants relevant to the research. Table 3.4 below shows 14 participants being interviewed during the post-pilot stage (see more details regarding the post-pilot study participants' demographic data in Appendix_3.12). The academic profiles of interviewees ranged from professors (2), holders of a PhD (8), and of a MSc (4).

Table 3.4. Post-pilot study interview entities and participants

#	*Participant's ID	Organisation Name	Organisation Category	Organisation Type	Participant's functional area	Participant's gender
1	Participant_PPS01	RP	Academia	Academia in KIC Proximity	High level administrator in university	Male
2	Participant_PPS02	UR	Academia	Academia in KIC Proximity	Researcher and academic staff	Female
3	Participant_PPS03	ACE ESD, UR	Academia	Academia in KIC Proximity	High level administrator in university	Male
4	Participant_PPS04	NCST	Government	Central Government	High level administrator in government	Female
5	Participant_PPS05	Mutare Educate Ltd.	Industry	Industry Outside KIC	High level administrator in firm	Male
6	Participant_PPS06	CMU-Africa	Academia	Academia in KIC Central	Researcher and academic staff	Male
7	Participant_PPS07	Sayin Partners Ltd	Industry	Industry Outside KIC	High level administrator in firm	Male
8	Participant_PPS08	NCST	Government	Central Government	High level administrator in government	Male
9	Participant_PPS09	RAWISE	Civil Society	Local NGO	High level administrator in LINGO	Female
10	Participant_PPS10	**Coventry University Africa Hub	Industry	Academia in KIC Proximity	High level administrator in university	Male
11	Participant_PPS11	NIRDA	Government	Central Government	High level administrator in government	Male
12	Participant_PPS12	ICTP-EAIFR	Academia	Academia in KIC Proximity	High level administrator in centre	Male
13	Participant_PPS13	Technoserve	Civil Society	International NGO	High level administrator in INGO	Male
14	Participant_PPS14	MINICT	Government	Central Government	High level administrator in government	Male

*Explanation of participants' anonymised name codes: PPS stands for Post-Pilot Study, and numbers in the code are associated with research participants' first names in alphabetic order.

** University's own firm

Source: Author's compilation based on primary data

Similarly to the pilot phase, the recruitment process for the post-pilot phase involved participants being given a range of options to select the optimal virtual interview approach to suit their individual circumstances. The average interview time was 49 min 17 sec and 52 min 7 sec for the pilot- and post-pilot study phases, respectively, making 50 min 38 sec the average interview time for this work (see detailed calculation of average interview times in Appendix_3.13).

A Work-in-progress seminar was organised and conducted in part in response to Rwanda's local ethics approval requirements. The seminar was held as a transition between pilot- and post-pilot phases, with the purpose of disseminating and discussing the key findings of the pilot study with the stakeholders from Rwanda's science and innovation system. The seminar thus aimed at co-creating further knowledge for greater scientific, policy and practice, and societal impact from this doctoral study, as reflected in UCL's STEaPP research philosophy¹³. In addition, a further objective of

¹³ <https://www.ucl.ac.uk/steapp/research-0>

the seminar was to enable the research participants to partake in shaping and framing the post-pilot phase research design from both the methodological and conceptual perspectives. Considering the multi-stakeholder nature of KIC – as conceptualised in this research – the seminar targeted officials from government, academia, industry, and non-government entities whose mandates were directly or indirectly linked to KIC development aspirations. The seminar particularly targeted the participants who had contributed to the pilot study as interviewees, and potential participants in the post-pilot study. The seminar was attended by 18 participants in total, including 10 representatives of academia, two government officials, four representatives of industry, and two participants from civil society as illustrated in Fig. 3.7 below. The fact that the key stakeholders in the pilot study were either from an academia or government background, with extensive expertise in ST&I policy and governance, as evidenced by their professions shown in Tables 3.3 and 3.5 above, was deemed highly favourable for minimising any problematic issues in the knowledge co-production process, or regarding the legitimacy of any findings (Edelenbos et al., 2011).

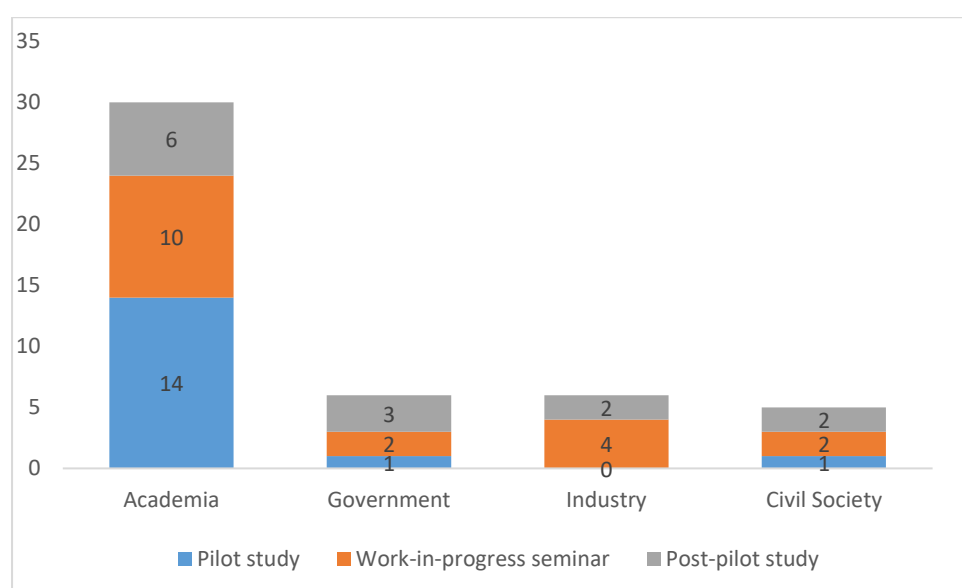


Figure 3.7. Research participants by organisation category

Source: Author's compilation based on primary data

Fig. 3.8 below illustrates how women were far less represented than men in this research, with women accounting for only 23% of participants in the pilot study and

30% in the post-pilot study. It is worth recalling that the participants in these studies included researchers, and senior officials in academia, government, industry, and NGOs, in Rwanda's science and innovation system. This intra-country case study highlighted the contemporary and systemic gender divide in Rwanda, and in a broad developing country context, as Kingiri and Onana (2021) posited.



Figure 3.8. Research participants by gender

Source: Author's compilation based on primary data

3.6 Data organisation and analysis

3.6.1 Thematic analysis and why it was the best choice for this research

Qualitative research employs diverse analytical methods, including grounded theory, narrative analysis, discourse analysis, content analysis, and thematic analysis. Grounded theory aims to build theories from data, where researchers develop codes and categories through iterative comparison, making it ideal for generating new theoretical insights (Barney Glaser and Anselm Strauss, 1973; Chun Tie et al., 2019). Narrative analysis focuses on the structure and content of personal stories, making it valuable for understanding individual experiences over time (Riessman, 2008). Discourse analysis studies communication patterns within social contexts, making it ideal for understanding social structures, power relations, and cultural norms within specific contexts (Hodges et al., 2008; Owen, 2014). Content analysis systematically quantifies and interprets textual data, often used to categorise pattern and themes in

large datasets (Krippendorff, 2018; Adu, 2019). Thematic analysis is often viewed as the best choice for qualitative studies because it offers flexibility in identifying, analysing, and reporting patterns within data, making it suitable for various research aims, epistemologies, and contexts (Braun and Clarke, 2006). Moreover, thematic analysis approach allows researchers to rigorously organise data while remaining adaptable to varying levels of analysis, making it highly effective for interpreting complex data without being constrained by rigid theoretical frameworks (Nowell et al., 2017; Adu, 2019).

The purpose of this doctoral research was to explore universities' interactions with other actors for RIL in a place-based innovation ecosystem. As the research was designed as a complex case study, empirical data were primarily drawn from semi-structured interviews of experts within their respective fields. This meant that, in addition to secondary data collected from desk reviews, this work emphasised the interpretivist approach to the views, perceptions, and insights from interviewees. Guided by the research questions and theoretical frameworks deployed in this research, qualitative data were fundamentally scrutinised using a thematic analysis approach, which consisted in performing a descriptive analysis of each of the themes identified. Whilst there is a plethora of definitions of the term 'thematic analysis' based on a range of factors and applications, this work adopted Mugwagwa's (2008) definition of thematic analysis as the 'interpretation of qualitative data through organising it into codes, categories and themes (...) Themes, which are patterns found in the data, may be generated inductively from the raw data or deductively from theory and prior research' (Mugwagwa, 2008, p. 98). In qualitative data analysis, patterns play a crucial role in identifying *what* is similar, *what* is dissimilar, *why*, and *how*. Any quantitative data sets were analysed using tabulation and statistical analysis methods. The tendency among most researchers to narrowly interpret the meaning of 'qualitative' and 'quantitative' research methods by associating these with the nature of their respective data, such as for example text messages versus statistical data, or inductive versus deductive reasoning (Ketokivi and Choi, 2014) was recognised. From an analytical point of view, this work thus interpreted the qualitative and quantitative research methods on the basis of the definitions of these two terms suggested by Zenzin and Lincoln (2011), cited in Ketokivi and Choi (2014): 'Qualitative [research] is a research approach that examines concepts in terms of their meaning and

interpretation in specific contexts of inquiry. And Quantitative is a research approach that examines concepts in terms of amount, intensity, or frequency' (Ketokivi and Choi, 2014, p.233). This study hence employed both inductive and deductive approaches in an iterative manner. Initially, theory (or conceptual framework) was used deductively to inform the categorisation and organisation of raw data. Subsequently, the data were analysed inductively to identify emerging patterns. These patterns were then interrogated through the lens of existing theory, allowing for theoretical refinement and deeper contextual interpretation. The latter mainly involved triangulation of interview-based data with desk-review results to validate the findings in the empirical chapters of this thesis. The data analysis was thus carried out in the three stages described below:

Firstly, raw data transcripts automatically generated by online interview tools (UCL MS Teams and UCL Zoom platforms). These data were initially downloaded in plain unclean text. The first step was to clean the data followed by data organisation in line with the semi-structured interview questions check list. At that stage, the empirical data were sequentially processed through eight steps: (i) arranging initial interview transcripts in separate folders according to participant categories, (ii) removing metadata from Teams and Zoom captions, (iii) additional data cleaning, (iv) further data cleaning, (v) anonymising transcripts, sending them to respective participants for review, and updating transcripts from participant feedback, (vi) theoretical categorisation of empirical data using a deductive approach, (vii) Final cleaning of theoretically categorised data, (viii) Final anonymisation of interview transcript, and creation of a separate file for the demographic data prior to importing data into NVivo software for analysis.

Secondly, the theoretically categorised empirical data were inductively analysed using UCL's NVivo software. This stage involved three steps undertaken in a rolling and iterative manner: (i) importing anonymised interview transcripts alongside an excel file with participants' demographic information, (ii) using NVivo's 'Explore' feature to develop participant demographic information maps – see the map for participant PPS01 in Fig. 3.9 below for example, word frequency and similarities, and hierarchy charts showing indicative coding preferences, (iii) using NVivo's 'Autocoding' feature to collate data, and identify and create containers (or codes) for research-based pre-defined themes, and (iv) using both description-focused and interpretation-focused

coding strategies to identify the themes that emerged from extracting significant information that addressed the research questions. As Adu (2023) suggested, description-focused coding involves three stages: extracting relevant statements, understanding them, and tagging or labelling them. An interpretation-focused coding strategy also follows the same three stages, but instead of describing what was found in the data, the researcher is expected to interpret those findings. That is, the researcher has to make sense of the data before they can address the RQ. The distance between the data and the RQ is so wide that information that is needed is intrinsically embedded in the data, and thus it is impossible to merely describe what the participant is telling. The researcher has to make sense of the data by considering who is saying what and what kind of circumstances a participant finds him/herself in, in order to be able to develop a code that best represents participant information whilst at the same time addressing the RQ (Adu, 2019). In addition to using auto-coding to collate data and identify pre-defined themes, this research also adopted both descriptive and interpretivist coding strategies, mainly due to divergences in the research questions.

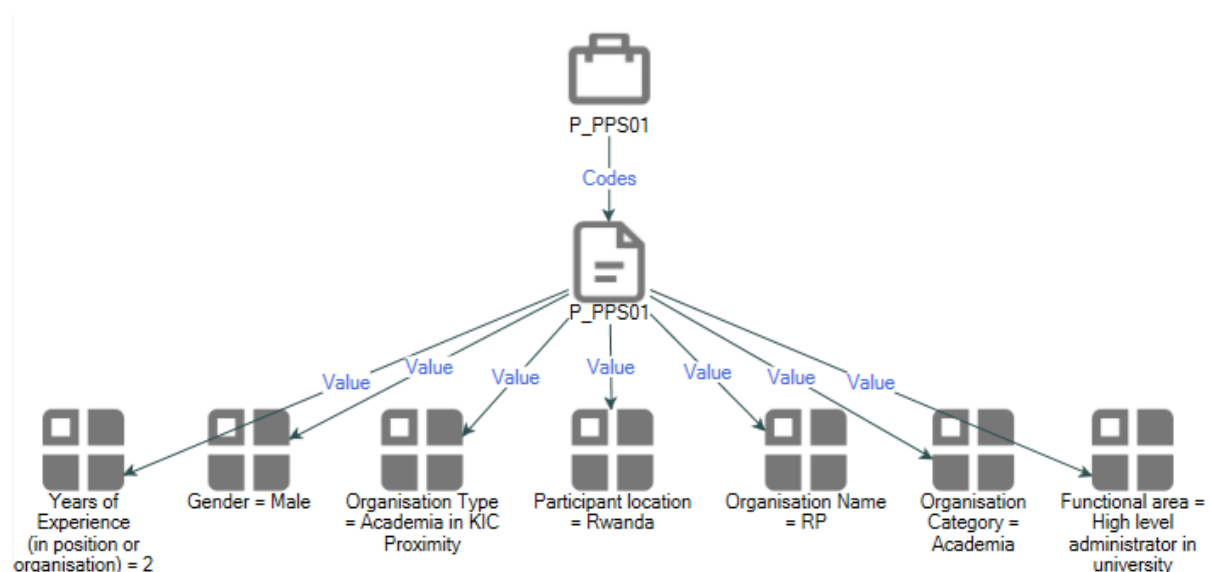


Figure 3.9. Example of NVivo-generated participant demographic data mapping

In addition to playing an instrumental role in empirical data analysis, NVivo served to map participants' demographic data. For instance, Fig. 3.9 above illustrates key demographic information for one participant, anonymously identified as 'P_PPS01', including: years' experience, gender, organisation type, participant location – at

interview time, organisation name, organisation category, and participant's functional area. Taking the example of years' experience in the position or in the organisation, participant P_PPS01's years' experience was two years. The average years' experience for the 14 post-pilot participants was seven, with the minimum experience being one year and maximum 23. For the 16 participants in the pilot study part of this work, the average years' experience was eight, making an overall average of seven years' experience for all 30 participants. Participants' experience therefore implied the researcher's perception and appreciation of the expert interviewees' knowledge of the topics investigated in this research. A detailed description of the pilot and post-pilot study participants' demographic information can be found in Appendix_3.11 and Appendix_3.12, respectively.

Thirdly and finally in this data analysis process, pre-defined and emerging themes were exported from NVivo into Microsoft Word as part of a theme-clustering process, which included dropping any pre-defined themes that did not carry any significant information addressing any of the Research questions. A summary of the data coding and the process of developing the themes for the post-pilot stage of this research is presented in Appendix_3.14. As indicated in Table 3.3 and Table 3.4 above, where possible during the interview process, two or more participants per entity were interviewed for the purposes of data triangulation. Drawing on the data and RQ-guided themes, generated in the NVivo software, a critical analysis of the empirical findings was undertaken, mainly through triangulation and validation with respect to literature review-based narratives for each theme. As indicated in the previous sub-section, any quantitative data emerging from the qualitative analysis were analysed using tabulation and statistical analyses – MS Excel Spreadsheets played a central role in this respect. Moreover, RawGraphs software¹⁴ and Kumu software¹⁵ were also employed to complement the Nvivo and MS Excel graphical representation of analysed data. For instance, while Excel and RawGraphs were used for identifying and mapping KIC's Knowledge Space actor interactions, Kumu software was instrumental in mapping the individual actors and the networks they formed (see details in chapter four).

¹⁴ <https://rawgraphs.io/>

¹⁵ <https://kumu.io/RemyT/kic-knowledge-space#untitled-map>

3.6.2 Bibliometric and content analysis

Based on the findings from the qualitative empirical data analysis, a sedimental scoping review of bibliometric data or a descriptive bibliometric analysis and content analysis were carried out. The aim of this further quantitative approach was to explore further research questions through a nuanced in-depth analysis of the extent of KIC Central KS actor interactions with the KIC's Knowledge Space actors in proximity. The work adopted Jalilian and Zanjirchi's (2022) definition of bibliometric analysis as 'a form of statistical analysis that is conducted to create a little insight into publications published in a scientific field (...) Bibliometric analysis evaluates the level of growth of publications in a research area over a specific period and finds the current knowledge in that area by analysing the information existing in the database related to research works as bibliometric indicators' (Jalilian and Zanjirchi, 2022, p. 4). In the same vein, the research adopted Jalilian and Zanjirchi's (2022) definition of content analysis as 'a research method based on observation, which uses written context for systematic evaluation' (Jalilian and Zanjirchi, 2022, p. 5). Over the past few years, bibliometric analysis (and related content analysis) have underpinned systematic reviews and mapping in a range of areas including, *inter alia*, the fourth industrial revolution aka industry 4.0 (Khoshroo and Talari, 2022); technology and innovation management (Mukhopadhyay, 2023); innovation ecosystems (Jalilian and Zanjirchi, 2022; Zen et al., 2023; Gölgeci et al., 2021); innovation systems and ecosystems (Suominen et al., 2018); and scientometric portraits of recognised scientists (Serenko et al., 2022; Jacso, 2018; Chen, 2018).

Through a cognitive proximity lens (Mattes, 2012; Marrocu et al., 2013), the fundamental question: *How are KIC central KS actors interacting and who are they interacting with? (RQ1 & RQ2)*, was further explored. Bibliometric and content analyses were therefore deployed to elicit an understanding of specific dimensions of actor interactions for RIL amongst KIC's Knowledge Space actors. Three examples of types of interactions, aka 'bibliometric indicators' (Jalilian and Zanjirchi, 2022), were therefore examined: (i) *Co-publication*, (ii) *Co-publication by research area*, and (iii) *Co-publication by funding agency*. Chapter four of this thesis draws on the findings from this further nuanced analysis of KIC actor interactions to provide a detailed account of KIC central KS actors' role in influencing (or not) knowledge and innovation exchanged with KIC's ecosystem and across Rwanda's broad NIS. The same chapter

also explores the academic and policy implications of the findings for KIC development strategy and for Rwanda's broad ST&I policy objectives (see details in Fig. 1.1 in Introduction chapter). As part of the content analysis, VOSviewer software was deployed to create 'visual maps' based on network data or co-occurrences of keywords in published articles (Jalilian and Zanjirchi, 2022, p. 5).

3.7 Research ethics

3.7.1 Ethics requirements and approval processes

Considering the empirical nature of this research, approval was required to be sought and obtained from both UCL and the National Council for Science and Technology (NCST) of Rwanda. NCST is Rwanda's Science Granting Council (SGC) whose mandate includes, *inter alia*, 'research management' (Mugwagwa et al., 2020a, p. 5), that is, the coordination and regulation of all research activities taking place in Rwanda. As discussed in the Literature review chapter of this thesis, a recent study found that NCST was the only public entity with such a mandate (Twiringiyimana et al., 2021).

The Introduction chapter of this thesis and sub-section 3.2 above in the present chapter highlighted that this research was conducted into two stages: pilot phase and post-pilot phase. In both phases, empirical data were to be collected from Rwanda before being transferred, stored, and analysed in the UK. The Pilot research was conducted from February 2021 to December 2021. Approval for the Pilot study from UCL's Research Ethics Committee (REC) was sought and granted under the Low-Risk Project category with Data Protection Number Z6364106 20201167, UCL REC Project ID N^o: 19295/001, and validated until 22nd February 2022. Under this approval, all 16 interviews were conducted remotely (12 via UCL's Microsoft Teams and four via UCL's licensed Zoom platform). Consent was sought from and granted by each interviewee prior to their respective interviews. 15 of the 16 participants were able to complete, sign, and return consent forms in timely fashion by email to an appropriate UCL address, with one participant giving verbal consent prior to the interview. Transcripts were shared electronically with all participants to review, with a few being able to return written feedback. UCL REC's letter of approval for the pilot study is attached in Appendix_3.2. Due to the COVID-19 pandemic, the research method was changed from face-to-face to online contact as indicated in Appendix_3.3. As indicated

above, permission to conduct the pilot research in Rwanda was sought from its NCST. The Research permit Project ID: NCST/482/211/2020 was granted and validated until 6th December 2021. The pre-conditions for obtaining an NCST research permit included seeking an affiliation to a relevant local entity, along with a local supervisor. The local affiliation was requested from and granted by University of Rwanda (UR). The letter of affiliation from UR and NCST's Research Permit are enclosed in Appendix_3.4 and Appendix_3.5 respectively.

As presented in previous sections of this chapter, the post-pilot research consisted of an expansion in scope and scale of the pilot-study of this research work. In a similar manner to the pilot study phase, post-pilot research ethics clearances were sought and secured from Rwanda's NCST and UCL's SLREC on 17th July 2022 (research permit n^o: NCST/482/341/2022) and 19th July 2022 (SLREC approval N^o: 0018), respectively, with the post-pilot research being affiliated to Rwanda Polytechnic (RP). Further to securing research ethics approval, participant identification, data collection, and data organisation processes were conducted from August 2022 to April 2023. Under this approval, all 14 interviews were conducted virtually, 10 using UCL's Microsoft Teams, two via UCL's licensed Zoom, and one using the participant's organisational Zoom platforms. Consent was sought from and granted by each interviewee prior to their respective interviews. 12 of the 14 participants were able to complete, sign, and return the consent forms in time by email to an appropriate UCL address, while two participants provided verbal consent prior to the interview. Transcripts were shared electronically with all participants for review with written feedback being received from a few. UCL's SLREC letter of post-pilot study approval, affiliation letter from RP, and NCST Research Permit are attached in Appendix_3.7, Appendix_3.8, and Appendix_3.9, respectively.

3.7.2 Ethical issues and COVID-19 impact

3.7.2.1 *Ethical issues*

This research started in 2020 when all ethical approval applications were meant to be processed centrally by UCL's university-wide REC. The prolonged ethics process induced an adverse effect on the research as it delayed the project for about six months beyond the proposed project timeline. For instance, it took nearly four months to obtain UCL's ethics approval. As a result, the primary data collection through

interviews that had originally been expected to begin in January 2021 could not start until March 2021. The shift in project timelines affected other stages of the pilot research process. For instance, the data analysis, including the interview follow-up interactions with participants, was undertaken in summer and at a relatively slower pace. This was mainly due to delays in participants' availability confirmation for interviews. It was assumed that the process would have been much faster if this activity had been completed before the summer break as had initially been scheduled. UCL's policy on research ethics was later changed, allowing applications for low-risk research to be handled at departmental level, making the process much faster than previously. Hence the post-pilot research ethics review and approval processes were all carried out by UCL's SLREC.

The design, interview processes, and handling of this research were fundamentally unlikely to cause any stress or personal distress, or to lead to any disclosure of confidential information that could lead to criminal charges. Each participant was given a research information sheet and made aware of their right to opt out of the research (see example of participant information sheet in Appendix_3.10). In addition, participants were made aware of the data that would be collected, and how these would be processed and stored. Drawing on the British Educational Research Association's (BERA) Ethical Guidelines for Educational Research, the Economic and Social Research Council's (ESRC) Framework for Research Ethics, and UCL's Code of Conduct for Research that this research had undertaken to abide by, there nevertheless remained a few ethical issues potentially associated with this research: (i) *Limited number of key informants*: as indicated in section 3.6 above and in particular in Fig. 3.8, this research involved 47 participants in total, with 16 and 14 respectively having been interviewed during the pilot- and post-pilot phases. These respondents were experts and senior or middle-level leaders, or managers from the participating entities whose mandates directly or indirectly related to the development of KIC. As interviews constituted the main source of data for this research, caution was taken about how participants were selected. In addition to identifying the respondents through staff contact details on the respective participating entities' websites, and with the potential support from the local supervisor, the researcher's previous role as a senior public servant in Rwanda was also leveraged to reach out to research participants through former colleagues. (ii) *Approaching participants*: as discussed in

section 3.5 of this chapter, remote communication channels were used to approach the participants, with emphasis being placed on researchers' commitment to confidentiality and on raising participants' awareness of any limitations to this confidentiality (see point 11 on the participant information sheet in Appendix_3.9). Despite this effort, the researcher's former position in the public sector may have generated the risk that participants may have perceived the researcher as a ministerial agent conducting a staff monitoring and evaluating exercise rather than undertaking scientific research. To mitigate or minimise that risk, interviewees were reassured of the fact that the interviewer was a genuine doctoral research student, and thus an independent and impartial researcher. This was fundamentally demonstrated by the interviewer using a UCL email account and other UCL virtual platforms such as Teams and Zoom to interact with the participants. Lastly, *(iii) Managing power relationships and sensitivities*: Although full consent was sought prior to starting the interviews, the fact of speaking with individuals in positions of power from organisations which are organically hierarchical created an anticipation of the following three power dynamics and sensitivity issues:

- Possibility of participants feeling as though their jobs were at risk in case their comments and perspectives were made public, hence being reluctant to be interviewed or choosing to not speak freely in the interview. To manage such power dynamics and sensitivity, interviewees were assured that their comments would be anonymised, with the caveat that no guarantee could be given that interviewees could not be identified. All these points were discussed ahead of the interviews, particularly with reference to sections 4 and 14 of the consent form (see Appendix_3.9).
- Participants tending to 'toe the party line' in their responses to advance their career or set their respective organisations' agendas rather than engage in a truthful discourse. While this was naturally unavoidable, Research questions and triangulation processes helped generate valid evidence to the greatest extent possible.
- Given the nature of respondents' jobs and positions, it was anticipated that their schedules would be so overloaded with work that they would have very limited time for interviews. Appointments were thus constantly adapted in response to individual respondent's preferences and availabilities, including last-minute

interview cancellations and postponements. The remote and home-based work environment furthermore influenced the interviewee/interviewer interaction in such unusual localist settings. From an epistemological and ontological perspective, this research thus adopted a localist position where the interview process did not follow an impartial approach to 'evoke rational response and uncover truth, but rather a situated event in which the interviewer creates the reality of interview situation' (Qu and Dumay, 2011, p. 10).

Most of the ethical issues described above constitute a range of research biases. These qualitative research phenomena are discussed in sub-section 3.9 of this chapter.

3.7.2.2 Impact of the COVID-19 pandemic on the research design and process

The beginning of this research coincided with the influx of the COVID-19 pandemic that disrupted nearly all aspects of society including how university research was conducted. This research had initially been designed to include the physical collection of empirical data from Rwanda, which would have involved international travels. This method of data collection featured in the original application submitted to UCL REC for approval. With UCL's policy of banning all international travel and data collection involving face-to-face contacts amidst the COVID-19 pandemic, UCL REC commented on the application, recommending redesigning the research method to make it fully virtual. Additional recommendations by UCL REC related to arguing that the researcher should explore all options possible to avoid using UCL's licensed Zoom platform for research activities involving personal data collection. The recommendation went on to warn that, in an unavoidable circumstance where Zoom was the only option available, precautional measures should be taken to not record personal information as part of the interview. While necessary steps were taken to abide by this UCL REC guidance, the reality on the ground proved that for some research participants in Rwanda, Zoom was the only option for a virtual interview. Hence, four out of the sixteen interviews were conducted using the Zoom platform.

Ethical approval for both the pilot and post-pilot research phases provided for any quantitative data sets to be analysed using tabulation and statistical methods. Bibliometric analysis was deployed at a rudimentary and modest level to further elicit

the meaning of some of key findings from the empirical qualitative data. Although this method was not explicitly stated in the ethical approval applications, it was implicitly considered as part of the quantitative analysis of academic publications by the ecosystem actors identified from the qualitative empirical data. Collecting these additional data did not arguably require ethical approval as the process was entirely based on reviewing published 'information freely available in the public domain', making the method exempt from ethics committee review in accordance with UCL REC hitherto guidelines¹⁶.

3.8 Research design challenges, realities, and remedies

3.8.1 Research biases

Being categorised by UCL REC as under 'Social Sciences', the research was prone to a range of research biases. Qualitative research is inherently subject to prejudice and bias as these phenomena appear at and through all aspects of the research process. Borowska-Beszta (2017) described prejudice and bias as 'an embarrassing phenomenon of research in social sciences'. He categorised research biases into three types, namely: (i) research design bias, (ii) actor's biases, and (iii) gender bias. Fig. 3.10 below illustrates the presence of a range of biases across all stages and facets of the research process, and hence its potential influence on the reliability and quality of research outcomes. Other forms or types of biases have been abundantly researched. Acquiescence response bias is based on interviewees' tendency to stand in agreement with the research questions regardless of their content (Lelkes and Weiss, 2015). Social desirability bias is where participants tend to alter their responses in situations where they fear that answering a specific question in a full, true, and open manner might place their position or their organisation's reputation at risk (Bergen and Labonté, 2020).

¹⁶ <https://ethics.grad.ucl.ac.uk/exemptions.php> [Accessed:05 May 2023]

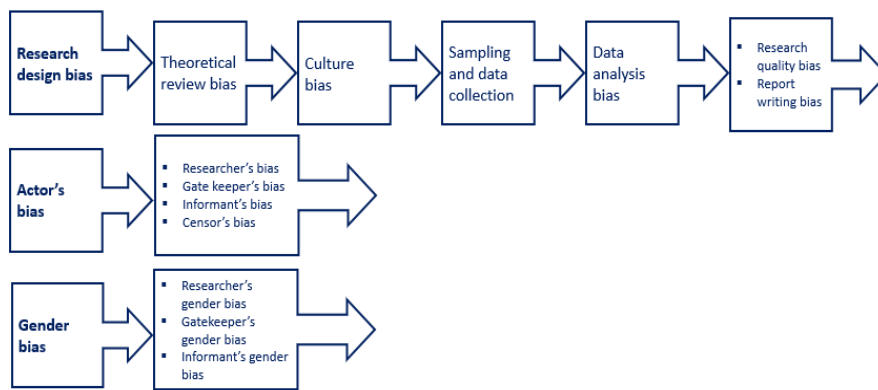


Figure 3.10. Architecture of qualitative research bias

Source: Adapted from Borowska-Beszta (2017, p. 57)

3.8.2 Research bias realities and remedies

Earlier sections of this chapter discussed the qualitative research and expert/interview-based approach to responding to a set of research questions. As illustrated in Fig. 3.8 above, the majority of participants were male, with female participants constituting 26.5% of total respondents. This phenomenon reflected the reality of the gender divide within Rwandan science as well as its innovation ecosystem and epistemic community, as discussed in the Introduction and Literature Review chapters of this thesis. This fundamental, systemic gender gap implies the potential for research design and gender issue biases, as Borowska-Beszta (2017) claims. Moreover, despite all the positives relating to the semi-structured interview format and its relevance in eliciting answers to this research's questions, the study was conducted with the caveat that the expert interviews may not capture the views of other actors and stakeholders outside the epistemic community of experts (Qu and Dumay, 2011). To avoid or at least lessen the aforementioned biases, a range of strategies below were deployed despite subconscious bias, and the intrinsic systemic realities of the ecosystem within which the research was conducted:

- Research design: research questions were made to be as specific and reflecting the research topic and aims as possible, as (Qu and Dumay, 2011) posited. Moreover, a reflective practitioner's perspective was consistently deployed throughout the research process in order to map the researcher's philosophical assumptions, contextual assumptions, theoretical foundations, and research methods. For greater representation in participant sampling and data collection,

the research aimed to recruit at least two respondents per organisation. However, the reality on the ground meant the remoteness of the research was hindered in its effort to reach out to as many respondents as had been anticipated. A RQ-driven approach to data analysis and discussion was deployed, supported with triangulation of the findings and of data sources. Finally, the thesis writing process was carried out by making constant reference to the research aims, objectives, and questions to avoid the potential pitfall of drifting away from the research problem being investigated.

- Actor biases or interviewer/interviewee bias: during the interview, the tendency was to select research questions to discuss based on the prior knowledge of the interviewee's expertise and position in his/her organisation. At times and across all interviews, the tendency for interviewees to concur with the research questions being posed was observed, leading to acquiescence response bias (Lelkes and Weiss, 2015). This could have resulted in prior knowledge and a professional relationship with the interviewees. Social desirability bias was also assumed, especially for participants from senior positions who might have altered their responses in instances when they felt answering a specific question in a full, true and open manner might put their position or organisation's reputation at risk (Bergen and Labonté, 2020). This social desirability bias was anticipated right from the research design stage. It was thus considered as an ethical issue, and to mitigate such a bias, the research informed consent form, participant information sheet, and RQ checklist all provided participants with assurances of the safety and anonymisation in participating in the study. Interviewees were also provided with space, freedom, power, and control to decide about which questions and sub questions to answer or not. For instance, the introductory section of the research questions check list ended with a statement reading "...*All responses will be anonymised in the analysis and evaluation reports. You do not have to answer any question that you feel is not relevant to you or that you would prefer not to answer...*" (See Appendix_3.10). Besides, point four of the informed consent form – assumed to be carefully read and signed by the interviewee prior to starting the interview – provided three options in relation to the levels of anonymity of the interviewees' responses and/or comments (See Appendix_3.10).

3.9 Positionality, reflexivity, and sensibility

The extent of transparency in qualitative research is often contingent upon whether the researcher (or research team) hold an awareness and mindfulness of, and openness about their positionality, and their ability to deploy a reflective perspective across all stages of the research process, although these principles are often less emphasised than is required by research regulators (Olmos-Vega et al., 2023). In fact, ‘a researcher’s background and position will affect what they choose to investigate, the angle of investigation, the methods judged most adequate for this purpose, the findings considered most appropriate, and the framing and communication of conclusion’ (Malterud, 2001, pp. 483–484). The researcher’s former senior public sector position in the country where this research case study was being undertaken was indicated earlier in this chapter. The researcher’s previous senior position in the Ministry of Education helped access to key informants with senior role in government, universities, research organisations, industry, and civil society. However, this background may have led some participants to view the researcher as a representative of ministerial interest, rather than an independent academic. To mitigate this misperception transparently, the researcher clarified that the engagement was part of doctoral research, not linked to any government directive (see details in section 3.7.2.1 above). Moreover, chapter two of this thesis revealed the researcher’s extensive work experience in, and contextual understanding of, ST&I policy for the development arena, with this research design being partly shaped and informed by the researcher’s recent work on ST&I policy and governance in SSA (Twiringiyimana et al., 2021).

This research recognised a myriad of definitions and interpretations of reflexivity in qualitative research ranging from it being epitomised as a research tool, practice, or act or process. Finlay and Gough (2008) define reflexivity as ‘a tool used to analyse personal, intersubjective and social processes with shape research projects (...) It enables researchers to acknowledge their role and the situated nature of their research’ (Finlay and Gough, 2008, p. 1). Drawing from a collaborative research perspective, Olmos-Vega et al. (2023) define reflexivity as ‘a set of continuous, collaborative, and multifaceted practices through which researchers self-consciously critique, appraise, and evaluate how their subjectivity and context influence the

research process' (Olmos-Vega et al., 2023, p. 24). Based on the literature review of the history of reflection in qualitative research, Olmos-Vega et al. (2023) proposed a distinction between reflection and reflectivity, with the former being described as the momentary and cross-sectional 'act of turning back [on] one oneself and engaging in introspection' while the latter denotes 'an intersubjective act in which self, others, and self-in-relation-to-other are considered and recognised'. They go on to posit that reflectivity is a continuing process that requires 'researchers [to] situate themselves within the social and contextual aspects of their study, while openly exploring the self, others, and relationships as the field work proceeds' (Olmos-Vega et al., 2023, p. 165). The reflective approach to this research was underpinned by an ontological approach to the PhD research as 'a process rather than outcome' (Sharma, 2020, p.17). This 'process-oriented' approach to research that involved a range of proven approaches at different stages of the research process including, *inter alia*, 'reflexive journal-keeping' (Cohen and Crabtree, 2008, p. 4), 'PhD process journal' (Sharma, 2020, p. 17), and 'PhD ideas journal' (Sharma, 2020, p. 31), during desk and empirical data analysis, and 'responsibility partners' approach involving the deliberate search of reviews and comments on research tools and processes from peer research students. In addition to these reflexivity strategies, a critical realist approach enabled the application of a range of 'qualitative sensibility' skills across all the stages of the research process as Clarke and Braun (2023) recommend. These include, *inter alia*, (i) keeping *interest in process and meaning* beyond cause-effect dynamics, (ii) deploying a critical *approach to life and knowledge* about identified phenomena through asking questions beyond accepting and describing them 'at face value', to investigate 'why they may be that way, whose interests are served by them, and how they could be different', (iii) being able to identify and 'bracket off' researcher's assumptions, (iv) deploying *double-consciousness* involving active listening and critical reaction to what is said in a simultaneous manner, and (v) being driven by a critical reflection on the research process and on the investigator's role as a researcher aka *reflectivity*, and (vi) embarking on *good interactions* with research participants. Clarke and Braun (2023) define qualitative sensibility as 'an orientation towards research – in terms of Research questions and analysing data – that fits within the qualitative paradigm' (Clarke and Braun, 2013, p. 7).

The aforementioned awareness and openness about the researcher's positionality and reflexivity, and the sensibility approach to this research enabled the work to be completed in as objective and trustworthy as possible a manner, as embodied in the strategies set out to identify and mitigate any ethical issues and attend to any research biases discussed in sections 3.8 and 3.9 above. The researcher contends that this approach, underpinned by critical realist thinking, was the best possible method to enable the findings of this research to provide a true representation of the data. Nonetheless, this work is recognisant of the inevitable reality of the researcher's position and bias and how these might have affected the interpretation and presentation of this research. Section 3.11 below draws on the research design and the researcher's inevitable shortfalls discussed in this chapter as they relate to the validity and reliability of this research.

3.10 Data validity, reliability, and source of uncertainty

The contemporary concepts of validity and reliability are fundamentally rooted in quantitative research (Whittemore et al., 2001; Cohen and Crabtree, 2008). Attempts have been made to establish validity and reliability (or credibility) of criteria in qualitative research. This presented the challenge of establishing a common ground amongst researchers as the notions of validity and credibility lie at the interface of the subjectivity and rigour of qualitative research as a scientific methodology. This thesis thus recognises the multiple interpretations of these concepts of validity and reliability, as an indicator of scientific potency of qualitative research (Whittemore et al., 2001; Cohen and Crabtree, 2008; Galdos Frisancho, 2022). Through a critical realist perspective in qualitative research, a range of terms such as 'adequacy, trustworthiness, accuracy, and credibility' were often found to have been used as substitutes for 'validity' (Cohen and Crabtree, 2008, p. 335). Drawing on the systematic literature review of the history of 'validity' and 'reliability' in qualitative research and related challenges, (Whittemore et al., 2001) characterised the validity criteria in two categories: *primary* and *secondary validity criteria*. The primary validity criterion comprises four components: *credibility*, *authenticity*, *criticality*, and *integrity*, with the secondary validity criteria being constituted by five dimensions: *explicitness*, *vividness*, *creativity*, *thoroughness*, *congruence*, and *sensitivity*. Whittemore et al.

(2001) went on to propose an indicative model for the evaluation of primary and secondary validity criteria in qualitative research as indicated in Table 3.5. below.

Table 3.5. Primary and secondary validation criteria assessment

Criteria	Assessment
▪ Primary criteria: ○ Credibility Do the research results reflect participants' experience and/or context? ○ Authenticity Does a representation of the emic perspective exhibit awareness to the subtle differences in the voices of all participants? ○ Criticality Does the research process demonstrate evidence of a critical appraisal? ○ Integrity Does the research reflect recursive and repetitive checks of validity as well as a humble presentation of the findings? ▪ Secondary criteria: ○ Explicitness Have methodological decisions, interpretations, and investigator biases been addressed? ○ Vividness Have dense and faithful descriptions been portrayed with artfulness and clarity? ○ Creativity Have imaginative ways of organising, presenting, and analysing data been incorporated? ○ Thoroughness Do the findings convincingly address the questions posed through completeness and saturation? ○ Congruence Are the process and the findings congruent? Do all the themes fit together? Do the findings fit into a context outside the study situation? ○ Sensitivity Has the research been carried out in a manner that is sensitive to the nature of human, cultural, and social contexts?	

Source: Adapted from Whitemore et al, (2001, p. 13)

Drawing on the typology of techniques for validation demonstration at all stages of the research process: *design consideration, data gathering, analytics, and presentation* – developed earlier by Whitemore et al. (2001, p. 12), Cohen and Crabtree (2008) elaborated four techniques that could be deployed to check and confirm the validity and reliability in qualitative research, as illustrated in Table 3.6 below. They went on to contend that validity in qualitative research could be verified through a range of approaches such as having a research process audited independently or having 'research participants validate findings', denoted in Table 3.6 as 'member checking' (Cohen and Crabtree, 2008, p. 335).

Table 3.6. Techniques used to verify validity in qualitative research

Technique	Definition
Triangulation	Using multiple data sources in an inquiry to create understanding
Peer review/debriefing	The process of exposing oneself to a disinterested peer in a way paralleling an analytical session and for the purpose of exploring aspects of the inquiry that might otherwise remain only implicit within the inquirer's mind.
External audits or auditing	Having a researcher not involved in the research process examine both the process and product of the study. The aim is to assess the accuracy and evaluate whether the findings, interpretations, and conclusions are supported by the data.
Member checking	Data, analytic categories, interpretations, and conclusions are tested by members of those groups from whom the data were originally obtained. This can be done both formally and informally, as opportunities for member checking may arise during the normal course of observation and conversation.

Source: Adapted from Cohen and Grabtree (2008, p. 335)

Given the nature of this research, two techniques – triangulation and member checking – were applied across various stages of the research process. As discussed earlier in this chapter, in accordance with the research design, data triangulation was to be realised through interviewing at least two informants per organisation. Table 3.5 and Table 3.6 above show that this was not always feasible due multiple realities highlighted in section 3.9 above. Moreover, triangulation was also deployed at the analytical stage, particularly when seeking to interrogate or complement the empirical data findings with desk research reviews.

By deploying reflectivity and sensibility skills described earlier in this chapter, the assessment questions in Table 3.5 above were used to test both the primary and secondary validation criteria throughout the research process. For instance, the work-in-progress seminar that aimed to present and discuss the pilot study findings and to co-design the post-pilot research phase, constituted an effort to attain the absolute optimal integrity of the work. Moreover, participants in both the pilot and post-pilot phases of this work were senior representatives of academia, government, industry, or civil society domains, with extensive expertise in ST&I policy and governance, as

evidenced by their functions shown in Table 3.3 and Table 3.4 above. This contextual perspective of the participant recruitment process was deemed highly favourable for minimising any problematic issues in the knowledge co-production process or regarding the legitimacy of any findings (Edelenbos et al., 2011), making the research as credible and authentic as possible. From a methodological perspective, and as indicated in the empirical chapters of this thesis, the research questions and relevant analytical frameworks were designed so that the research findings addressed the research questions in as explicit, reflective, and congruent a manner as possible. The ethical requirements were observed at all stages of the research in a way that was sensitive to contextual imperatives, that is, by following the research regulatory frameworks both in the UK and in Rwanda. To ensure the congruence of the research process and findings, the research was progressively presented to a varied range of audiences at different stages. The purpose was twofold: (i) to source a range of inputs, comments, and critiques all aimed at shaping the work through gathering as many voices and perspectives as possible, and (ii) to create policy and practice, and academic impact. Appendix_3.16 provides details of the main events where the research was presented. It highlights the diverse inputs sourced and how they contributed to shaping this work.

While measures were taken to attain validity, reliability, and impact withstanding capability, this work was, like any other scientific research, susceptible to unavoidable aspects of uncertainty. Recognisant of varied definitions of uncertainty, this work adopted Ravetz's (2006) description of uncertainty as 'a special state of knowing, whereby imperfections in our knowledge can be recognised, understood and used creatively' (Ravetz, 2006, p. 78). Referring to the typology of uncertainty (see Table in Appendix_3.11), unavoidable sources of uncertainty in this work stemmed from two main dimensions (i) *research design as a social science* embedding contextual assumptions, expert judgement, conceptual frameworks, tools used, and data, and (ii) *research participants (people)* exhibiting variability of behaviour and plurality of views as discussed in empirical chapters. Sub-section 3.8 of this chapter provided a detailed descriptive account of these sources of uncertainty, their recognition, and mitigation effort. Drawing on the qualitative sensibility necessary in the qualitative research paradigm (Clarke and Braun, 2013), the unpredictability and complexity of people (participants) was recognised, and hence the work thus aimed to fundamentally create

knowledge based on assumptions and principles that would make it possible to deal with the aforementioned uncertainty as opposed to traditional idealistic way of seeing science as too powerful to provide complete certainty (Ravetz, 2006).

3.11 Chapter summary

This chapter has provided a detailed description of the methodological approaches deployed in guiding this research process. The chapter demonstrated how crucial realist ontology and epistemology, supported by the researcher's reflective practitioner's approach, have underpinned the body of research through all its stages, from problem design, participant identification and recruitment, data collection to desk research, semi-structured interviews, and data analysis. Drawing on the previous chapters, this chapter described the structural and methodological design of this research, thereby attempting to answer the questions as to *why*, and *how* this research was conducted in two phases – pilot and post-pilot, and the implications of this approach for the presentation of the research findings and for the overall thesis structure.

Given the empirical nature of the case study in question and noting the complexity of the research questions, the predominant approach deployed was a critical transdisciplinary method. The aim was mainly to engage research participants from diverse spaces – academia, government, industry, and civil society – at different stages of the research process, in co-designing the research and co-creating knowledge. Notwithstanding the qualitative nature of the study, sedimental quantitative analysis was employed on limited quantitative data that stemmed from a qualitative analysis. All ethical approval requirements were rigorously observed in order to identify, analyse, and mitigate any ethical research issues as well as handle the various types of biases and sources of uncertainty emanating from or associated with this research. Despite an array of practical and unavoidable realities, a range of proven and well-researched techniques were thoroughly utilised to attain optimal validity and reliability of the research whilst ensuring a sound impact on the relevant actors in academic, policy, and practice fields.

The next chapter starts Part II of this thesis and presents the findings of the pilot phase of this research.

PART II. PILOT STUDY PHASE EMPIRICS, AND CONCEPTUAL FRAMEWORK DEVELOPMENT

Chapter 4. Understanding of the KIC Knowledge Space Actors and their interactions to promote research, innovation, and learning

4.1 Introduction

Part I of this thesis demonstrated that this research was conducted in two phases – pilot and post-pilot. The primary aim of this research in the pilot phase was to investigate the extent of universities or academic actor interactions to promote research, innovation, and learning (RIL) within and across KIC's Knowledge Space. Moreover, the main objective of this study in the pilot phase was to explore whether and how these interactions contributed (or not) to KIC's development in response to societal challenges. The pilot phase of this research thus aimed to explore four research questions: 1) *Who are the KIC Knowledge Space actors?*; 2) *How do KIC Knowledge Space actors interact for RIL, and do these interactions influence the RIL among these Knowledge Space actors?*; 3) *Are these interactions related to KIC regional (place-based) planning and development activities and if so, how?*; and 4) *How has the COVID-19 pandemic influenced actor interactions in respect of RIL?*

Drawing on thematic analysis, this chapter presents the findings in response to the first three research questions one, two, and three, with the findings for RQ4 on COVID-19 pandemic being presented separately in chapter five of this thesis. As highlighted in the Introduction chapter of this thesis, the findings for RQ4 are presented separately in chapter five to allow for an elaborate and critical analysis of COVID-19 impact on KIC's Knowledge Space actor interactions for RIL. The empirical data for this research in the pilot phase was collected through semi-structured interviews with 16 experts from ten universities constituting KIC's Knowledge Space actors – both central and those in proximity, with complementary secondary data from search engines such as Web of Science and organisational websites. The analysis revealed six themes: (i) *Types or categories of interactions*; (ii) *Nature of interactions*; (iii) *Actors leading or influencing interactions*; (iv) *Measuring KIC's Knowledge Space actor interactions based on network analysis and bibliometric analysis*; (v) *Perception of actors' role in KIC's knowledge platform*; and (vi) *an assessment of KIC's development prospects through the lens of a THS conceptual framework: a few knowledge gaps and new contextual perspectives*. These themes are explored in detail in the following sections,

and they are discussed with regard to Research questions and in relation to the existing knowledge found in the relevant literature.

4.2 Identifying KIC Knowledge Space actor categories and their interactions in relation to RIL

The first part of this research was to identify KIC's Knowledge Space actor categories and explore their interactions aka interactive capabilities¹⁷ in response to the first two research questions: *1) Who are the KIC Knowledge Space actors? and 2) How do KIC Knowledge Space actors interact for RIL, and do these interactions influence the teaching and R&I among these Knowledge Space actors?* Considering KIC as a social network, this research found that KIC's Knowledge Space comprised several actors organised into four main categories: KS central academic actors, academic actors in proximity, hybrid actors, and government agencies. The ways in which these categories influenced KIC's Knowledge Space actor interactions are unpacked in this chapter based on the analysis of empirical and secondary data. The analysis of the information reported by interviewees from KIC's Knowledge Space academic actors (central and those in proximity) identified thirty-nine (39) different interactive capabilities (or types of interactions). As shown in Fig. 4.1 below, these interactive capabilities were identified across five dimensions, namely, (i) Nature of interactions including, Intra-actor interactions and Inter-actor interactions; (ii) Types of leading actors, including the KIC's Knowledge Space central academic actors, academic actors in proximity, hybrid actors and government agencies; (iii) Types of interactions, that is, any R&I or teaching activity bringing the actors together; (iv) Leading actors or R&I organisers, namely, the actors that initiate or lead or with direct influence on the identified interactions; and (v) Actors involved, meaning any actors involved in any of the identified interactive activities for RIL. As can be seen in Fig. 4.1 below, the identified interactive capabilities were organised in a top-bottom descending order, that is, from large to small size or as a percentage share.

¹⁷ **Interactive capabilities:** For the purposes of this pilot study, interactive capability is defined as any condition or ability to identify and allow a relationship, within one actor or between two or more actors, for R&I and teaching.

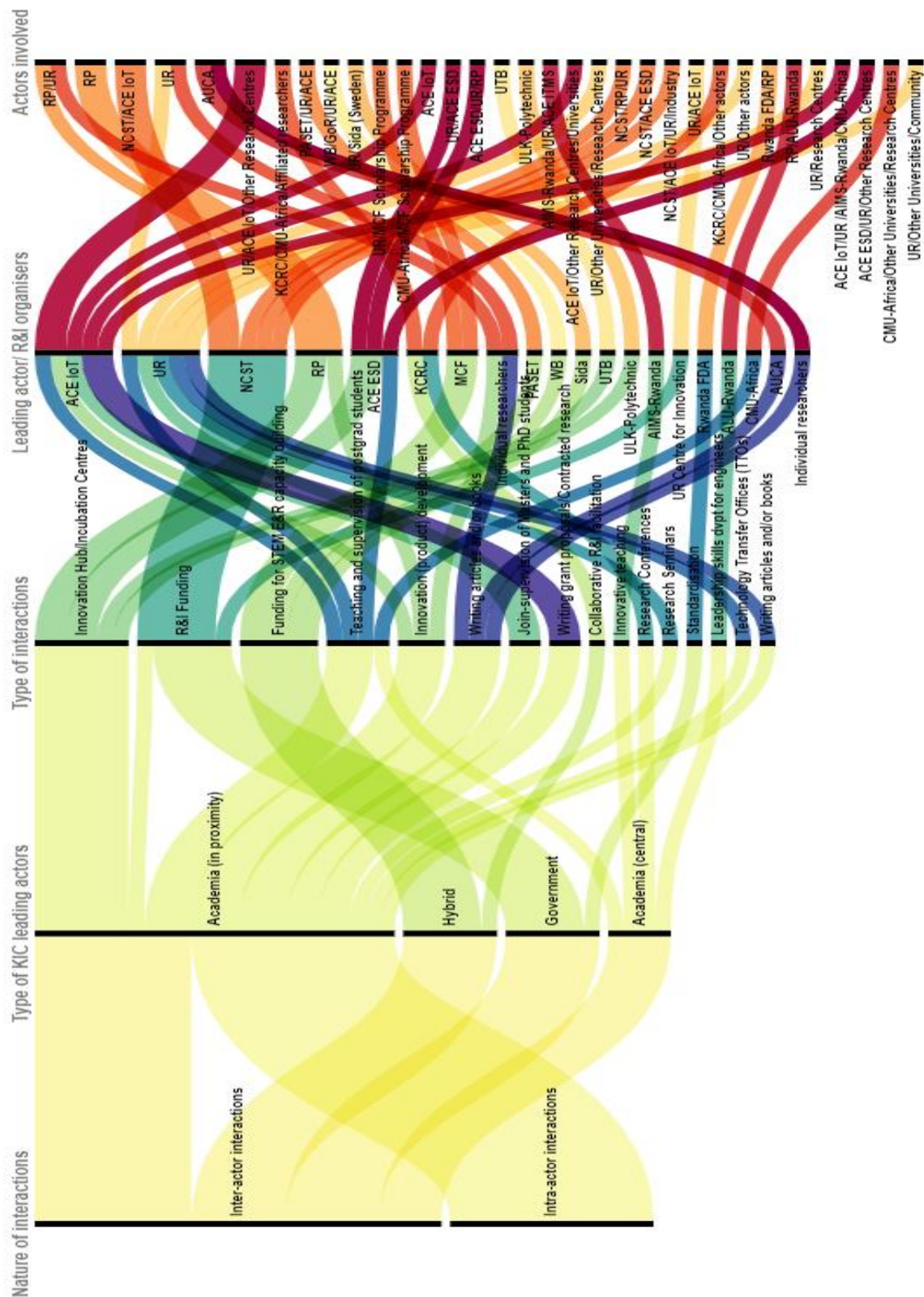


Figure 4.1. Mapping of the KIC Knowledge Space actor interactions

Source: Author's compilation using RawGraphs software¹⁸

¹⁸ <https://rawgraphs.io/>

In order better to grasp the findings summarised in Fig. 4.1 above, the identified interactive capabilities were further unpacked according to their scope. See Appendix_4.1 for a detailed description of KIC's Knowledge Space actor interactions.

4.2.1 Types or categories of interactions

The share and magnitude of individual interactive capability types (or actor interactions) were meticulously established from the 39 reported actor interactions. As encapsulated in Fig. 4.4 below, funding for innovation hubs or incubations centres and for R&D was reported as the most dominant interactive capability underpinning actors' collaborations within KIC's Knowledge Space, with a 15 % share each of the total of interactions. Funding for science, technology, engineering, and mathematics (STEM) education and research capacity building was found to be the second major type of interaction with a 13 % share, followed by Teaching and Supervision of Postgraduate Students, and writing of Academic Articles accounting for a 10 % share each. One remarkable finding was that it was the hybrid actors who proved to be strongly leading the way in terms of funding- and/or financing-related interactions. This highlighted to some extent the importance and value of funding for R&D and STEM capability-building actors engaged in place-based THS development strategies in the context of LICs. The share dedicated to teaching and supervision, and joint supervision of graduate and postgraduate students (Master's and PhD) was a further key finding. Fig. 4.2 below illustrates how the combination of both student-related interaction types can, and in the present instance did, develop into one of the most prevailing types of existing interactive capabilities within KIC's Knowledge Space.

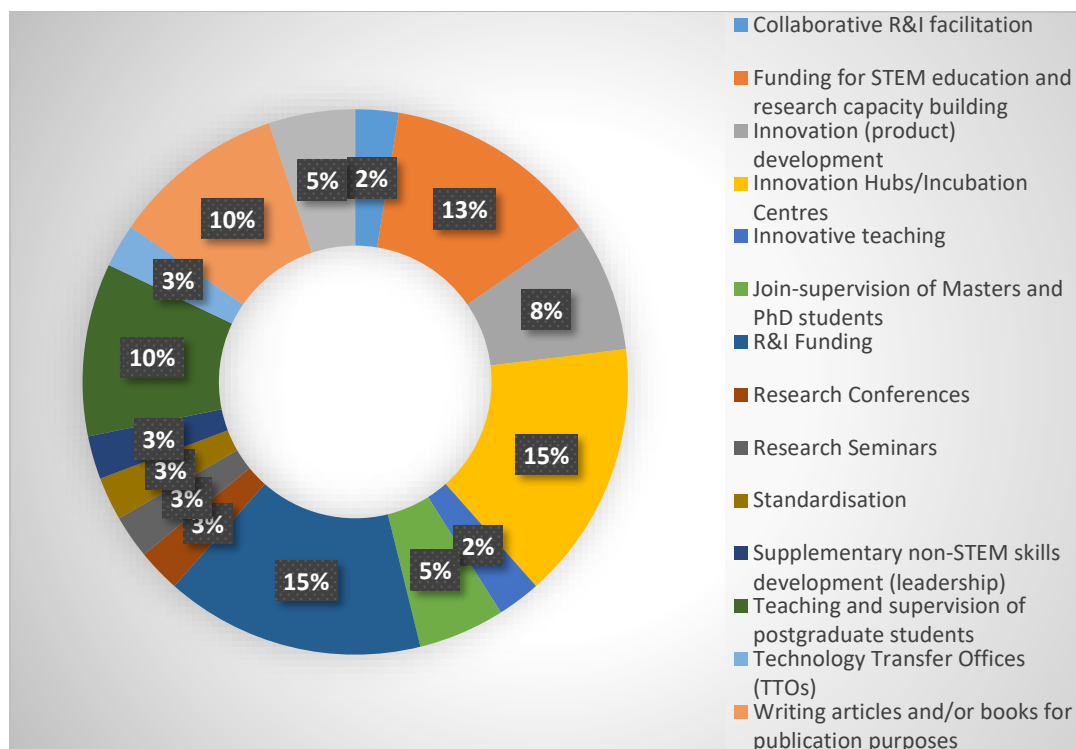


Figure 4.2. Types of KIC's Knowledge Space actor interactions

Source: Author, based on Pilot Research Interviews (2021)

In contrast to these reported findings, Fig. 4.2 above highlights that the main interactive capabilities for the creation, dissemination, and use of knowledge, technology, and innovation – such as Technology Transfer Offices (TTOs), Innovation (product) development (prototyping), conference organising, collaborative R&I facilitation, R&I environment enhancement, and standardisation – were found to rank among the least established capabilities within KIC's Knowledge Space.

4.2.2 Nature of interactions

Regarding the nature of interactions, Fig. 4.1 showed that of 39 reported interactions, inter-actor interactions amongst KIC's Knowledge Space actors were more than double the intra-actor interactions for RIL. This is also illustrated in Fig. 4.3 below.

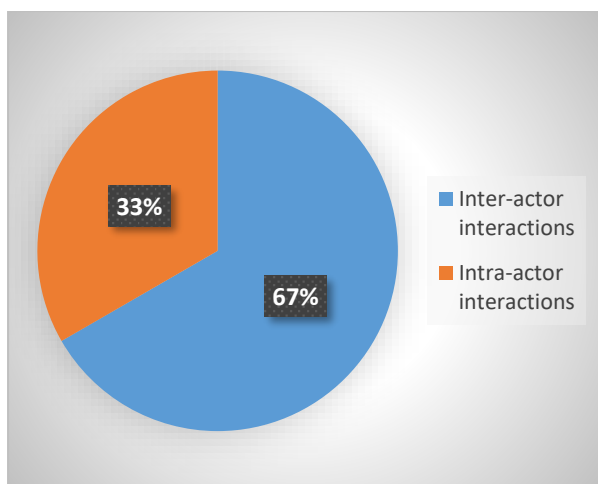


Figure 4.3. Nature of KIC Knowledge Space actor interactions

Source: Author, based on Pilot Research Interviews (2021)

As illustrated in Fig. 4.3 above and in relation to Fig. 4.1, this study found that all KIC's Knowledge Space actor - including central academic actors, academic actors in proximity, hybrid actors, and government - were engaged in inter-actor interactions. Intra-actor interactions were only predominant KIC's Knowledge Space academic actors in proximity.

4.2.3 Actors leading or influencing interactions

As can be seen in Fig. 4.4 below, irrespective of the nature (intra- or inter-actor) of interactions, it was the actors in proximity who were found to be playing the leading roles in initiating interactions within KIC's Knowledge Space, while the central actors were shown to be contributing the least. The role of central government in this context predominantly related to R&I funding through the Rwanda National Council for Science and Technology (NCST), and to regulation, which was overseen by Rwanda's Food and Drug Authority (Rwanda FDA). The hybrid organisations comprised a range of different actors including local and international NGOs, multi-governmental and multi-partnership programmes, bilateral-driven initiatives, as well as financial organisations for development.

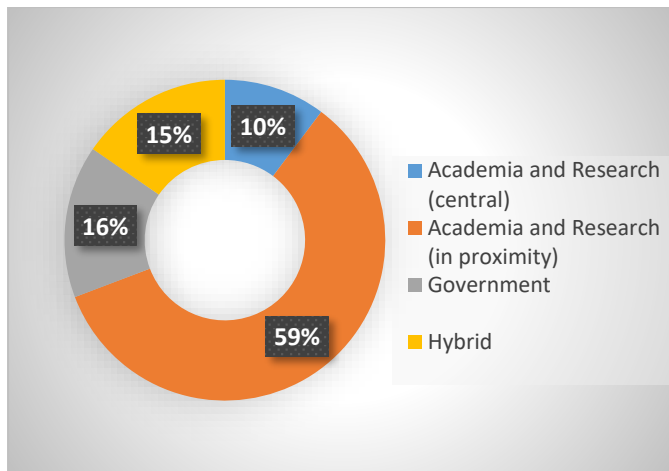


Figure 4.4. Actors initiating interactions within KIC's Knowledge Space by percentage of actor type

Source: Author, based on Pilot Research Interviews (2021)

4.2.4 Measuring KIC's Knowledge Space actor interactions based on network analysis and bibliometric analysis

Further to the analysis of intra- and inter-actor interactions in section 4.1 above, this section focuses on the in-depth analysis of the interactive capabilities of KIC's Knowledge Space actors at micro- (or individual actor) scale. The findings relating to the distribution capability among KIC's Knowledge Space actors were first diligently collated, which included in particular recording the details of the nature of actors' various interactions as summarised in Fig. 4.1 above. Then, whilst regarding KIC's Knowledge Space as a social network, Kumu Stakeholder Mapping software was used to map out the KIC's Knowledge Space actors as illustrated in Fig. 4.5 below.

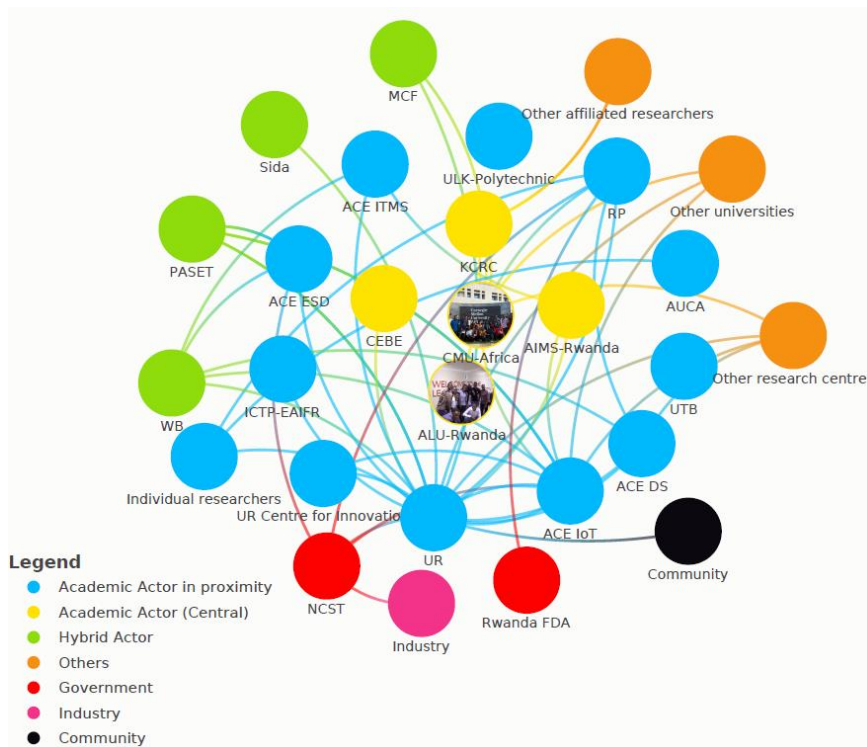


Figure 4.5. Actors network mapping within KIC's Knowledge Space

Source: Author's design with <https://kumu.io/RemyT/kic-ks-all#untitled-map>

Based on the network in Fig. 4.5 above, and for illustration purposes, two of the many centrality metrics of the Kumu software were employed to identify the key actors within the network on the basis of their relationships. These were, *degree centrality* and *betweenness centrality*.¹⁹ After analysing KIC's Knowledge Space network with the Kumu software, it was found that UR was the actor with the highest *degree centrality* score with 20 connections, followed by ACE IoT with ten, and RP with six. The first KIC's Knowledge Space central academic actor identified was CMU-Africa, in fifth position with five networks²⁰. In terms of the betweenness centrality metric, UR was found to have attained the highest betweenness value of 0.558, followed by RP with 0.143, CMU-Africa 0.136, and ACE IoT 0.131. The Individual researchers ranked in

¹⁹ **Degree centrality:** number of connections an actor has, with the actors having the highest degree being considered as local connectors or hubs. **Betweenness centrality:** measuring how many times an actor lies on the shortest path between two other actors. Actors with high betweenness have more control over the flow of information and act as key bridges within the network. They can also be potential single points of failure. <https://kumu.io/RemyT/kic-ks-all#untitled-map> [Accessed: 26.10.2021]

seventh place with a betweenness centrality value 0.068, which demonstrated the degree of influence of researcher-driven initiatives on KIC's Knowledge Space 'systemness'. According to these findings, the KIC's Knowledge Space academic actors in proximity, in particular UR, played a leading role both as interaction hubs and influential forces on the interactions within and throughout KIC's Knowledge Space. In contrast, the private domestic universities were shown to rank very low in respect of both metrics. Detailed findings and positioning of KIC's Knowledge Space actors according to their degree of centrality and extent of interactive expansion are provided in Appendix 4.2 and Appendix 4.3 hereafter, respectively. Of interest here was the low ranking of KIC's Knowledge Space central academic actors in terms of both degree and betweenness centrality metrics, implying that KIC's Knowledge Space central actors interacted less with other local KS actors in their geographical and cognitive proximity.

In an effort to unpack this rather surprising finding, bibliometric analysis was conducted to understand who KIC's Knowledge Space actors interacted with for RIL. Drawing on the types of interactions as presented in Fig. 4.1 and Fig. 4.2 above, and using 'Co-publication' as an exemplar bibliometric, this study found that the main KIC's Knowledge Space central actor, CMU-Africa for instance, predominantly collaborated with international actors as shown in Fig. 4.6 below.

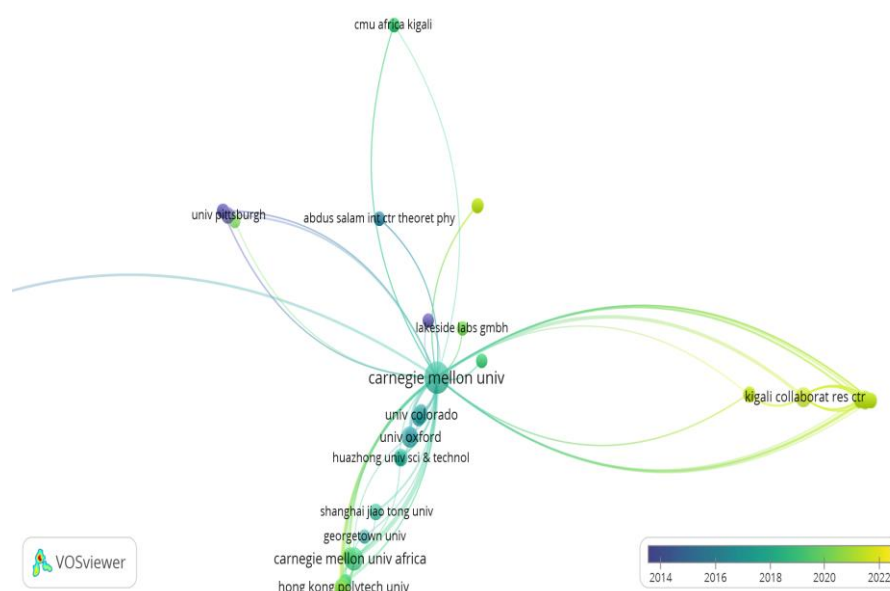


Figure 4.6. KIC Knowledge Space central actor interactions by 'co-publication'

Source: Author's compilation with VOSviewer

As can be seen in Fig. 4.7 below, this study found that KIC's Knowledge Space central actor interactions through co-publication with international actors presented in Fig 4.6 above, were predominantly conducted in STEM research areas, notably electrical and electronic engineering, telecommunications, and computer science.

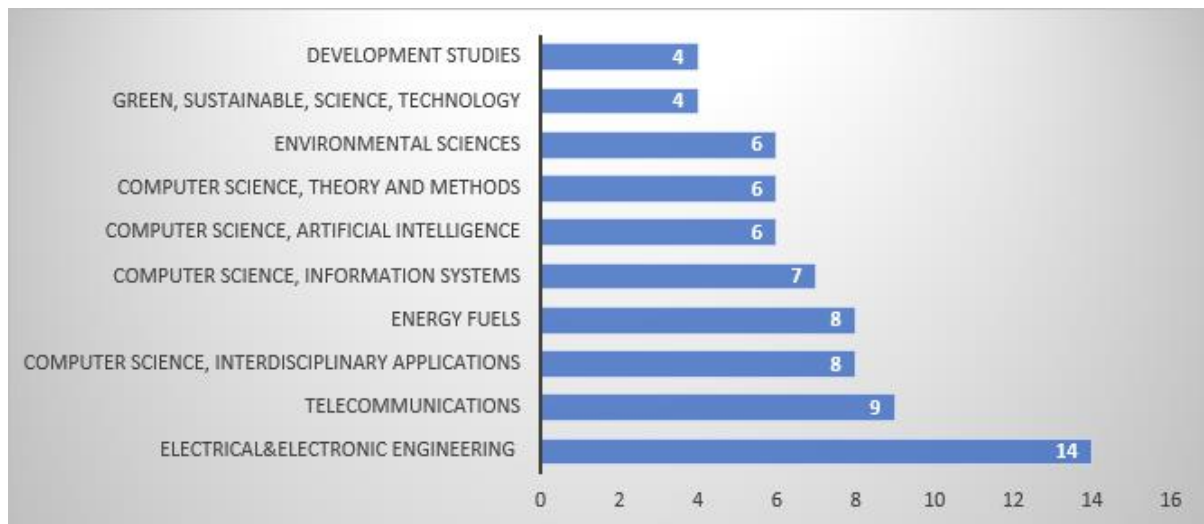


Figure 4.7. KIC's Knowledge Space central actor interactions by 'co-publication by research area'

Source: Author's compilation drawing on Web of Science²¹

As shown in Fig. 4.8 below, research activities by KIC's Knowledge Space central actors are mainly funded by international funding agencies including, *inter alia*, the National Natural Science Foundation of China (NSFC), National Science Foundation (NSF), French National Research Agency (ANR), UK Research Innovation (UKRI), European Commission, Rockefeller Foundation, and the Centre for Climate and Energy Decision Making.

²¹ The findings presented in Fig. 4.6, Fig. 4.7, and Fig 4.8 were drawn from 48 results from Web of Science Core Collection, period 2018 – 2022. CMU-Africa was used as point of reference with two identifiers: organisation (OG): CMU, and address (AD): Rwanda <https://www.webofscience.com/> [Accessed 01.09.2024]

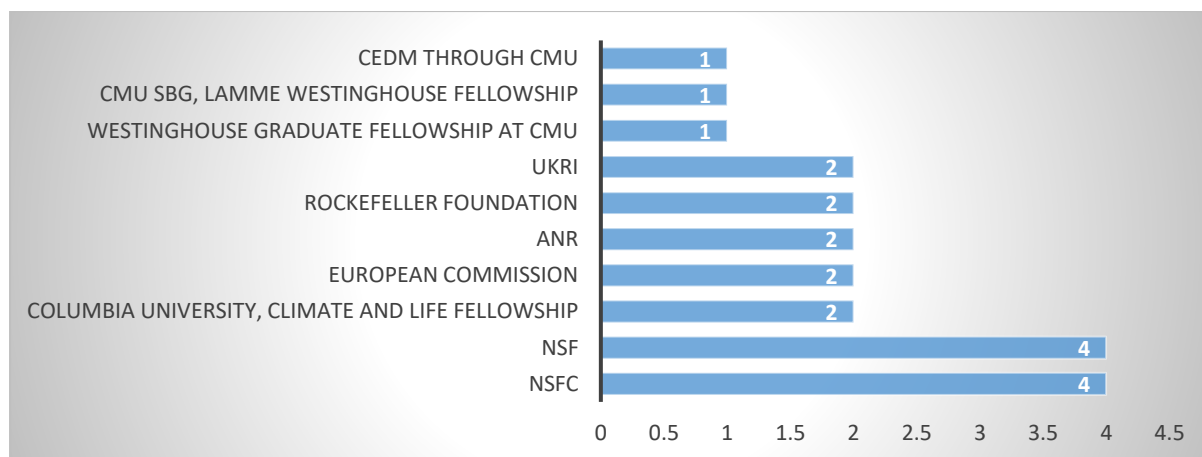


Figure 4.8. KIC Knowledge Space central actor interactions by ‘co-publication by funding agency’

Source: Author’s compilation drawing on Web of Science

The correlation between KIC’s Knowledge Space central actors’ interests in co-publishing with international collaboration, and their research being predominantly funded by international funding agencies, provides important insights into how and why R&I funding might constitute part of the main determinants as to whom to interact with (or not).

4.3 Understanding of actor interactions in relation to KIC’s development

Following up on the findings in relations to research questions one and two above, the analysis in this section presents the findings in response to RQ3 of this study: *Are these interactions related to KIC’s regional (place-based) planning and development activities and if so, how?* By exploring this RQ3, the purpose of the study in the pilot phase was to develop an understanding of the interactions among KIC’s Knowledge Space actors for the development (or lack thereof) of KIC as an ST&I policy flagship, place-based strategic programme for national development. The findings presented in this section stem from interviews and relevant document reviews.

4.3.1 Perception of actors’ role in KIC’s knowledge platform

The objectives of this study included exploring whether or not the interactions of KIC’s Knowledge Space actors were and remained related to KIC’s place-based development activities and planning. On the basis of interviewees’ responses as to

whether they were aware of their respective organisations forming part of KIC's Knowledge platform or not, it transpired that KIC's Knowledge Space actors held a diverse range of perceptions and understanding of the nature of what KIC represents, and of their own role in helping KIC fulfil its aspirations. Ten out of fifteen respondents confirmed their awareness of both KIC's role and that to be played by their respective institutions, as hosts of expert creators of graduates as well as R&I for KIC's ongoing development. In contrast, five respondents conceded that they either had little knowledge of KIC or were fully ignorant as to what KIC was, and how their respective establishments may have been contributing to KIC's development. On the basis of the previously described findings from the micro- and meso-level analyses of KIC's Knowledge Space actor interactions, these actors' understanding of KIC and of the contribution of their activities to KIC's development, KIC's prospects for growth are explored through the lens of a THS conceptual framework in the section below.

4.3.2 Assessment of KIC's development prospects through the lens of a THS conceptual framework: a few knowledge gaps and new contextual perspectives

KIC's development prospects were examined on the basis of the formation, transition, and directionality of THS Spaces as discussed in section 4.2 above. Ranga and Etzkowitz (2013) studied the importance and effects of THS growth for regional (place-based) innovation capacity and the development of competitiveness. Cases studies from the New England Council, Silicon Valley, and Stockholm's Kista Science City served as the most appropriate examples of conceptual frameworks to guide the analysis, despite the fact that these had only been applied in the context of HICs. With the caveat of potentially significant contextual contrasts, KIC's development stages (genesis, implementation, consolidation, adjustment, and self-sustaining growth and renewal) were explored in light of the study's empirical findings. This was conducted through *in-situ* analysis and critical documentation of the mechanisms involved in the creation of THS Spaces: KS, IS, and CS. as illustrated in Table 4.1 below.

Table 4.1. KIC Development stages as seen through THS space creation mechanisms

Mechanisms for creating THS Spaces	Implications for KIC Development (based on empirical evidence from the study)	Stage of THS Space creation²²
Mechanisms for creating a Knowledge Space (KS)		
1. Relocation and aggregation of existing research resources	- Relocation of CMU-Africa, ALU-Rwanda, and AIMS-Rwanda from their temporary campus in Kigali city centre to KIC in Bumbogo sector, Gasabo district. - Relocation of Biomedical Engineering and eHealth (CEBE) from UR College of Science and Technology Nyarugenge campus (in Kigali city centre) to KIC in Bumbogo (construction of campus underway)	Implementation
2. Attracting leading researchers through the founding of science-based universities	Internationally renowned researchers (including Nobel Laureates in their domains of science and expertise) from AIMS, CMU-Africa, AIMS, ALU, and ACEs contribute the latest knowledge and innovation, and widespread experience to KIC	- Implementation - Consolidation and adjustment
3. Creation of new university resources to support the development of new industries or raising existing ones to a higher level	In addition to CMU-Africa, AIMS, and ALU-Rwanda offering STEM-related programmes (such as computer science or related disciplines) at Master's and Bachelor's (ALU) levels, UR decided to relocate CEBE, providing Master's and PhD programs in these disciplines.	- Consolidation and adjustment - Self-sustaining growth and renewal
4. Virtual congregation of geographically dispersed groups from university and industry around common research themes, with government support	Existing inter-actor interactions for collaborative research (particularly through postgraduate joint supervision and research grant applications), and research collaboration initiatives with industry spanning above and beyond physical co-location within KIC's geographical area.	- Implementation - Consolidation and adjustment - Self-sustaining growth and renewal

²² THS creation stages in black text are those already achieved (Genesis and Implementation) whereas those in purple (Consolidation and adjustment, and Self-sustaining growth and renewal) indicate prospects.

Mechanisms for creating THS Spaces	Implications for KIC Development (based on empirical evidence from the study)	Stage of THS Space creation²²
5. Networking of existing knowledge-based organisations and creation of new ones through collaboration among existing actors in order to become internationally competitive	- Empirical study on KIC's actor interactions revealed inter-actor interactions within KIC's Knowledge Space. - For instance, CMU-Africa spearheaded and facilitated the creation and operation of KCRC.	- Implementation - Consolidation and adjustment - Self-sustaining growth and renewal

Mechanisms for the creation of an Innovation Space (IS)

1. Creation of a university in a region without higher education capacity, as a means of raising the technological level of existing clusters or as a source of new ones	Most of KIC's Knowledge Space central actors' (e.g., CMU-Africa) goals are more geared towards producing highly skilled ICT experts capable of responding to Africa's and global knowledge economies'/market's needs, than towards developing or raising local/domestic technological levels among existing actors (academic and industry).	- Implementation - Consolidation and adjustment - Self-sustaining growth and renewal
2. Building an integrated environment for university technology transfer and entrepreneurship	Aside from entrepreneurship being explicitly integrated in the curriculum of all KIC's Knowledge Space actors studied, and with the exception of a few incubation centres/hubs, the present pilot study findings revealed an absence of functional intra- and inter-actor approaches to technology transfer within and across KIC actors. The government of Rwanda (GoR)'s effort to put in place adequate infrastructure provides potential for an integrated innovation ecosystem, e.g. GoR agreement with Africa50.	- Implementation - Consolidation and adjustment - Self-sustaining growth and renewal

Mechanisms for the creation of a Consensus Space (CS)

1. Provision of access to resources	- GoR has provided the physical space (land) and incentivised the regulatory and operational authorities to facilitate the	- Genesis - Implementation

Mechanisms for creating THS Spaces	Implications for KIC Development (based on empirical evidence from the study)	Stage of THS Space creation²²
required to implement a project	construction of campuses for the KIC's Knowledge Space actors in KIC. - Regional Centre of Excellence in ICT (overseen by CMU and hosting CMU-Africa) and ALU-Rwanda campuses were completed and inaugurated in 2019. UR CEBE campus is under construction and AIMS-Rwanda has been allocated land to build its permanent campus in the same location. - The construction of CMU-Africa was funded by AfBD whereas that of UR CEBE campus is being funded by the World Bank (WB). - Through its Scholars' Programme, the Mastercard Foundation supports vulnerable African students from deprived layers of society (academically talented but economically disadvantaged) in accessing the sought-after, high-quality education offered by CMU-Africa and UR.	
2. Creation or transformation of an organisation to provide facilities for brainstorming sessions, problem analysis, and devising of plans	KIC's Knowledge Space actors suggest the creation of a consultation platform to share insights from a broader perspective, on the mission and collective plan for KIC's development trajectory.	- Consolidation and adjustment - Self-sustaining growth and renewal

Source: Author's compilation based on Pilot study project interviews (2021) and document review, adapted from Ranga and Etzkowitz (2013)

4.4 Discussion

In light of the main research questions 1, 2, and 3 and related themes, the findings were interrogated through the lens of a THS framework. Chapter two of this thesis, the Literature Review, provided details on the THS conceptual framework and explained why this theoretical concept was appropriate for guiding the discussion of the findings in this chapter.

4.4.1 Identified KIC's Knowledge Space Actors and their Interactive Capabilities in relation to RIL

In accordance with the objectives of this study, this section focuses on discussing key findings in relation to KIC's Knowledge Space identification or categorisations, KIC's Knowledge Space intra- and inter-actor interactions, and the implications of these interactions for RIL. The findings related to research questions 1 and 2 - 1) *Who are KIC's Knowledge Space actors?* and 2) *How do KIC's Knowledge Space actors interact for RIL, and do these interactions influence the learning and R&I among these Knowledge Space actors?* – are examined through two themes in the sub-sections below.

4.4.1.1 Identification of KIC's Knowledge Space Actors

The first RQ of this study set out to develop an understanding of who KIC's Knowledge Space were and how they ended up being part of KIC. Guided by a THS framework and deploying a critical realistic approach, this study found that KIC's Knowledge Space comprised a range of actors classified in four main categories: (i) KIC's Knowledge Space central academic actors; (ii) KIC's Knowledge Space academic actors in proximity; (iii) Hybrid actors; and (iv) Government agencies. Academic actors – central: As indicated in Fig 4. 5 above, this study found that, by the time this study was conducted, there were five KIC's Knowledge Space central academic actors, namely CMU Africa, AIMS- Rwanda, ALU, KCRC, and UR CEBE. By the time this research was conducted, two universities (CMU-Africa and ALU-Rwanda) and one research centre (KCRC) were physically located on KIC premises. The UR CEBE campus was under construction, while AIMS-Rwanda was still operating in a temporary location elsewhere in City of Kigali, awaiting relocation to its designated site in KIC. One common feature of KIC's Knowledge Space central academic actors is

that they constituted branches or campuses of international universities operating in Rwanda under a PPP model with GoR, with the exception of UR CEBE, which is a public university. Of interest here is the fact that three of the six international universities operating in Rwanda under the PPP model are located in KIC, indicating the significance of KIC in Rwanda's higher education system. This finding confirms the complexity of Rwanda's higher education system as highlighted earlier in the Literature Review (chapter two) of this thesis. In reviewing the literature, this study found that, like the other three international universities operating in Rwanda under the PPP model, the academic and research programmes offered by KIC's Knowledge Space central academic actors were predominantly in STEM fields. Moreover, their programme was particularly and strategically aligned with Rwanda's identified priority sectors aimed at enabling Rwanda to fulfil her political and developmental aspirations of positioning the country as a knowledge, innovation, and technology hub for Africa as highlighted in the country's development agendas such as Vision 2050, NST1 (2017-2024) and STI policy (GoR, 2017a; GoR, 2020b; GoR, 2020h). KIC's Knowledge Space Academic actors in proximity include local public and private universities and research centres physically located within City of Kigali but outside KIC premises. The Hybrid actors, *aka* intermediaries comprise the international and/or bilateral agencies and/or programmes such as WB, PASET, the Swedish International Development Agency (Sida), and Mastercard Foundation, offering funding and capacity development support to KIC's Knowledge Space academic actors. In the case of the government category as part of KIC's Knowledge Space, this study found that public agencies played various facilitation roles. For instance, while RBD through KIC's Coordination Unit provides the coordination and estate management of KIC on a permanent basis, the NCST and Rwanda FDA play the respective roles of convening and science and innovation funding, and technical advisory. Most striking was how KIC's Knowledge Space actor categories, histories, cultures and/or purposes, influenced the ways in which each of these actors engaged in intra- and/or inter-actor interactions for RIL. The sections below discuss this phenomenon.

4.4.1.2 Intra-actor research, innovation, and learning-related interactions

Under this theme, the study involved exploring participants' insights and perspectives on whether, and if so, how academic staff and researchers interacted within any

individual academic actor (university and/or research centre). The influence of these interactions on teaching, research, and innovation was also investigated. The study found that intra-actor interactions in KIC's Knowledge Space did indeed exist within the academic actors – predominantly within those in proximity – constituting 33 % of the total identified interactions, as indicated in Fig. 4.1 and Fig. 4.3 above. That in part means that KIC's Knowledge Space academic actors are more engaged in inter-actor interactions than they are in intra-actor interactions for RIL. The possible reason for the inability of Rwandan universities in general, and KIC in particular, to create internal interactions for RIL, lies in their discipline-silo form of structures. This may in part be in addition to inexistent or inadequate capacities, capabilities, and mechanisms to spur inter-disciplinary approaches to teaching and R&I within a university or across university components such as schools, faculties, and departments. However, this study found that numerous factors or initiatives could facilitate or hamper intra-actor interactions partly due to the nature of a particular academic actor. These factors could be organisational or driven by individual researchers. For example, multidisciplinary and interdisciplinary collaboration was shown to be encouraged across the various teaching/teaching and learning university colleges and/or departments, while this was essential in research centres such as ACEs, not least due to their organisational structure. For instance, one participant from KIC's Knowledge Space academic actors in proximity indicated that when an opportunity arose to apply for a research grant to undertake a study encompassing diverse disciplines, researchers from different colleges or departments could thus team up to jointly submit a proposal. Commenting about this approach, the same participant said: *"We have people that team up and come up with a proposal, with the research that actually will require input from all these different disciplines"* (Research Participant P_PS15, 2021). This view was echoed by another participant from KIC's Knowledge Space academic actors in proximity who posited that researchers from diverse disciplines also interacted in writing articles and/or books for publication, while university policies encouraged academic staff to publish with incentives in return, such as academic promotions and salary increases. It can thus be seen that University policies and policy instruments to stimulate collaborative undertakings amongst academic staff and researchers are essential to foster the indispensable intra-actor interactions for optimal research, innovation, teaching, and learning.

Researchers in universities were also found to interact through regular seminars to share knowledge and innovation ideas. In some instances, such events were reported to bring together people from the ICT School and the School of Engineering within UR's College of Science and Technology. Similar practices were described at AUCA Masoro campus, where it is understood that as part of the teaching curriculum, researchers meet every Wednesday afternoon to discuss ongoing research across different departments and disciplines. In the case of UR in particular, academics from diverse colleges were said to be involved in supervising postgraduate students (Master's and PhD students) according to their disciplines of expertise. The interviewees also indicated that physical spaces such as innovation hubs and incubation centres facilitated the interactions between researchers and students working on innovative research ideas and developing products or prototypes.

In contrast to the positive findings above, one troubling discovery was that not all Research centres (ACEs) hosted by UR enjoyed the benefits of permanent staff, but were instead run by the academic personnel from a range of different departments, schools, and colleges. In the author's view, their organisational structure and multidisciplinary nature make it imperative for these research centres to interact with one another and with other actors across the university to promote optimal research, innovation, and teaching. Such knowledge circulation within individual academic actors partly reflects the 'non-commercial innovation' capabilities being advanced by UKaid (2020, p. 42) in support for universities in Rwanda. Viewed through the lens of THS, individuals steering intra-actor interactions are known as 'innovation organisers' (Ranga and Etzkowitz, 2013). The more innovation organisers an academic actor has, the better it becomes intra- and inter-connected for RIL.

The existing intra-actor interactions within universities and research centres offer the potential for Rwanda University's system to distance itself from existential silos. In particular, deliberate and coherent policy frameworks encouraging inter-disciplinary and trans-disciplinary approaches to research, teaching, and learning may strengthen the relevance of the academic system as well as approximate universities and relevant actors such as government, industry, NGOs, and others. Such policy frameworks would notably contribute to improving the performance of national and place-based innovation environments as contended by Etzkowitz (1996) and Twiringiyimana et al. (2021).

4.4.1.2.1 Capacity building for inter-disciplinary teaching and research approaches – a key necessity

This study found that the multidisciplinary nature of research centres such as ACE and the role expected of them, namely, to provide relevant graduate and postgraduate training and conduct meaningful R&I in response to grave societal problems, placed pressure on the academic staff employed in these centres while the latter remained by nature entrenched in a traditional discipline-siloed (STEM and Non-STEM) university setting. It would therefore in the author's view be imperative to design capacity building programmes for university personnel in general, and research centre staff in particular, to promote a greater understanding and appreciation of the dynamics of teaching and research from an inter-disciplinary approach.

In their quest to understand whether, and if so, how STEM discipline-specific actors (universities and research centres) involved non-STEM scientists in their R&I projects, interviewees revealed that researchers in STEM disciplines tended to collaborate in research with colleagues from the same school or college. For example, a respondent from UR's School of Engineering indicated that engineers or researchers from the School of Engineering and the School of ICT (including Computer Science) engaged in joint research on and co-authored publications about emerging technologies such as AI and Machine Learning. The key finding from these responses was that the new and emerging technologies were being researched and taught in accordance with the discipline-siloed approach within STEM universities in Rwanda. This may explain to some extent the reason why pioneering research projects aimed at advancing knowledge in these domains are designed within a narrow technical spectrum, without necessarily reflecting and expanding on the implications of these technologies for society, as argued by Marr (2020). In contrast to the above responses from interviewees from traditionally structured university schools and/or faculties, respondents from research centres emphasised the involvement of non-STEM scientists not only in teaching but also in research activities within their respective research programmes. The multidisciplinary nature of the centres imperatively calls for the necessity to invite researchers from fellow centres and/or colleges to support their aspirations to remodel themselves (centres) into broader, more multidisciplinary teaching and research providers, including their remit to supervise Master's and PhD

students. Notwithstanding this critically important requirement, one interviewee was particularly keen to mention that the main supervisors came from engineering disciplines, while the invited experts from non-STEM disciplines were co-supervisors. This reality may to some extent elucidate the reason for the STEM bias and the imbalance in the design and implementation of multidisciplinary research projects undertaken by the research staff and students in these centres. The author would argue that, depending on the nature of a given project, the inclusion of non-STEM researchers as principal investigators, co-leads, or main supervisors for research projects undertaken in STEM research centres may promote broader, more diverse perspectives on and approaches to interdisciplinary research design in the new and emerging technological disciplines such as AI, ML, and IoTs. It is reasonable to assume that such a development would be likely to contribute, not only to promoting the significance and relevance of these technologies for other key actors, but also to foreseeing and evaluating any plausible (beneficial or detrimental) implications of these technologies and other STEM disciplines for the severe and complex issues facing contemporary and future society within local, regional, national, and/or global settings.

4.4.1.2.2 Proposed framework for greater interaction between STEM and non-STEM academia

The need for closer collaboration between STEM and non-STEM disciplines to further promote the relevance and usefulness of the new and emerging technologies referred to above was echoed by several interviewees. For instance, one participant said: *“the university [...] wanting to position itself as an excellent university in Big Data for instance, will be required to deal with technological aspects of this kind of new science to ensure it is relevant to society. From the design of that study (big data), people should bring different perspectives, from engineering, technology, and social sciences for instance, for the outcome of the study to be relevant”* (Research Participant P_PS03, 2021). This reiterated Marr’s (2020) emphasis on the imperative to bring Engineering and Computer Sciences (STEM subjects) closer to Social Sciences, Arts and Humanities (non-STEM disciplines) in order to stimulate and enhance R&I in the new and emerging technologies, in order for these to adapt and respond meaningfully and contextually to societal needs (Marr, 2020; UKaid, 2020). The advances in

knowledge and interdisciplinary research capacity and capabilities within and between STEM and Non-STEM disciplines within the discipline-siloed university system requires innovative and wilful policy alignment, coherence, and combination at national, place-based, and university levels. The findings of this study thus prompted the following key question: *How can the culture of interdisciplinary teaching and research be strengthened within and among these entities?* The study interviews provided insights into how interdisciplinarity within a particular actor (university) could be fostered to heighten the relevance of academia, as illustrated in the proposed framework in Fig. 4.9 below. Reading it from bottom to top, and from right to left: the *problem* (yellow) of how the discipline-specific university structures impede academia's response to wicked and complex contemporary societal issues (Mazzucato, 2018), precedes the *prerequisites* or foundation for achieving interdisciplinarity, including policy alignment, coherence, and policy mixes (pink). *Governance structures* offer support to dynamic interactive and interdisciplinary research capabilities, capacity, expertise, and provides shared workspaces amongst academic staff. At the same time, explicit government and university-level policy instruments are the *pillars* (orange) facilitating intra- and interdisciplinary interactions between STEM and non-STEM study fields (maroon), leading to a likely *enhanced relevance of academia to society* (blue). Robust Monitoring, Evaluation, and Learning (MEL) procedures should furthermore be proposed to ensure *system resilience* (grey).

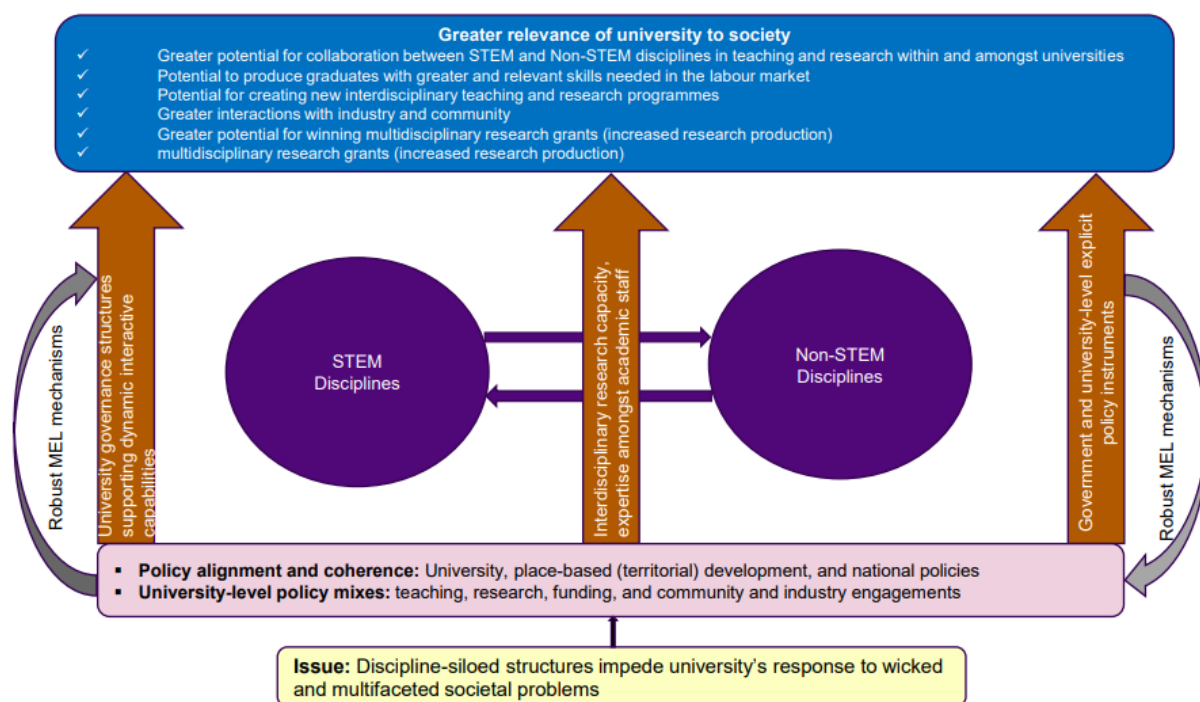


Figure 4.9. Proposed framework to foster interdisciplinarity in the discipline-siloed university setting

Source: Author's compilation based on Pilot Research Interviews (2021)

Developing significant interactive capabilities among researchers across STEM and non-STEM disciplines may enable individual KIC's Knowledge Space academic actors to help resolve KIC's complex place-based development problems and offer innovative solutions. This thesis argues that leading inter-disciplinary research and teaching capabilities might be key prerequisites for such skills, knowledge, and innovations to firmly and comprehensively underpin KIC's proposed leading role in generating high-value technology clusters in fields such as fin-tech, edu-tech, energy-tech, agri-tech, big-data management, pharmaceutical, biotech, and cyber-tech as alluded to in the Introduction chapter of this thesis.

4.4.2 Inter-actor research, innovation, and learning -related interactions

This study found that KIC's Knowledge Space academic actors engaged more in inter-actor interactions for RIL than they did in intra-actor interactions as illustrated in Fig. 4.1 and Fig. 4.2 in Section 4.3 of this chapter. Under this theme, participants were asked whether they knew of or valued knowing types of research or innovation activities either being currently conducted or planned in other organisations offering

comparable or related programmes. Eleven out of the fourteen interviewees who responded to this question confirmed that they knew of other academic and research entities offering similar programmes. Two of the three respondents who had responded negatively to being asked whether they valued such knowledge – stated that the main reason it was of no value to them was that no other academic or research entities were offering a similar R&I programme or employing a comparable approach to teaching and learning. Another interviewee from KIC's Knowledge Space academic actors in proximity revealed that his/her main reason for not knowing about (or valuing) other actors' operations was essentially due to dissimilarities in their respective discipline-specific approaches to teaching and research, particularly at domestic private universities.

4.4.2.1 Actors' perception of inter-actor interactions

The respondents who confirmed their awareness of R&I activities being undertaken by other actors with similar academic or related programmes highlighted a range of specific and general reasons why they valued knowing what was being done by other actors. These included, *inter alia*, learning from one another, complementarity, potential for writing grant applications together, the mobility of lecturers and Master's and PhD student supervisors, all of which they deemed as contributing expertise towards designing policy at organisational level, enhanced resource sharing amongst research programmes beyond teaching and learning, and ongoing raising of graduate and postgraduate academic standards and aspirations. They went on to indicate that the nature of research centre programmes drove their researchers to interact with other key actors to deliver on their mandate. As one respondent from KIC's Knowledge Space academic actors in proximity put it: “[...] *because we have realised that though we are in the IoT, we cannot work on our own, we have to work with other people because IoT is the cross-cutting field which can be applied in different fields*” (Research Participant P_PS05, 2021). Viewed through the lens of a THS framework, these partly constituted the knowledge exchange, collaboration, networking, and substitution functions of KIC's Knowledge Space actors for the generation, dissemination and use of knowledge and innovation (Ranga and Etzkowitz, 2013). On the basis of the insights gained from respondents' information, ACE IoT was singled out as a leading actor in developing and promoting research and interactive

capabilities in the field of compiling successful grant proposals, as recapitulated in Box 4.1 below.

Box 4.1. ACE in IoT's capability in proposal writing to gain research and innovation grants: a learning model for other actors

The ACE in IoT is one of four research centres hosted by UR. Since its creation in 2017, the ACE in IoT has been building a specialist niche in writing successful proposals that have resulted in winning multidisciplinary research grants in a diverse range of scientific disciplines, and from different funding organisations. For instance, the Centre was awarded a research grant for a 'smart agriculture or smart irrigation project' in collaboration with researchers from UR's College of Agriculture and Veterinary Medicine. This project required skills and expertise in ICT and Agriculture. The ACE in IoT also recently developed and submitted a research proposal to the National Institute of Health (NIH) in collaboration with researchers from the ACE in Data Science hosted in UR's College of Business and Economics, and others from UR's College of Medicine in the Health Sciences. The NIH proposal was highly multidisciplinary, requiring a combination of knowledge and expertise in the fields of health and medicine, data science, and 'embedded systems'. In addition, ACE in IoT recently won three research grants, including the NCST-funded 'industry/academia collaboration project', in collaboration with the private sector and other schools within UR. In all these ventures, ACE in IoT was contributing the knowledge and expertise of its academic staff or researchers and postgraduate students (both Master's and PhD candidates being actively involved in the implementation of these undertakings). The breadth and depth of its contribution to these projects unequivocally underlines the Centre's commitment to and proactive discharge of its mandate to promote a multidisciplinary, collaborative, interactive context in which research, innovation, teaching, and learning can evolve, and which substantiates the undeniable relevance of IoT programmes to society. ACE in IoT's outstanding capabilities in drawing up research proposals and collaborating closely with other actors, has attracted a range of eminent researchers from other centres seeking opportunities to collaborate with ACE in IoT. For instance, ACE in Energy and Sustainable Development in particular approached ACE in IoT to request collaborative assistance in learning how to write successful grant applications and proposals.

(Source: Research interviews in pilot phase, 2021).

Another interviewee from KIC's Knowledge Space central academic actor emphasised a range of specific reasons for calling upon UR, the only public research university in Rwanda, to familiarise itself with and gain an intimate understanding of CMU-Africa's and AIMS' efforts and activities to promote collaborative, interactive, multidisciplinary academic research. According to this latter interviewee, UR's interactions with CMU-Africa and AIMS were essentially linked to these universities' aspirations in terms of reputation, prestige, and track record, which they in turn anticipated translating into high rates of graduate employability, despite CMU-Africa and AIMS not broadly being regarded as research universities within Rwanda. This insight *inter alia* reflects the education and training strategy for KIC's development, which is based on targeting highly talented students from all over Africa, with the aim of producing exceptionally employable, skilled graduates for the entire continent, well beyond the borders of Rwanda. It therefore follows in the view of the author of this thesis that developing and implementing purposeful collective strategies and policy instruments aimed at enabling or enhancing interactions between KIC's Knowledge Space central academic actors, on one hand, and any academic establishments in proximity offering PhD programmes, on the other, would be both highly instrumental and critical in accelerating KIC's continued development into a knowledge and innovation hub. This may be achieved *inter alia* through the co-creation of R&I themes around the identified technology-led sectors such as fin-tech, edu-tech, energy-tech, agri-tech, big-data management, pharmaceutical, bio-tech, and cyber-tech in close affinity with Rwanda's development aspirations (GoR, 2020h). This thesis argument echoes the claim advanced by Bank and Sibanda (2018) that universities in a same location or city should plan to and engage in collaboration and support one another's niche areas of specialisation for them to collectively stimulate the place's development, instead of the various universities operating in silos and competing schools and departments. Box 4.2 below briefly describes CMU-Africa, a pioneering central academic actor within KIC's Knowledge Space.

Box 4.2. CMU-Africa, the epicentre of Regional ICT Centres of Excellence – a partnership between GoR, AfDB, and CMU

CMU-Africa – ‘The only US research university offering its Master’s degrees in a Faculty staffed with full-time personnel, and operating throughout Africa’ – was established in 2011 with the aim to address the ‘critical shortage of high quality engineering talent required to accelerate development in Africa’²³. The creation of CMU-Africa stemmed from the Connect Africa Summit held in 2007 in Kigali. This was in response to the fourth of the Summit’s five goals to ‘*support the development of a critical mass of ICT skills required by the knowledge economy, notably through the establishment of a network of ICT Centres of Excellence in each sub-region of Africa and ICT capacity-building and training centres*’²⁴. Following some three years of post-summit negotiations, a partnership was formed between the GoR, African Development Bank (AfDB), and CMU Pittsburgh in USA, to design and implement a Regional ICT centre of excellence aimed at developing advanced ICT capacity through different aspects of capacity building, namely: training (education), research, and innovation. The AfDB committed itself to funding the construction of the campus while CMU Pittsburgh was entrusted with implementing the Centre of Excellence scheme, starting with its epicentre, ‘CMU-Africa’, primarily focused on education. CMU Pittsburgh was also granted freedom to set up the three arms (education, research, and innovation) as it deemed fit. The resulting vastly enhanced understanding of the multiple aspects of these arms represents a significant and lasting progression towards achieving the Regional Centre of Excellence’s overall goal in ICT development:

Education arm: Officially started in 2011 and set up in the temporary location of Telecom House in Kigali, CMU-Africa launched its Master’s programs classes in August 2012. According to its original plan, it started off with a single Master of Science (MSc) program in Information Technology (MSIT) with an initial class size of 24 students, with a second program (Master of Electrical and Computer Engineering, MS ECE) starting in 2016. Its third and most recent programme (Master of Science in Engineering Artificial Intelligence (MS EAI)). By the time of the inception of this pilot study, CMU-Africa boasted some 150 enrolled students from over 15 countries²⁵.

²³ <https://www.africa.engineering.cmu.edu/about/index.html>

²⁴ <https://www.itu.int/net/itunews/issues/2009/06/35.aspx> [Accessed:15.09.2021]

²⁵ <https://www.africa.engineering.cmu.edu/students/index.html>

Research arm (Kigali collaborative Research Centre, KCRC): Soon after starting its inaugural teaching program in 2012, CMU-Africa began to explore various possibilities and options of creating an international research centre. A broad and detailed investigation of different aspects followed, including the proposed nature and purpose of the centre and associated research themes. Ensuing consultations with government and industry actors, together with efforts to capitalise on CMU's available resources in terms of expertise, resulted in the creation of KCRC in 2016, as a Rwanda-based NGO, with no explicit affiliation with CMU. CMU none the less offered support from the onset – including in the form of its faculty dedicating part of their time to run KCRC in the early days of its operations – despite each having formally been separate entities. With a primary focus on ICT, KCRC provided a prosperous environment for expanding collaborative research and innovation programs in Africa across different STEM disciplines, including climate change²⁶.

Innovation arm - Industry Innovation Lab (IIL): Unlike KCRC, the IIL was chosen to be retained within CMU-Africa, and as such, to form a part of CMU. On completion of the construction of the Research Centre of Excellence in ICT, CMU (CMU-Africa, including IIL and KCRC) activities were moved from their temporary to their permanent location within KIC in 2019. All of these CMU activities are therefore currently housed in the same building, in the same 'fully integrated campus', as had been anticipated (ITU, 2009, p. 39). CMU-Africa's IIL is further discussed in chapter seven of this thesis. (Source: Research interviews in pilot phase, 2021).

4.4.2.3 Innovative teaching approach and inter-actor interactions

Another key study finding was that several of respondents believed that, in addition to interacting with the other actors in similar STEM disciplines, it was of paramount importance to also engage with other actors offering specialised non-STEM disciplines. These disciplines could provide STEM students and staff with supplementary skills such as business, governance, and leadership, all of which are relevant to the growth of a knowledge-based innovation ecosystem. For example, one interviewee from KIC's Knowledge Space academic actor in proximity indicated that universities offering STEM programmes normally tended to collaborate with other

²⁶ <https://www.kcrc.rw/>

universities offering similar programs, such as UR. The same participant went on to reveal that his/her university was collaborating with other KIC's Knowledge Space academic actors on other much-needed innovative skills. Commenting about this, the same participant said: *"I know the Rwanda Polytechnic, which is coordinating the college, has the Memorandum of understanding with the different University including the African Leadership University (ALU). Because we know that they're really good in readership, that there are some good practices that they may have, which can be supplemented to engineering field to really equip the students and the staff with that kind of capability"* (Research Participant P_PS06, 2021). Although ALU-Rwanda, which currently offers Bachelor's and MBA degree courses, is not regarded as a research university, evidence from this research indicated that it possesses a unique and innovative approach to teaching and learning that is conducive to interacting with other actors. For instance, talking about the uniqueness of ALU's programme, one interviewee from KIC's Knowledge Space academic actor said: *"ALU is innovative in teaching and learning"* (Research Participant P_PS06, 2021). This view was echoed by another respondent from KIC's Knowledge Space central academic actor who stressed ALU's innovative teaching and learning programme as a contribution to KIC's development. Commenting about this, the same participant said: *"We have innovative undergraduate programmes at ALU", which are shaping it into another feeder – alongside UR and AUCA [Adventist University of Central Africa] – of potential candidates for CMU-Africa's Master's programmes in computer science and electrical engineering"* (Research Participant P_PS09, 2021). Box 4.3 below provides a brief description of ALU-Rwanda's innovative teaching and learning philosophy.

Box 4.3. ALU-Rwanda as an innovator in teaching and learning

ALU launched its Rwanda campus named 'ALU-Rwanda' in 2017. This followed the inauguration of ALU's main campus in Mauritius in 2015. The ALU-Rwanda campus hosts the ALU School of Business, which in addition to offering an academic MBA programme, provides short courses, research and executive education designed to respond to the needs of the entire African Continent²⁷. An undergraduate programme in computer science has also been initiated at the ALU-Rwanda campus. Prior to moving to its newly established permanent campus in KIC in 2020, ALU was operating

²⁷ <https://www.africanleadershipacademy.org/blog/alu-inaugurates-new-campus-kigali/>
[Accessed:16.09.2021]

in a rented location in Kigali. In a similar manner to CMU, the GoR supported ALU in various ways, including donating it land on which to build its campus in KIC, in the neighbourhood of CMU-Africa. As at the time of this research, ALU-Rwanda campus was home to a diverse student community representing about 41 countries.

Unlike the majority of academic actors, who tend to adhere to traditional education practices, ALU's approach has been and remains focused on training students to (i) become either sole leaders and proprietors of their own businesses, and/or (ii) share their knowledge with the local community whilst ensuring they maintain the leadership and entrepreneurial capability to uphold, exercise, and instil ethical values in others. Accordingly, ALU encourages students to pursue and develop their own learning, but also to focus on missions (as opposed to majors), with a problem-solving mindset. For instance, one of ALU's signature programmes is the 'Grand Challenges' scheme, which primarily focuses on Africa. Immediately after joining ALU (whether at Undergraduate or MBA level), each student is asked and supported to identify a challenge in their community and to set about finding a solution to it. ALU collaborates with partner organisations such as companies, businesses, and/or experts to assist and guide students in shaping or proposing a solution to the identified challenge throughout their study programme. Students are thus exposed to a 'learning by doing' teaching style in a such way that, on completion of their study, 'they have pragmatically solved a problem (or contributed to solving a problem) that may earn them a monetary gain but is also highly likely to prove beneficial to the community where they come from'.

(Source: Research interviews in pilot phase, 2021).

4.4.2.4 Role of hybrid actors in inter-actor research, innovation, and learning-related interactions

This study found that, in addition to donating the land on which to build the Regional centre of excellence in ICT and to covering the operating costs of CMU-Africa, the GoR was continuing to rank among the key funding actors benefiting the talented students enrolled at CMU-Africa, through a range of scholarships for eligible Rwandans and other African nationals. Other evidence gathered as part of this study furthermore suggested that both the GoR and CMU had formed a partnership with the Mastercard Foundation Scholars' Program to support 425 'academically talented but

economically disadvantaged students from across SSA'²⁸. Similarly, a ten-year partnership was also agreed in 2021 between the Mastercard Foundation and UR to provide 1,200 African youths access to STEM university education, with a particular focus on the most disadvantaged categories of people, namely: women, people living with a disability, as well as refugees and displaced young people²⁹³⁰.

When viewed through the lens of a THS framework, the GoR's roles may be argued to be multiple and to include those of 'entrepreneurial state' and 'knowledge organiser' (Ranga and Etzkowitz, 2013; Twiringiyimana et al., 2021), both indispensable in order successfully to achieve the goal of an effective, sustainable regional innovation development strategy. In addition to the above, the long-term involvement of development partners – who provide funds for infrastructure, R&I, and capacity building – constitute a further essential role for relevant THS Space actors, whose functions vastly exceed the remit of THS intermediaries. This thesis therefore argues that it is imperative to acknowledge the tangible, active role played by these hybrid actors in the co-creation of place-based key flagship ST&I policy interventions such as KIC, if such pioneering programmes are to generate knowledge resources and innovative solutions that are inclusive, environmentally sustainable, socially useful, and economically viable and transformative, whilst being intrinsically designed to reduce inequalities (Schot and Steinmueller, 2018; UKaid, 2020). Evidence in support of this claim is provided by the contribution of key NGO actors in shaping the essential interactive capabilities for KIC's development as illustrated in Figs. 4.1, Fig. 4.2, and Fig. 4.4 above.

4.4.3 Understanding of actor interactions in relation to KIC's development: implications for social and inclusive innovation

In light of the research approach of the present thesis, the discussion in this subsection focuses on theme 3 – Actor interactions in relation to KIC's development. Under this theme, the findings were cross-interrogated through the lens of a THS

²⁸ <https://www.africa.engineering.cmu.edu/mastercard-scholars/index.html> [Accessed:23.09.2021]

²⁹ <https://mastercardfdn.org/university-of-rwanda-mastercard-foundation-launch-55-million-partnership-to-develop-the-next-generation-of-african-leaders/>

³⁰ <https://ur.ac.rw/?University-of-Rwanda-Mastercard-Foundation-launch-55-million-partnership-to>
[Accessed:23.09.2021]

framework in response to RQ 3: *Are the actor interactions related to KIC's regional (place-based) planning and development activities, and if so, how?*

4.4.3.1 Perception of actors' role(s) in KIC's knowledge platform

This study found that there was no clear link between the contemporary interactions of the KIC's Knowledge Space actors with KIC's actual planning and development activities. The limited or partial understanding of KIC even amongst its prominent KS actors implied an inadequacy in the system that determined how policies and strategies were communicated to relevant stakeholders. Given all of the interviewees' elevated positions within their respective organisations, one may have been inclined to assume that they would have possessed a basic grasp of what KIC represented. The lack of or scant knowledge about KIC amongst its KS actors may in part have represented a threat to KIC's development. A similar experience was noticed in South Africa with regard to the Technical and Vocational Education and Training (TVET) institutes, located in close proximity to the Square Kilometre Array (SKA) network: these were found to be unable to interact with SKA network actors, mainly due to their lack of or limited knowledge about the aims and objectives of the SKA network (Cele et al., 2020). The author of this thesis argues that, on one hand, it is important for the government to put in place policy instruments that enable or facilitate awareness creation and capacity building for the KS actors, and other actors, neighbouring a place-based ST&I flagship programme, if these actors are to leverage the opportunities offered by that programme. On the other hand, it is essential for the actors adjacent to a flagship programme to possess innovative and entrepreneurial capacity to identify and seize these opportunities through interactions.

Other plausible, potentially related contributing factors to this ignorance may be attributable to the lack of policy coherence and of alignment of actors' strategies with KIC's development plans. For instance, while Rwanda's National Strategy for Transformation (NST1 2017-2024) specifically refers to UR as among the organisations appointed to 'develop and operationalise a thriving skills ecosystem for attracting and nurturing local and international talent around the KIC model' (GoR, 2017a p, 67), there is no mention of KIC in UR's Strategic Plan (2018-2025) (UR, 2018b). Chataway et al. (2019) emphasised the need for coherent 'ideas and policy narratives' in policy and organisational agendas for greater relevance of actors in

relation to diverse factors, including their geographical location. KIC KS actors' understanding of what KIC is and what is expected of them to further KIC's development plans is of paramount importance. The absence of understanding of concepts such as 'systemness' (Roper, 2021), may be problematic for actors to align their respective aims and strategies and networks with the place-based development plans (Cele et al., 2020; Twiringiyimana et al., 2021). Ideally, such actor interactions for RIL should be clearly geared towards optimising KIC's intended collective development outcomes, because 'without a clear understanding of the inner workings of the innovation system, the identification and alignment of inter- and intra-institutional responsibilities become haphazard at best' (Yongabo, 2021b, p. 80). This thesis' last argument above is being advanced with the caveat that in reality, the actors' proposed agenda alignment is not evident from a practical point of view. According to the findings of this study, KIC's Knowledge Space central academic actors consisted of campuses (or local branches) of parent organisations with diverse historical backgrounds, missions, philosophies, and approaches to education, research, and innovation, as well as contrasting cultural contexts that underpinned their respective worldviews. At the same time, the study findings also suggested that KIC's Knowledge Space central academic actors had already been operating and interacting with other KS actors within Rwanda's university, particularly those in KIC's proximity, prior to their move to KIC. It was found furthermore that they had also been interacting with KIC's Innovation Space and KIC's Consensus Space actors such as industry, government, and other development partners, as well as other relevant actors in Rwanda's broader NIS. These pre-existing interactions with other actors may provide a valuable impetus for KIC's Knowledge Space actors to commit to devising a collective scheme towards establishing themselves as a pre-employment and knowledge platform to optimise KIC's expansion. Whilst KIC's Consensus Space lies outside the scope of this research, Chapter seven of this thesis explores KIC's transition from KS to IS as part of its development prospect.

4.4.3.2 University-based innovation incubation centres: a central entrepreneurial capability of KIC's Knowledge Space actors

One the most striking aspect of this research's findings was the role of university-based innovation incubation centres in enabling actor interactions for RIL, and the

potential for these innovation incubation centres, *aka* innovation hubs, to create a deliberate and integrated environment conducive to the formation of KIC's Innovation Space. Examples of these facilities or capabilities include, *inter alia*, the Innovation and Entrepreneurship Centre at UR, Incubation Centres at RP and ACE ESD, and the Industry Innovation Lab (IIL) at CMU-Africa.

From an ST&I policy perspective, this thesis argues that creating a dedicated entity for funding and capacity building – targeted at enhancing the innovation and technological capabilities of KIC's Knowledge Space actors – may offer a strategic pathway to enhance the entrepreneurial potential of these actors. Implementing this might motivate the various knowledge-based innovation and technology start-ups and/or spin-offs, involving the current students and/or graduates as well as innovators and entrepreneurs from firms and hubs across KIC's priority areas (Steenbergen and Javorcik, 2017). Creating conditions for such existential interactive capabilities to thrive might in part contribute to creating new or fostering existing experimental development *aka* near-market research collaborations between KIC's Knowledge Space and KIC's Innovation Space actors (university-based start-ups and/or other relevant firms). Such collaborative research activities for the generation or adoption of new technology or and the contextualisation of imported technologies in priority areas of KIC might in part boost the systemness of KIC (Roper, 2021) and create or foster an integrated place-based, knowledge-based innovation ecosystem environment. As such, KIC might essentially mature into a connected, resilient, agile, self-sustained, place-based, knowledge-based innovation ecosystem, with a degree of self-governance (Mugwagwa et al., 2021; Washbourne et al., 2021; Smorodinskaya et al., 2017). This might thus add to the realisation of Rwanda's broad proof-of-concept state aspirations (Daniels, 2021) while contributing to increasing Rwanda's human capital, research, and knowledge, as well as technology outputs where Rwanda's science, technology, and innovation system is essentially lagging (WIPO, 2020a). Chapter seven of this thesis draws from post-pilot research empirics to explore the university-based innovation centres' potential as part of ST&I policy options in shaping KIC's transition from KS to IS.

4.4.3.3 Uncovering aspects of social innovation and inclusiveness in KIC's development trajectory

This study found that KIC's hybrid actors, including local and international NGOs, multi-governmental and multi-partner programmes, bilateral-driven initiatives, as well as financial organisations for development, essentially targeted young Africans – who excelled academically but were financially constrained, including women, people with disabilities, and refugees – to gain them access to the high-quality education offered by KIC's Knowledge Space actors. The interventions of the various aforementioned hybrid actors such as the Mastercard Foundation and Sida suggest that KIC's Knowledge Space development may *inter alia* be viewed as a society-focused activity that promotes place-based industrial development. The nuanced configuration of KIC's development pathways – in the sense that actors are involved from the perspective of their respective functions – reveals that despite being conceptually designed both in method and outcome as a national flagship ST&I project, targeting scientific and technological innovation towards industrial development, KIC's development scheme is deeply embedded in elements of 'social innovation'. The present study furthermore yielded unprecedented fresh empirical and contextual evidence supporting Chataway et al.'s (2020) discussion of their research findings on the extent of 'relationships between social and technological innovation', and Friederici's (2018) view of innovation hubs as social organisations operating as intermediaries, whose intermediation 'can never be expected to be a seamless, apolitical and uncontested process' (Friederici, 2018, p. 18). It is contended in this thesis therefore that considered consultation and acknowledgement of the multiple voices and powers when determining or influencing the selection of participants in and/or beneficiaries of the creation of a critical pool of engineers, researchers, scientists, innovators, and entrepreneurs, are paramount for flagship programmes such as KIC to succeed.

One interviewee from among KIC's Knowledge Space academic actors in proximity emphasised the need for inclusiveness and interaction among actors was the greatest factor impacting on KIC's attainment as a flagship place-based development project, stating that: *"Conceptually, it's [KIC] a very good idea and I think it's really a visionary project. Although I think its impact on the overall national socio-economic development will depend on how the concept is operationalised, and how development actors*

exploit the idea that is being brought on board. Because, ideally, flagship projects are meant to be very comprehensive, inclusive, and well-integrated into development trajectories of the place where they are being initiated” (Research Participant P_PS12, 2021). This observation resonates with Mulgan's (2019) emphasis on the critical importance of connectedness between government, funding agencies, industry, and civil society ‘involving some combination of shared plans, targets, and commitments’ – that can collectively lead to greater achievements, including place-based systems change (Mulgan, 2019, p. 99). Alignment between the different actors’ agendas and policies is hence essential in this context.

4.4.3.4 Prerequisites for KIC to evolve into an inclusive place-based innovation ecosystem – an epistemic inclusivity perspective

As presented earlier in this chapter, KIC’s Knowledge Space’ central actors were specifically identified as engaging the least in interactions towards research, innovation, and learning expansion. The key finding in this regard was that for these actors, their specific academic aspirations prevailed over their inclination to engage in interactions to promote KIC’s place-based development. For instance, one interviewee from KIC’ KS actor unequivocally said: *“We like to position ourselves as a Research Centre, [an] internationally renowned Research Centre (...) And so, our goal is to make sure that we're seen as internationally competitive, not just a local or regional centre”* (Research Participant P_PS16, 2021). When asked whether his/her university offered any programmes involving engagements and interactions with adjacent local communities and industries in KSEZ, the same participant stated that there was no formal or informal engagement with the local communities other than seeing them pass by the university on their way to carry out casual work in KSEZ. Interestingly, commenting on his/her relationship with adjacent industrial actors in KSEZ, the same participant posited that there were no forms of interaction except the intermittent noise from manufacturing factories in KSEZ. Such actors’ perspectives might partly be attributable to a range of underlying factors including, *inter alia*, individual actor’s historic circumstances (Mulgan, 2019), the diversity of approaches to teaching and R&I, and differences in types and levels of academic and/or research programmes. The existing dichotomy regarding KIC’s Knowledge Space central international actors’ strategic goals of achieving international reputation and prestige, overriding the aim of cultivating place-based knowledge and technological development, may contribute to

perpetuating academia's undesirable 'ivory tower syndrome' (Saad et al., 2008; Albuquerque et al., 2015; Galvao et al., 2018) and 'silos syndrome' (Twiringiyimana et al., 2021) within Rwanda's higher education system. This Prioritisation choice might thus hinder the creation and propagation of inclusive knowledge and innovation activities within KIC. Overcoming this dichotomy would merit and require purposeful, place-based policy interventions to address questions such as: *How can interactions between KIC's Knowledge Space central international actors and actors in proximity be enhanced to consolidate the latter without jeopardising the former's global aspirations?* Failure to devise and implement balanced collective policies to accommodate individual actors' strategies would only exacerbate academia's prevailing 'ivory tower syndrome', to the grave detriment and downgrading of Rwanda's university system (Twiringiyimana et al., 2021; Yongabo and Göransson, 2020). From an epistemic inclusivity perspective, this thesis therefore argues that KIC's aspiration to morph successfully into an inclusive place-based innovation ecosystem would be largely contingent upon the extent of interactions among its KS actors.

4.4.3.5 Contrasting perspectives on KS' central academic actors' contribution to the KIC vision – a potential motivational factor for social and inclusive innovation

A further key but contrasting study finding in this regard was that, from their experience of having been based within KIC for a few years to date, KS' academic central actors expressed the need for engagement in joint planning on the part of all actors to shape a common agenda for KIC development. Viewed from the perspective of a THS conceptual framework and K-bRD theory, this empirical evidence indicated that KIC's Knowledge Space had by then reached the transitional stage from Implementation to Consolidation and Adjustment, as illustrated in Fig. 4.10 below. However, conflicting views remain as to who might be the most appropriate actor to initiate or lead in such engagements. One interviewee called for KIC's Knowledge Space actors to be granted the opportunity to participate in and share their empirical insights within a KIC development planning forum, rather than the government's views being unilaterally implemented unchallenged: *"I think now that there's more actors, we have more of a vision and more antennas on what's there and what's possible, rather than just a small number of people in the government who happened to be charged with overseeing*

this. And I think they do a good job, but you know, any small group of people will have a small view on what's going on” (Research Participant P_PS16, 2021). This statement importantly called into question the government’s capability or otherwise of managing such a complex ST&I flagship program as that of KIC, which in this author’s view merits exploring. In contrast, another interviewee took the view that KIC’s Knowledge Space actors should instead autonomously and jointly organise and implement any joint plans to move KIC further forward. Commenting about this issue, that same interviewee said: *“I’m sure it’s now up to us to actually put together those structures or put together those platforms that can help us talk more often [...] I feel like the government has done all they could. But I think that now it’s up to us to make use of this opportunity that we are here. How can we actually improve KIC?”* (Research Participant P_PS09, 2021). Inter-actor collaborations can more often than not do arise from such complementary or conflicting perspectives – even in strained times and with competing priorities – which can generate a favourable ecosystem environment. Such actors’ diverse insights may also elicit ‘motivation for social innovation’ (Mulgan, 2019, p. 135) and inclusivity, favouring the planning and development of and inclusive technological innovation, as alluded to earlier in this chapter.

Drawing on the findings presented and discussed earlier in this chapter, the following sub-section offers a critical analysis of the conceptual flaws in KIC’s planning and development trajectories, which could in part intrinsically contribute to the identified misalignment with KIC’s Knowledge Space actor interactions.

4.4.4 Gaps in THS’ conceptual framework – contextual issues

As recapitulated in Table 4.1 above, the implementation of KIC’s Knowledge Space physical infrastructure was largely funded by funding agencies, namely AfDB and WB, by way of soft loans to a GoR entity, constituting it a financial investment for development purposes rather than funding *per se*. Viewed through the lens of a balanced Triple Helix configuration, KIC’s Knowledge Space is represented in Fig. 4.7 below, where these funding agencies may be categorised as ‘hybrid organisations’ (Ranga and Etzkowitz, 2013), intended to finance or fund physical infrastructure for education and R&I. The Mastercard Foundation falls in this same category, with a focus on STEM capacity building through the Mastercard Foundation’s Scholars Program. The ‘hybrid organisations’ category also comprises foreign government

organisations responsible for international development that operate through bilateral cooperation agreements, such as Sida, which is spearheading the Sweden-UR PhD training program aimed at strengthening the research capacity of UR. Additionally, this study revealed that Rwanda's NCST had been funding R&I projects involving KIC's Knowledge Space actors, thus making Rwanda's Science Granting Council (SGC) part of the hybrid actors. Drawing from the above evidence, this author contends that, contrary to Ranga and Etzkowitz's (2013) conceptualisation of place-based THS frameworks in HICs, it is essential not to underestimate the central role played by 'hybrid actors' in putting in place the conditions to generate, disseminate, and use knowledge and innovation to develop innovation ecosystems in LIC contexts. This observation resonates with Mulgan's (2019) assertion that '[...] if something works in one place and one time, [it] does not imply that the same model will work in another place and another time'. He follows this statement by echoing other scholars in declaring that 'we make the circumstances dance by singing to them their own melody' (Mulgan, 2019, p. 135). Context absolutely matters. In response to the aforementioned conceptual gap in Ranga and Etzkowitz's (2013) THS framework, this author suggests that hybrid actor roles could be pragmatically achieved within a specific THS **'Funding/Financing Space'**. In the specific case of KIC's development, and as can be seen in Fig. 4.10 below, funding for infrastructure, R&I, and capacity building – mainly spearheaded by non-governmental hybrid actors – has prevailed and continues to do so across all four stages of KIC's development.

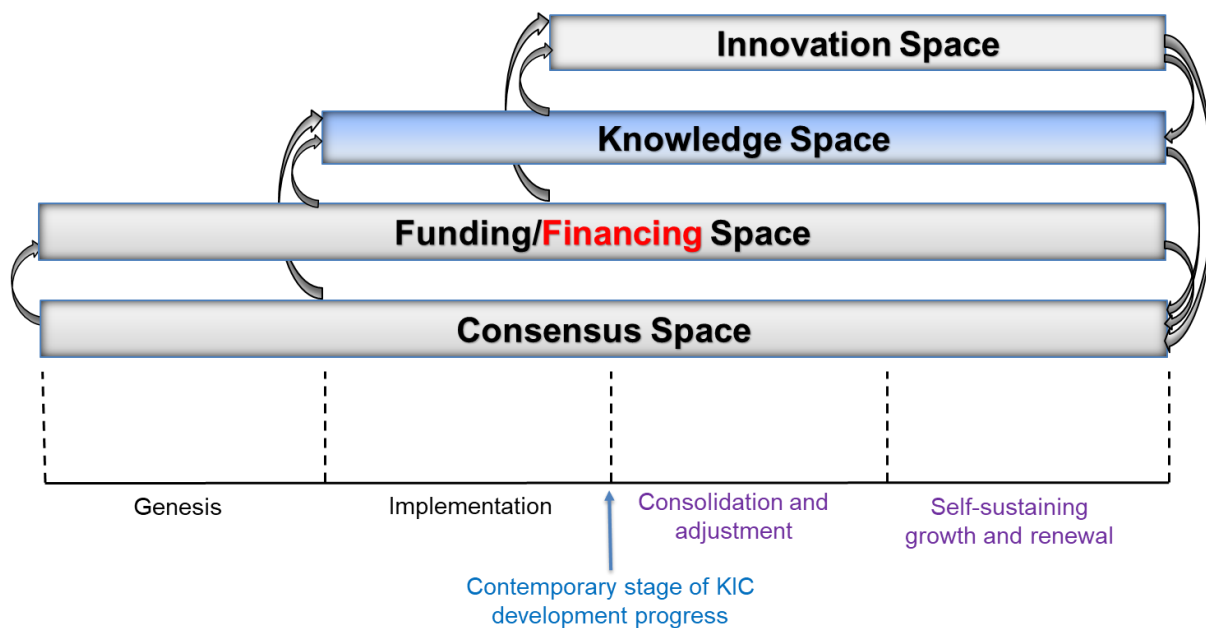


Figure 4.10. Kigali Innovation City's development prospects

Source: Author's compilation, based on Pilot research project interviews (2021), adapted from Ranga and Etzkowitz (2013)

Given the aforementioned role and influence of the hybrid actors on Rwanda's science and innovation system, particularly for R&I funding and ST&I capacity building, this author argues that the recognition and operationalisation of the Funding/Financing Space might serve as a starting point, in line with KIC's Knowledge Space actor interactions in R&I and learning, according to KIC's development agenda. As alluded to in the Introduction chapter of this thesis, KIC is geographically located at the interface of the urban and rural settings of the City of Kigali. The engagement of all actors, including KIC's Knowledge Space academic actors, local community, and industry in KIC's geographical proximity, as well as that of the government, might partly contribute to KIC's sustainable transition from the contemporary stage of Implementation to that of Consolidation and adjustment, as shown in Fig. 4.10 above. However, the investigation of these aspects lay beyond the scope of this research's pilot phase, and outside of the remit of the THS framework, hence the necessity of a post-pilot research. Chapter six of this thesis details the conceptualisation of this research in its post-pilot phase. The following section provides a summary of the chapter.

4.5 Chapter summary

This chapter focused on understanding actor interactions for RIL within KIC's Knowledge Space from a THS perspective, exploring three research questions: 1) *Who are KIC's Knowledge Space actors?*; 2) *How do KIC's Knowledge Space actors interact for RIL, and do these interactions influence the teaching and R&I among these Knowledge Space actors?*; 3) *Are these interactions related to KIC's regional (place-based) planning and development activities and if so, how?* Guided by this work's research methodology – as presented in chapter three of this thesis, and driven by these research questions, the empirical findings from the pilot phase of this research revealed several key insights: The study found that KIC's Knowledge Space academic actors possessed varied interactive capabilities underpinning the creation, dissemination, and use of R&I and learning. These interactive capabilities were initiated and/or influenced, or else were led either by the individual academic actors or other actors, notably the government, or governmental and hybrid actors. The results also indicated that intra-actor interactions were predominant among KIC's Knowledge Space academic actors in proximity and in STEM disciplines. This study thus attempted to propose an inter-disciplinary approach to intra-actor interactions while bridging the STEM – Non-STEM gaps.

Furthermore, in response to Research questions one and two, this study found that inter-actor interactions were also dominant among KIC's Knowledge Space academic actors, with KIC's Knowledge Space central actors being the least involved, whereas government and hybrid actors played leading roles in funding or financing R&I and capacity building. One of the significant implications of the interaction types identified was that both intra- and inter-actor collaboration amongst their respective personnel was primarily driven by students' research projects. This finding stressed the critical role played by graduate and postgraduate research students as key '*Knowledge and Innovation Brokers*' within KIC. This thesis proposed a revised THS conceptual framework incorporating a Funding Space (FS) to reflect the indispensable role of funding in the development of place-based innovation ecosystems in a LIC context. Portraying KIC's Knowledge Space as a social network, this study found that actor interactions may have stemmed from or been influenced by organisational innovative structures and processes including, *inter alia*, university-based innovation or

incubation centres or hubs, R&I funding and research capacity building programmes, collaborative R&I funding mechanisms, research conferences and seminars, and joint-supervision of Master's and PhD students. It was of particularly paramount importance to note that interactions for RIL may well have stemmed from individual researcher-driven initiatives within the organisations, which demonstrated the essential preconditions and potential for KIC to transition to a place-based innovation ecosystem. Further research was deemed necessary to examine the role of KIC's Knowledge Space university-based incubation centres in enabling (or not) KIC's transition from KS to IS as part of KIC's development prospect.

In the quest to respond to RQ3 of this research – regarding whether (or not) the identified interactions were related to KIC's planning and development activities – the study found no direct or explicit connection between KIC's Knowledge Space activities and KIC's development plans. The analysis of empirical data in response to this RQ suggested that part of the reasons for this phenomenon of disconnectedness included, on the one hand, a range of factors such as, *inter-alia*, strategic misalignments of individual organisations' agendas, lack of coherence and strategies and policy narratives, as well as scanty or non-existent awareness of KIC's development agenda across the KS actors – including individual researchers and senior administrators. On the other hand, the empirical evidence suggested that the disconnectedness identified between KIC's Knowledge Space actors and KIC's development strategy, and the imbalance of power dynamics for actor engagement in KIC's development drove KIC's Knowledge Space central academic actors into silos. This systemic phenomenon may have been attributable to the governance and coordination of KIC's development agenda having been highly centralised, which in part reflected Rwanda's mainstream state-led and top-down approach to ST&I policy and governance at national as well as at place-based regional levels. Moreover, the evidence uncovered in the pilot phase of this research and presented in this chapter thus highlighted the paramount importance for KIC's Knowledge Space academic actors – as primary producers of knowledge and human capital – to acquire entrepreneurial, developmental, and social networking and collaborative skills, and to apply these capabilities to enhance governance, and RIL, leading to an inclusive place-based innovation ecosystem in place-based LIC settings. Further study with more focus on interactions for RIL from the perspectives of other KIC's Knowledge Space actors – such as government, hybrid

actors, and adjacent industries and local communities – was therefore suggested in the post-pilot phase of this work (see details in chapter six of this thesis).

The next chapter presents and discusses how the COVID-19 pandemic affected KIC's Knowledge Space actor interactions for RIL.

Chapter 5. COVID-19 effect on KIC's Knowledge Space actor interactions for research, innovation and learning: A transition to a new era of collaboration?

5. 1 Introduction

The Introduction chapter of this thesis referred to this study as having been carried out amidst the COVID-19 pandemic. As presented in the Literature Review chapter of this thesis, as it did other sectors, the pandemic affected the way Rwanda's science and innovation systems in general – and its higher education system in particular – operated. Drawing on the empirical findings of this study, and as stipulated in the Methodology chapter of this thesis, this chapter presents and discusses the empirical findings on the impact of the COVID-19 pandemic on the interactions within and across KIC's Knowledge Space academic actors, in response to the fourth RQ of the pilot study phase of this research – *How did the COVID-19 pandemic influence KIC's Knowledge Space actor interactions in respect of RIL?* Drawing on research participants' insights, the chapter discusses the ways in which the COVID-19 pandemic affected – positively and/or negatively – KIC's Knowledge Space actor interactions relating to RIL. The discussion maps and examines the unprecedented interactive capabilities that were developed across KIC's Knowledge Space academic actors, and the conditions for such capabilities to prevail (or not) in the post-COVID pandemic era within KIC's region and beyond. Although this question may seem to lie outside the scope of the conceptual underpinnings of this study, this author argues that understanding the COVID-19-driven changes in dynamics and conditions of actor interactions for RIL, would generate an abundance of thoughts for the benefit of academic and policy purposes in the post-COVID-19 pandemic era.

5.2 Exploring the COVID-19 pandemic's effects on KIC's Knowledge Space actor interactions in respect of RIL

The first part of RQ4 aimed to explore the ways in which the COVID-19 pandemic had affected KIC's Knowledge Space academic actor interactions in respect of R&I and learning. The thematic analysis of the empirical data in response to this part of RQ4 revealed that the pandemic had had both negative and positive effects, as reported by the overwhelming majority of research participants, and presented in sub-sections 5.2.1 and 5.2.2 below.

5.2.1 Adverse effects of the COVID-19 pandemic

Fourteen interviewees responded that the COVID-19 pandemic had had adverse effects on interactions for RIL amongst KIC's Knowledge Space actors. Six interviewees reported that the pandemic had disrupted research activities, while six participants said that the pandemic had had a negative effect on learning and teaching delivery. Additionally, two interviewees attributed the pandemic to funding reductions and uncertainties.

On the subject of how COVID-19 had affected research activities, one interviewee from KIC's Knowledge Space academic actor in proximity stated that travel and contact restrictions during lockdown had hampered field work, thereby disrupting primary data collection, and thus slowing down the implementation of research projects. Commenting about this issue, the same interviewee said: *"People being in lockdown that would be very difficult for people to go in the field to collect data"* (Research Participant P_PS01, 2021). This view was echoed by another interviewee from another KIC's Knowledge Space academic actor in proximity who said that a number of ongoing research projects had been put on hold due to the travel restrictions. The same interviewee went on to say: *"For example in the project that I'm the Principal Investigator, I haven't started collecting data because there are restrictions with the movements, and so do some other colleagues"* (Research Participant P_PS07, 2021). Another interviewee from KIC's Knowledge Space academic actor in proximity alluded to the notion of lab-based research, stating that their organisation had run short of research equipment as researchers could not travel to buy the components for experimental activities during lockdown, forcing research to migrate to working remotely and doing experimental research by simulation. The same interviewee went on to reveal that researchers were less optimistic about changing their working habit from lab to home and from physical experimentations to simulation. Of interest here was another interviewee who echoed this pessimism with regard to doing research remotely and by simulation, being critical of research outputs that stemmed from this model of research. As the same interviewee said: *"(...) the publications which were done, they were not innovative publications because they were not practical oriented. It was not possible to buy components for lab-based*

research.” (Research Participant P_PS05, 2021). Another most striking finding emerging from the data was that the pandemic had exposed the limited access to adequate digital technologies for research amongst university researchers. Talking about this issue, one interviewee from KIC’s Knowledge Space academic actor in proximity said: “(...) *it [COVID-19] provided another opportunity to use technology in terms of data collection, but you can imagine that not all people are able to access those kinds of technological gadgets.*” (Research Participant P_PS01, 2021). Two of the six interviewees who talked about the detrimental impact of the pandemic on research reported that several academic collaborations were put on hold, with uncertainties about whether these collaborations would resume after the pandemic.

When discussing teaching and learning, six participants were unanimous in the view that the COVID-19 pandemic had caused major disruptions to education delivery, with universities being forced to close for the most part of the 2020 academic year. Commenting about this experience, one interviewee from KIC’s Knowledge Space academic actor in proximity reported that universities were closed for almost two-third of the academic year during the national lockdown between March and October 2020. The same participant went on to reveal that during lockdown, the university had to migrate from face-to-face to online teaching and learning mode using e-learning platforms, on a limited capacity as the university was not prepared for such a massive switch. Moreover, the same participant revealed that, unlike students from public universities, who benefited from government sponsorship to purchase laptops for learning and research, their students, who were privately sponsored were not prepared to embrace the shift to online mode of learning due to the lack of personal digital devices and/or couldn’t afford the cost of the internet bandwidth. Talking about this issue, the same participant said: “*Most of students in our private institution (...) sponsor themselves. So, it was difficult. Most of students don't have those laptops. Those who have laptops, they lacked capacity to buy internet bundles*” (Research Participant P_PS13, 2021). Many students and researchers did not have access to digital tools and (or) were unable to use them adequately.

Another interviewee representing another KIC’s Knowledge Space academic actor in proximity alluded to the notion of ‘behavioural change’, reporting that university students and teachers demonstrated slowness in changing their habit from in-person

to online teaching, learning, and working. Commenting on the changes brought about by the unexpected and lengthy university closure, another participant from KIC's Knowledge Space academic actor in proximity felt that staying off campus, neither teaching nor studying for almost the whole academic year, had driven students and academics into detrimental and uncertain conditions. This view was echoed by another interviewee from the same participating entity who felt that COVID-19 had affected students' mental and psychological health in many ways. Commenting on this issue from a public university management perspective, the same interviewee said: *"We have got this generation of young people now who missed the graduation. They have missed an entry point into university (...), and I think one of the real tragedies is the COVID-19 pandemic on young people is that it has not just put a hold on their lives but has actually set them back quite a long way."* (Research Participant P_PS15, 2021).

Talking about COVID-19's negative impact on research, innovation, and learning from a university finances perspective, one interviewee from KIC's Knowledge Space academic actor in proximity revealed that, as the main and largest public university, one of their primary sources of income was government scholarship payments for sponsored students. The same interviewee went on to reveal that these payments had been stopped during the university closure period. Despite this, and to avoid placing additional pressure on researchers and other staff, the university had borne the burden of continuing to pay staff salaries during the closure period. Another interviewee from KIC's Knowledge Space central academic actor reported that several R&I projects had been adversely affected due to external funding having been put on hold. Commenting on this, the same interviewee said: *"One of the things that has happened is many of our international sponsors have either slow down or paused or otherwise delayed the projects. And so that has impacted us."* (Research Participant P_PS15, 2021).

5.2.2 Positive effects of COVID-19 pandemic

The second theme that emerged from the analysis of participants' responses to RQ4 was the positive impacts of the COVID-19 pandemic on KIC's Knowledge Space actor R&I and learning-related interactions. The overwhelming majority of interviewees who commented on the positive impact of the pandemic referred to COVID-19 having

offered the opportunities for universities to leverage their information communication and technology (ICT) capabilities and tools to teach and learn and conduct research virtually. Talking about how the ICT facilities were instrumental in enabling KIC's Knowledge Space's academic actors to continue teaching and learning activities during the lockdown period, one interviewee from KIC'S KNOWLEDGE SPACE's academic actor in proximity said: *"I should say that we kept really teaching our Master's students despite the Covid pandemic."* (Research Participant P_PS02, 2021). This view was echoed by another interviewee representing another KIC's Knowledge Space's academic actor in proximity who said: *"Efficient ICT helped us overcome the challenges of teaching students. So, we taught online, and that was very helpful."* (Research Participant P_PS03, 2021). Another interviewee from KIC's Knowledge Space's academic actor in proximity stated that the COVID-19 pandemic had been an eye-opener for universities to leverage their ICT infrastructure to migrate to online teaching. Commenting on how universities in Rwanda in general, and those in KIC in particular had managed to switch to online education delivery despite being at different levels of ICT infrastructure readiness, one interviewee from KIC's Knowledge Space's academic actor in proximity revealed that universities and other education providers had benefited from a cost exemption offer from internet service providers. As the same interviewee said: *"We managed to get zero rating from the telecoms and I don't think that contribution by the telecom will last forever (...) We have had a lot of conversations around the world, as well as in Rwanda about access to technology and machines for students and academics."* (Research Participant P_PS15, 2021). The most striking aspect of the participants' answers about actors' responses to the COVID-19 pandemic from teaching delivery and learning perspectives was that KIC's Knowledge Space central academic actors were relatively the least severely affected among the higher education providers in the country. For instance, one interviewee from KIC's Knowledge Space central academic actor reported that the African Leadership University, Rwanda Campus (ALU-Rwanda) was already using e-learning teaching methods in pre-pandemic times, with online courses accounting for 70 % of their overall program. COVID 19 had therefore been of little consequence as they merely needed to switch the remaining 30 % of the tuition to online mode during lockdown periods. Another interviewee representing another KIC's Knowledge Space academic central actor revealed that Carnegie Mellon University in Africa (CMU-Africa) had made a swift transition from face-to-face to remote learning

mainly due to their robust pre-existing ICT infrastructure and intellectual capabilities in the field.

In discussing the positive impacts of the pandemic from an R&I perspective, a number of interviewees reported that during the university closure, most researchers – with no or reduced teaching duties due to the suspension of face-to-face classes – had embraced the lockdown period as an opportunity to write academic papers and compile research grant applications for research and associated publications. For example, as one interviewee from KIC's Knowledge Space's academic actor in proximity said: *"When it comes to writing papers, we have benefited because people were sitting at home, doing simulation, and we have made many papers. Even some grant [applications] were done during COVID because people were busy at home, reading and writing proposals"* (Research Participant P_PS04, 2021). This view was echoed by another participant representing KIC's Knowledge Space academic actor in proximity who reported that lockdown had been a great opportunity for researchers to increase their academic publication record. Talking about this phenomenon, the same interviewee said: *"People were working from home and they were not teaching, and they were staying home. They had time to write proposals and they also had time to publish."* (Research Participant P_PS05, 2021).

Another interviewee said that during lockdown, numerous academic staff and researchers from KIC's Knowledge Space had gained opportunities to participate in and access virtual knowledge exchange forums such as online international conferences and seminars, which would otherwise have been impossible under the pre-pandemic financial imperatives and travel requirements to attend such events in person. In addition, the same interviewee revealed that researchers had gained capabilities in organising scientific forums such as seminars while saving financial and time resources invested in such academic activities. Commenting about these experiences, the same interviewee from KIC's Knowledge Space academic actor in proximity said: *"Another positive story from COVID is that now people [have] learned how to organise research seminars online. People attended virtual conferences and organised virtual conferences. That's something that made [an] increasing number of people attend conferences, and also saved resources"*. (Research Participant P_PS12, 2021). When commenting on how the changes brought by the pandemic might shape the ways in which university research activities such as conferences and

seminars might be handled in the post-COVID world, the same interviewee anticipatedly said: *“...I think even in the future, in the new normal, we will be able to keep that momentum. I do not think that resources will still be a constraint factor for organising a conference as we have learned that virtual conferences can work.”* (Research Participant P_PS12, 2021).

A further significant, yet arguably peculiar, positive finding relating to the effects of the COVID-19 pandemic on KIC's Knowledge Space actor interactions in respect of R&I was the unprecedented engagement of the scientific realm in policymaking in the context of emergency. One respondent from KIC's Knowledge Space central academic actor asserted that Kigali's Collaborative Research Centre (KCRC) had played a key role in building Rwanda's capability to devise evidence-based policy interventions in response to the pandemic. According to the same interviewee, KCRC had been co-leading a substantial project on the subject alongside the Ministry of Education (MINEDUC) and other government agencies. Commenting about this role, the same interviewee assuredly said that: *“(...) we were trying to use some data analytics to give the government a better tool for sort of deciding what to do in terms of lockdowns and other measures [...] and what is the economic impact of these.”* (Research Participant P_PS15, 2021). This view was echoed by another interviewee from KIC's Knowledge Space's academic sector in proximity, who revealed that their university had provided expertise during the design and validation process of the Rwandan government's COVID-19 policies.

A few interviewees commented on how COVID-19 had sparked the untapped R&D-based innovation potential among KIC's Knowledge Space's academic actors. For example, several interviewees unanimously agreed that the local development of ventilators for COVID-19 patients had marked a significant example of the untapped R&D-based innovation capabilities that had emerged during times of emergency and desperate societal need. Talking about this innovation, one interviewee from KIC's Knowledge Space's academia actor in proximity said: *“COVID-19 was a mind-blowing opportunity leading to disruptive thinking for innovation and collaboration in response to contemporary societal need. [For example], emergency of development of ventilators for COVID-19, a collaboration between UR [University of Rwanda] and RP [Rwanda Polytechnic].”* (Research Participant P_PS06, 2021). The same participant, when asked how they had been able to afford to invest in such a complex and arguably

expensive technology as a ventilator, revealed that the research team had obtained a grant from Rwanda's Science Granting Council (SGC), with the National Council for Science and Technology (NCST). The same interviewee went on to report that researchers working on that innovation sourced technical advice and guidance from Rwanda FDA. This view was echoed by another participant from the same KIC's Knowledge Space's academic actor, who associated the multi-actor and trans-disciplinary collaborative development of low-cost ventilators by researchers in response to COVID-19, with the positive impact of the pandemic on R&I. Another complementary yet contrasting view from another interviewee representing another KIC's Knowledge Space's academic actor in proximity, suggested that the idea of developing ventilators had originated from an expert from the industry – the hospital, who had wanted to create a local ventilation system made in Rwanda, but had run short of funding to sustain the idea. Commenting about this issue, the same interviewee said: *"For the production of ventilators locally for COVID-19, the initiative was mainly led by people within the University, but there was a biomedical engineer from outside. He was actually a biomedical engineer at King Faisal Hospital."* (Research Participant P_PS15, 2021). Despite the above-mentioned researcher-driven innovation gaining deserved commendation, the same interviewee expressed concerns about the sustainability of such innovative and entrepreneurial ambition among researchers, engineers, and scientists within the incumbent university subsystem structure and practice.

When providing insights about the above ventilator project, the same interviewee thus went on to emphasise the imperative requirement for change in university policies for academic career development to stimulate and sustain such researcher-driven R&I initiatives. As the same interviewee said: *"While there was collaboration [for local ventilator development], there was very little that was provided to sustain it. I think people need incentives and part of the incentives are not only about finance, but also about academic progress. Academic careers, as well as really understanding the intellectual property aspects of innovation and entrepreneurship."* (Research Participant P_PS15, 2021). Speaking from the public university senior management perspective, the same interviewee went on to suggest that university policies should be adjusted to incentivise actors to engage in R&I activities with economic and (or) societal impact such as ventilators, but at the same time to disincentivise other aspects

of academic careers, which were always about publication. Commenting about this issue, the same participant said: *“(...) with research publication-obsessed actors and a university system where universities are ranked on [the basis of] their research output, we are always going to be fighting this battle between what true innovation and true entrepreneurship mean, and the needs of the ranking and rating systems’* (Research Participant P_PS15, 2021).

5.2.3 Insights into proposed support for researchers’ continued engagement in and interactions for RIL amidst the COVID-19 pandemic

The second part of RQ4 aimed to solicit research participants’ views and perspectives on what could (or should) be done by their respective organisations and (or) the government to support researchers and innovators in engaging and interacting for RIL amidst the COVID-19 pandemic. Three broad themes emerged from the analysis of the empirical data for this part of the questions: (i) strengthening ICT infrastructure and capabilities; (ii) reviewing research policies; and (iii) accrediting online programmes. Suggestions were directed to an individual organisation, ministry, and/or government. For example, commenting about ICT infrastructure, one interviewee from KIC’s Knowledge Space academic actor in proximity suggested that universities should improve and reinforce their e-learning platform capabilities, including providing high-speed internet. This view was echoed by another interviewee representing the same KIC’s Knowledge Space’s academic actor who claimed that online platforms for teaching, research, and virtual meetings required the availability of high-speed internet. Commenting on this issue, the same interviewee said: *“We need to have these platforms and have better Internet connection. Because I know some staff are struggling to get Internet connection, and even some places where we are, internet connection is not good”*. (Research Participant P_PS05, 2021). Another interviewee from KIC’s Knowledge Space academic actor in proximity suggested that universities should leverage programmes such as Rwanda Research and Education Network (RwedNet³¹) to strengthen ICT facilities, thereby enabling students and staff to gain access to teaching and learning resources. On the subject of research, one

³¹ RWedNet, as part of UbuntuNet, aims to enable universities and research entities in Rwanda to access affordable and efficient connectivity services.
<https://ubuntunet.net/category/members/rwednet/> [Accessed: 15.07.2024]

interviewee recommended that universities and research organisations should adjust policies to permit and facilitate researchers to use secondary data where possible while aiming to provide equally credible and relevant research output. Commenting on this issue, the same interviewee said: “*Instead of relying on primary data, you can also plan on using secondary data to achieve your research objectives.*” (Research Participant P_PS01, 2021). Another interviewee, representing a different KIC’s Knowledge Space academic actor in proximity, called on the relevant government ministries to draw on the experience of online education delivery during the COVID-19 pandemic to provide accreditation to online courses. The same interviewee went on to reveal that online courses are often not given equal weight compared to face-to-face courses by the higher education accreditation entities.

5.3 Discussion

The previous section of this chapter presented the findings of this research in relation to the analysis of empirical data in response to RQ4 of the pilot study phase of this research - *How has the COVID-19 pandemic influenced KIC Knowledge Space actor interactions in respect of RIL?* With KIC’s Knowledge Space academic actors constituting the prime sources of data and knowledge generation, the discussion of the findings in this chapter was primarily guided by a THS framework. A particular emphasis was placed on exploring how the COVID-19 pandemic had affected KIC’s Knowledge Space’ relationships such as *inter alia*, knowledge exchange, technology development/acquisition/transfer, collaborative leadership, substitution and networking. Moreover, the findings were also interrogated through the lens of an Innovation Ecosystems (IE) framework, particularly focusing on the agility and interdependence of actors, and the emergence of actors’ technological and interactive capabilities in the context of a social and economic crisis. Chapter two of this thesis, the Literature Review, provided details on the THS and IE conceptual frameworks and explained why these theoretical concepts were appropriate for guiding the discussion of the findings in this chapter. Drawing on the themes presented in the previous section, the findings are discussed in three themes: (i) Adverse effects of the COVID-19 pandemic; (ii) Positive effects of the COVID-19 pandemic; and (iii) Insights on proposed support for researchers’ continued engagement with and interactions for RIL amidst the COVID-19 pandemic.

5.3.1 The COVID-19 pandemic disrupted research, innovation, and learning, unveiling university silos, tech inefficiencies, and societal relevance

The first part of RQ4 was to explore the negative and positive effects of the COVID-19 pandemic on KIC's Knowledge Space academic actor interactions for RIL. As presented in the previous section of this chapter, under the theme of negative effects of the pandemic, this study found that during the lockdown period, R&I and learning activities were greatly disrupted. This was mainly due to a lack of adequate ICT infrastructure and limited knowledge of how to use digital tools among researchers and students. Additionally, laboratory-based research was adversely disrupted during the lockdown periods and related travel restrictions, with some of these analytical activities being carried out at home using simulation software, where possible. Another important finding was that field visit-dependent research for primary data collection was also disrupted, resulting in delays in obtaining findings, or even in some cases cancellations of the process. This finding was consistent with that of Daniels et al. (2022) who indicated the ways in which the COVID-19 pandemic had exposed the perpetual problem of inadequate research infrastructure and had exacerbated its impact on students, researchers, and society. A further most striking finding was the observation that, with a full operational ICT infrastructure in place, travel restrictions may reasonably have been expected to have morphed into opportunities for KIC's Knowledge Space researchers to capitalise on the availability of state-of-the-art technology to complete their data collection. However, contrary to expectation, this study found that some researchers were devoid of access to good internet, and there was uncertainty regarding the ability to conduct research remotely using digital technology, which in turn hampered or delayed a range of research elements including primary data collection.

Another interesting finding was that the response to the pandemic in education delivery was also hampered by a range of factors, including, *inter alia*, scarcity of ICT infrastructure for e-education delivery and the affordability of ICT equipment for students. These findings supported the evidence from a previous study by the WB which highlighted the contemporary ICT infrastructure and skills gap in Rwanda, with

only 21.8 % of Rwanda's population using the internet, while 76.5 % of Rwandans hold a mobile phone subscription³².

From the perspective of education delivery, particularly for KIC's Knowledge Space academic actors' private students without government sponsorship for ICT devices, these results aligned with an earlier study which indicated that COVID-19 further restricted access to ICT devices for disadvantaged students who needed them most for e-education (Ngamije and Yadufashije, 2020). This regrettable phenomenon likewise manifested elsewhere in several other developing countries. It was a sobering fact to establish that Rwanda's children from all levels of education lost a full academic year's learning partly because the government did not have the adequate capacity to provide e-education during the COVID-19 pandemic.

From the perspective of research, one salient negative effect of COVID-19 for research within KIC's Knowledge Space was that, with the exception of the few instances previously mentioned, nearly all respondents who reported having conducted research during lockdown, declared that the research subjects they were involved in were unrelated to the pandemic. The absence or paucity of engagement in pandemic-related academic research has in this author's view exacerbated academia's 'silos syndrome' (Twiringiyimana et al., 2021; Nyamaka et al., 2020). As in other parts of Africa, this once again raised the question posed by Kraemer-Mbula et al. (2020) as to what relevance university research excellence has to society – in particular in the context of a crisis and emergency situation where scientific evidence and advice is critical to inform policy.

As presented in chapter two of this thesis, the Literature Review, the COVID-19 pandemic and its healthcare, social, and economic impacts on Rwanda (Bizoza & Sibomana, 2020; Louis et al., 2020), and on other countries such as South Africa (Sekyere et al., 2020), brought to the fore the need to achieve significantly improved resilience in multiple dimensions in terms of ST&I capabilities and capacity for national systems. This resilience was arguably based on the premise that the COVID-19 pandemic had emerged following the Ebola outbreak in the East African region in

³²https://databank.worldbank.org/views/reports/reportwidget.aspx?Report_Name=CountryProfile&Id=b450fd57&tbar=y&dd=y&inf=n&zm=n&country=RWA, accessed 5 October 2021

2019. For instance, drawing on the Ebola experience, Rwanda's swift response to COVID-19 was largely driven by an agility in policy and practice preparedness and readiness for travel restrictions to mitigate and control the spread (Agbiboa, 2021), and for healthcare and mental health systems (Louis et al., 2022). Moreover, Rwanda's healthcare and socio-economic response to COVID-19 was partly contingent on the deployment of high-tech – including smart anti-epidemic robots and flying robots (drones) (Musanabaganwa et al., 2020), mobile technologies for communication and financial transactions, as well as 3D printing technologies for the manufacturing of essential tools locally such as face masks and face shields. This has hitherto resulted in a double helix of government-industry innovation, and intensive inter-ministerial coordination. Despite Rwanda's government's efforts in providing support for university students to access learning material remotely, through collaboration with industry for a zero-rate access to the internet, the majority of KIC's Knowledge Space academic actors and indeed other universities beyond KIC remained detached from the rest of those actors who were producing knowledge and innovation relevant to societal needs in response to the pandemic. The findings presented here suggest that the absence of universities at the centre of knowledge creation and innovation relevant to policy and practice in response to the COVID-19 pandemic meant that Rwanda's NIS was grounded in an external 'supply-push'-oriented market technology transfer through the double helix of government-industry interactions. This limited the learning process and opportunities for innovation (Saad *et al.*, 2008), making Rwanda's NIS resilience less likely. Drawing on the lessons learnt from this work, this thesis argues that a THS strategy of university-government-industry innovation in Rwanda is paramount if Rwanda is to cope with socio-economic dynamics of post-COVID-19 pandemic and any other health crisis requiring a multifaceted knowledge-based responses in the future. This argument concurs with a recent Academia-Industry collaboration research award of a public-funded grant, launched by Rwanda's NCST as part of the National Research and Innovation Fund (NRIF), demonstrating the policy shift towards a THS approach. Such governmental policy efforts will partly build confidence in local universities and research organisations in engaging with devising 'home-grown' technologies and innovations to transform academia and industry into a resilient national social and economic entity. It is nonetheless worth noting that the trends in inter-governmental ministries' and agencies' interactions and links with industry (including both local and trans-national

firms) amidst the COVID-19 pandemic, did contribute to the construction and strengthening processes of Rwanda's emerging NIS, particularly from the absorptive capacity front as Göransson & Yongabo, (2018) suggest. The lasting uncertainty around daily living as well as academic pursuits was reported as a further detrimental effect of the pandemic on R&I interactions for both students and staff. The literature suggests that UR, through its College of Medical and Health Sciences, launched a mental health service for the wellbeing of the university community amidst COVID-19 pandemic (UR, 2020b). Details of the nature of the wellbeing issues encountered such as uncertainties, whether financial, social, mental, or other were however not provided, and would require further investigation.

5.3.2 COVID-19 positives: exposing IT infrastructural capabilities and disparities, government-university trust, and emergence of unprecedented ST&I capabilities and funding opportunities for RIL activities

The second theme emerging from the first part of RQ4 was the positive elements of the COVID-19 pandemic for KIC's SK academic actor interactions for RIL. Under this theme, this study found that the pandemic had (i) exposed disparities in Rwanda's university ICT infrastructure capabilities, and (ii) influenced the emergence of unprecedented ST&I capabilities and funding opportunities.

On the unveiling of the disparities in ICT infrastructural capabilities, this study found that the impact of COVID-19 on teaching and learning had proved relatively less critical for KIC's Knowledge Space actors compared to other higher education providers in Rwanda. A possible explanation for this relative resilience on the part of KIC's Knowledge Space actors may partly be the advanced level of existing digital technology infrastructure and expertise within the relevant establishments, which greatly facilitated their transition from face-to-face to digital platforms. This study found that, following MINEDUC's advice to leverage the zero-rating cost for online educational material by telecom companies, major universities immediately switched to remote learning. For example, one KIC's Knowledge Space central academic actor, ALU-Rwanda, had already been deploying e-learning teaching methods before the COVID-19 pandemic, with 70 % of its overall program being delivered online. This pre-pandemic ICT infrastructural capability of ALU-Rwanda enabled the university to face few challenges when moving its remaining 30 % of material online. Another KIC's

Knowledge Space central academic actor, CMU-Africa, managed to transition to remote learning in less than a week following the announcement of countrywide lockdown (Stokes, 2020). Two KIC's Knowledge Space academic actors in proximity, namely, the University of Rwanda (UR) – the only public university, and Rwanda Polytechnic (RP) – the only public technical and vocational education and training (TVET) establishment, followed pace. This adaptability and agility of KIC's Knowledge Space academic actors to transition from face-to-face to an online mode of learning and teaching delivery exhibited the features of KIC as a place-based innovation ecosystem (Palmberg, 2009; Washbourne et al., 2021; Mugwagwa et al., 2021). While similar scenarios were largely reported in respect of all KIC's Knowledge Space actors, it was noticed that the rapid shift to online teaching and learning solutions (Stokes, 2020) had had a disproportionate impact on students' learning in Rwanda's university system. While most students attending KIC's Knowledge Space academic actors, which are public academic institutions, or those operating under a PPP model, were among those who enjoyed the benefit of government sponsorship (Chataway et al., 2019), including access to individual laptops, this research found that most students from private domestic research universities constituting KIC's Knowledge Space academic actors in proximity such as AUCA, University of Tourism, Technology and Business Studies (UTB) and ULK-Polytechnic, were unable to afford the costs of accessing online content despite the telecom companies making online education resources available to all education providers free of charge. Moreover, this study found that these local private universities were short of high-speed internet access in part due to inadequate ICT infrastructure. The degree of effectiveness of remote learning and the manner in which students and lecturers had been coping with this transition would require further empirical investigation in a separate study. The findings of this research suggested that a policy intervention by MINEDUC to extend the existing government support scheme of loaning laptops to government-sponsored university students to include those in private Rwandan universities and institutes may help to enable and maintain resilience and equity in ICT capabilities for learning in the post-COVID-19 university system in Rwanda.

Another thought-provoking finding was the unprecedented government reliance on and trust in KIC's Knowledge Space actors' expertise in producing reliable evidence for policymaking in response to the COVID-19 crisis, which in this author's view

unequivocally demonstrated Rwanda's Higher Education system's growing capabilities in producing relevant scientific evidence and advice for policy interventions to meet societal needs. The possible implication of this innovative government/academia collaborative interaction might be setting a powerful and lasting precedent for continued, closer, mutually beneficial partnerships between academic researchers and State policymakers across a range of different fields and areas of national as well as place-based development. It might furthermore promote and strengthen university research excellence, as discussed by Kraemer-Mbula et al. (2020). In this author's view, the adoption of such a constructive policy to further and nurture interactions between academia and government constitutes a game-changer in terms of addressing the persistent issues encountered in the policymaking process, which is perceived as 'top-down and ultimately state-driven, with limited consultations with concerned stakeholders', as expressed by Yongabo (2021b, p. 71) and UKaid (2020, p.13). These findings are consistent with Yongabo's (2021b) conclusions, who, from his empirical study of Rwanda's NIS, further emphasised that 'the use of international consultants with less knowledge of the Rwandan context is also seen as [one] among the factors that slow the [policy] implementation process, because most of the policies consider less the realities of the local context. They are formulated in a normative way based on what [has] succeeded in other countries that have made considerable progress in ST&I' (Yongabo, 2021b, p. 123). As mentioned in the Literature Review chapter, the functional substitution and collaborative capabilities between academia and government for knowledge and innovation creation, use, and dissemination reflect the features of a functioning THS (Ranga and Etzkowitz, 2013). In the present author's view and in agreement with the foregoing, a policy-making process underpinned by local, context-specific, scientific evidence is essential to achieving improved policy implementation, as largely vindicated by Rwanda's overall policy in response to the COVID-19 crisis. Whether this novel, only recently evidence-corroborated approach to public policymaking, will be sustained and upheld in a future post-COVID-pandemic era remains to be seen. What this Thesis, in contrast, considers in no doubt, is that this outcome will fundamentally determine the quality and success of growth, performance, and resilience of KIC's ecosystem and Rwanda's broader NIS. Of interest here is that this study found that, apart from the continued delivery of education through remote learning, the response to the COVID-19 pandemic from non-KIC universities in Rwanda remained almost entirely invisible. The

roles of these universities in the national and/or regional COVID-19 pandemic response within their respective geographical proximities would merit further empirical investigation.

Another most striking finding that stood out from the results presented earlier was that the pandemic had furthermore presented opportunities for intuitive researchers and engineers to exert their untapped potential, technical know-how, and expertise in response to the expanding and desperate societal needs. Together with other resources, the availability of funding for R&I to combat the COVID-19 crisis further contributed to stimulating actor interactions. As part of the GoR's rapid policy intervention, Rwanda's NCST made a specific call for R&I to address the pandemic, in response to which competitive grants were awarded to numerous KIC's Knowledge Space actors to support them in conducting researcher-led projects (Mugwagwa et al., 2020b). These were primarily focused on developing emergency products such as: wearable devices to monitor COVID-19 symptoms, developed by ACE in IoT, and low-cost ventilators, a collaboration of innovative researchers and practitioners from RP, UR, and King Faisal Hospital in Kigali, as summarised in Box 5.1 below.

Box 5.1. COVI-19 battery-powered ventilator development:

A University/Government-funded and engineer/researcher-driven collaboration

In a quest to help address the desperate need for medical equipment to treat COVID patients, home-grown biomedical engineers from Rwanda Polytechnic (RP) and the Integrated Polytechnic Regional College (IPRC-Kigali) ventured into the production of battery-powered ventilators. The aim was to produce two models of the device, including a portable ventilator that could be used in ambulances, and a fixed design for use in hospitals³³. In view of their own limited understanding of clinical and medical disciplines, IPRC-Kigali's engineers called upon the knowledge and expertise of clinical experts and medical professionals from UR to develop and test their mobile ventilator prototype. This engineer/researcher-driven collaboration and interactive learning to achieve innovation led to a ventilator prototype being submitted to Rwanda's FDA for review and advice regarding standardisation. The project was thus

³³ <https://www.rp.ac.rw/news-detail/iprc-kigali-biomedical-engineers-to-produce-ventilators>
[Accessed:22.09.2021]

awarded an R&I grant from NCST for a post-prototype product development program based on Rwanda's FDA input.

(Source: Research interviews in pilot phase, 2021).

Despite the above-mentioned researcher-driven innovations gaining deserved commendation, this research found that there were concerns among a few research participants about the sustainability of such innovative and entrepreneurial ambitions among researchers, engineers, and scientists within the incumbent university's subsystem structure and practice.

5.3.3 Insights into proposed support for researchers' continued engagement with and interactions for RIL and learning in post-COVID-19 pandemic KIC and Rwanda university system.

The second part of RQ4 in this study sought to acquire participants' insights on what could (or should) have been done by their respective organisations and (or) the government to support researchers and innovators in engaging and interacting with R&I and learning in the post COVID-19 era. In response to this particular question, three broad themes emerged from analysing the empirical data: (i) strengthening ICT's infrastructure and capabilities such as providing high-speed internet to run online platforms and tools for learning, teaching, administration, and research; (ii) reviewing research policies to encourage and support online research where and when possible; and (iii) reviewing the accreditation processes with the view to affording greater recognition of online or e-learning programs. In line with these three themes which participants perceived as potentially leading to greater engagement and interaction for RIL once addressed, previous sections of this chapter presented and analysed the newly acquired interactive capabilities among KIC's Knowledge Space academic actors, such as organising and running virtual conferences and seminars, and the sustainability of emerging researcher-driven innovations such as battery-powered ventilators. For these capabilities to strengthen existing and generate new interactions for RIL will, in the author's view, require appropriate national and organisational policies on the part of government and universities. This would be conditional for them to continue to flourish in the post-pandemic era. These findings support the argument advanced by Mugwagwa et al. (2020) who posited that 'doing science as unusual' is

paramount in the post-pandemic world. Moreover, the present study findings on the impact of COVID-19 on R&I within KIC's Knowledge Space in particular and in Rwanda in general were not far removed from what was being experienced elsewhere in the world. For instance, a conference on knowledge-sharing between research centres and government³⁴ revealed that throughout the pandemic, increasing instances of multi-/inter-disciplinary science and scientific advice, as well as of integration of these disciplines into policymaking in response to the pandemic, had emerged. This evidence implies that the pandemic highlighted new positives in relation to actor interactions for RIL development as discussed in section 5.2.2 above.

5.4 Chapter summary

The fourth RQ of this study presented in this chapter was '*How did the COVID-19 pandemic influence KIC's Knowledge Space actor interactions in respect of R&I and learning?*'. In response to this RQ, the empirical data findings were considered and discussed through the lens of Triple Helix Systems (THS) and Innovation Ecosystem (IE) frameworks. During the data analysis, three broad themes emerged: (i) adverse effects of the COVID-19 pandemic including disruption to R&I and learning, and unveiling of university silos, technology inefficiencies, and societal irrelevances; (ii) COVID-19 positives such as exposing IT infrastructural capabilities and disparities between KIC's Knowledge Space academic actors and the rest of the university system actors in the country, the unprecedented government/university trust through scientific and policy advice, and emergence of unprecedented ST&I capabilities and funding opportunities for RIL activities; and (iii) insights into proposed support for researchers' continued engagement and interactions with R&I and learning in post-COVID-19 pandemic KIC and Rwanda's university system. On the third theme, this study found that the following three factors, once addressed by relevant authorities, might spur greater academic engagement with R&I and learning in post-COVID-19 KIC and Rwanda's university system: (i) strengthening ICT infrastructure and capabilities such as high-speed internet to run online platforms and tools for learning, teaching, administration, and research; (ii) revising research policies to encourage and support online research where and when possible; and (iii) reviewing the accreditation

³⁴ <https://steppsociety.com/en/events/knowledge-brokering-between-research-and-governmen.html>
[Accessed:22.09.2021]

processes to afford greater recognition to online or e-learning programs. The COVID-19 pandemic primarily being a health crisis, it produced massively disruptive knock-on effects on the ways in which KIC's Knowledge Space academic actors interacted in respect of R&I and teaching. This study thus found that the lasting uncertainty around daily living as well as academic pursuits was reported as a further detrimental effect of the pandemic on R&I interactions for both students and staff. However, the depth and breadth of the nature of such uncertainties, whether financial, social, mental, or psychological were not widely discussed and thus warrant further investigation. Although this RQ4 may appear outside of scope of the conceptual underpinnings of this study, this author would argue that understanding the ways in which the COVID-19 pandemic influenced KIC's Knowledge Space actor interactions in respect of research, innovation, and learning, and the change in dynamics and conditions of the greater actor interactions for RIL, as presented and discussed in this chapter, offer food for thought in respect of the academic and policy purposes as the world transitions to a post-COVID-19 era.

The next chapter starts Part III of this thesis. It draws on both the conceptual and empirical gaps in the pilot phase of this research, as highlighted in the present and previous chapters, to develop an integrated analytical framework, paving the way towards and guiding the analysis of empirical data collected in the post-pilot phase of this research.

PART III. POST-PILOT STUDY PHASE EMPIRICS, FINAL CONCLUSIONS AND RECOMMENDATIONS

Chapter 6. Fostering actor interactions in a place-based innovation ecosystem – a context-specific and multi-staged Integrated Analytical Framework

6.1 Introduction

The initial chapters of this thesis, including the Introduction, and Literature Review, provided an analytical account of actor interactions in respect of research, innovation and learning (RIL), as a wicked policy and research problem, and as one of the main factors underpinning the perpetual failures of innovation policy, particularly in low-income country (LIC) contexts. By way of a recall, using Rwanda and Kigali Innovation City (KIC) as a case study, the main RQ for this work was threefold: *How do the academic and research organisations located in KIC interact with other science and innovation system actors for RIL? To what extent do these interactions contribute (or not) to KIC development? and What are the possible pathways towards fostering these interactions?* This triple main RQ was thus investigated in the pilot and post-pilot phases. Drawing on the aforementioned research aim, and as presented in chapters five and six of this thesis, the pilot phase of this work aimed to explore four research questions: 1) *Who are KIC's Knowledge Space actors?*; 2) *How do KIC's Knowledge Space actors interact for RIL, and do these interactions influence the RIL among these Knowledge Space actors?*; 3) *Are these interactions related to KIC's regional (place-based) planning and development activities and if so, how?*; 4) *How did the COVID-19 pandemic influence actor interactions in respect of RIL?* These questions, including RQ4 related to the COVID-19 pandemic, which was added based on contemporary circumstances, were fundamentally designed and explored based on the Triple Helix System (THS) of government, academia, and industry collaboration for innovation. Knowledge-based regional development theory was also deployed offering the most comprehensive lens through which to explore how actor interactions may have contributed (or not) to the development of KIC in response to RQ3. Moreover, the THS was complemented by Innovation Ecosystems (IE) framework that guided the investigation of RQ4. Drawing on the review of a range of systems theory-based conceptual frameworks, the THS was deemed the most appropriate lens through which to interrogate the state and extent of academic actor interactions with other actors in respect of RIL, as framed in the pilot research questions. However, the findings in the pilot phase revealed that the THS approach did not suffice to serve as

conceptual lens to fully explore the main aforementioned research objective. Based on these findings, this thesis contributes to the existing scholarship that questions whether conceptual frameworks developed in the global North – such as “ National Innovation Systems and Triple, Quadruple and Quintuple Helix models of innovation, which are routinely promoted for enhancing innovation in the Global South” (Jimenez et al., 2025, p.3) – are suitable for the Rwandan context.

6.2 Learning from the pilot phase – empirical and conceptual gaps, and the aim of this chapter

Chapters four and five of this thesis discussed the empirical findings from the pilot phase, that is, the insights pertaining to actor interactions in relation to RIL within KIC’s Knowledge Space. The pilot phase research revealed that Rwanda’s KIC, as a *national ST&I policy intervention in regional (or place-based) setting, aka* flagship programme, was conceptually designed with universities as the primary actors for its development. This main finding led to the scholarly assertion that the university system remained a central actor for human capital development, and with potential for knowledge and innovation generation, dissemination, and use in developing countries (Kruss and Visser, 2017; Kruss et al., 2021). Moreover, the central role played by THS hybrid actors in influencing and shaping the development of KIC into an innovation ecosystem – particularly through funding and capacity building – provided fresh insights into this research field. From a knowledge-based regional development (K-bRD) theory perspective, the pilot research found that KIC was transitioning from implementation to consolidation and adjustment stages of development as discussed in in chapter five). Notwithstanding these key findings, gaining a more in-depth understanding of the dynamics of KIC’s Knowledge Space actor interactions within the existing KIC’s Innovation Space, Consensus Space – and indeed the Funding Space actors – and their implications for KIC’s development, remained an essential subject for investigation that lay beyond the scope of the pilot phase of this research, while at the same time, the present doctoral thesis aimed to uncover these dimensions. Moreover, as presented in the Introduction chapter, this research viewed KIC as a complex, socially constructed phenomenon comprising a range of actors including central and local government, academia, industry, civil society, and community, all with different levels of power, interest, and capability to influence the creation, use and

dissemination of knowledge and innovation for KIC's development. Therefore, from a conceptual perspective, and given the contemporary development status of KIC and Rwanda innovation's [ST&I] policy context, which aimed to achieve knowledge-based economic growth, the research in the pilot phase revealed that a THS remained the most relevant analytical framework to understand academia's interactions with government, industry, and intermediary organisations (Ranga and Etzkowitz, 2013), as presented in empirical chapters four and five of this thesis. However, for the reasons outlined above, THS framework proved to be unsatisfactory for comprehensiveness in this research. The systemic, complex, socio-technical, and developmental issues and realities underpinning the geographical location of KIC reflects its dual features of being an ST&I policy flagship intervention and urban innovation initiative at the interface of urban and peri-urban settings, in a LIC context. Additionally, how KIC related to Rwanda's innovation policy landscape made it imperative to complement the THS framework with other context-specific analytical frameworks to guide the post-pilot research questions and related empirical data analysis. These theoretical concepts reviewed in chapter three of this thesis, included the National Innovation System (NIS) (Daniels et al., 2017; Datta et al., 2019; Twiringiyimana et al., 2021) and its derivatives, namely: the Regional Innovation System (RIS) (Doloreux and Parto, 2005); Sectoral Innovation System (SIS) (Reinstaller, 2003; Asheim, 2019); Innovation Ecosystem (IE) (Palmberg, 2009; Granstrand and Holgersson, 2020; Washbourne et al., 2021; Mugwagwa et al., 2021); Transformative Innovation Policy (TIP) (Schot and Steinmueller, 2018; Daniels et al., 2020; Daniels et al., 2022), Smart Specialisation Strategy (S3) (Dosso et al., 2020; Daniels et al., 2021); Dosso et al., 2022); Multi-level Perspectives (MLP) and Socio-Technical Systems (STS) (Geels, 2002) ; Knowledge System Innovation (KSI) (UKaid, 2020); Science Diplomacy (SD) (Ruffini, 2017); Political Economy (PE) (Byrne and Mbeva, 2017; Daniels, 2020; Paganelli, 2020), and the Urban Innovation (UI) (Bulkeley et al., 2019; Nilssen, 2019; Achieng et al., 2021).

6.3 Towards conceptualising actor interactions for research and innovation – a proposed new knowledge contribution to place-based innovation ecosystem development

This chapter drew on the characteristics of each of the theoretical frameworks discussed in the Literature Review, chapter two of this thesis, to provide a descriptive analysis of these frameworks inasmuch as they were deemed relevant to this work. Given the central role and relevance of actor interactions across all these theoretical concepts, and underpinned by a Critical Realist (CR) approach, this chapter drew on the analysis of the aforementioned frameworks to propose a context-specific, integrated, analytical framework. The analysis of these theoretical frameworks involved four steps, namely, (i) mapping of the theoretical dimensions from an actor interactions for RIL perspective; (ii) delineating the centrality of actor interactions for RIL within the innovation ecosystems architecture at micro-, meso-, and macro-scales; and (iii) investigating the contextual radices of individual theoretical frameworks to indicate the geographical context within which the concept was originally developed or deployed for empirical research; and lastly (iv) developing a multi-staged and context-specific integrated analytical framework for actor interactions for RIL. The newly developed conceptual framework was thus deployed to guide post-pilot Research questions. Moreover, the same framework was employed to analyse post-pilot empirical data as presented in the empirical chapters seven, eight, and nine of this thesis. The four steps of the conceptualisation of actor interactions are presented in the sub-sections below.

6.3.1 Theoretical framework mapping – an actor interactions perspective

Chapter two of this thesis provided an overview of the theoretical or conceptual frameworks that were thought to be relevant to this study. Despite their contextual idiosyncrasies and theoretical assumptions, the common feature of these frameworks was that they were all intrinsically attuned to actor interactions for global, regional, national and place-based innovation policy and development strategies. Taking a systemic perspective and drawing on Ranga and Etzkowitz's (2013) neo-functional approach to innovation – actors, functions, and interactions – , a descriptive analysis of these theoretical frameworks was carried out as illustrated in Table 6.1 below. For the purposes of this research, the analysis focused on nine dimensions, namely: (i) purpose or principal aim of the concept; (ii) key actors involved; (iii) central actor(s) leading and/or facilitating the innovation process; (iv) governance structure; (v) types of knowledge generated as a result of actor interactions; (vi) spatial dimension of the

concept; (vii) contextual radix³⁵ of the concept; (viii) contextual relationship with SSA³⁶ to understand how the concept had been applied to a developing country context; and finally (ix) research method (s) used to deploy the conceptual framework.

³⁵ Contextual radix: indicates geographical context where the concept was initially deployed for empirical research

³⁶ In relation to the contextual concept radix.

Table 6.1 Theoretical framework mapping – an actor interactions perspective

Theoretical/ Conceptual frameworks ³⁷	Aim/Principle	Actors	Central actor (s)	Governance and/or coordination structure	Type or mode of knowledge and innovation flow pathways	Spatial dimension	Contextual radix ³⁸	Contextual relationship with SSA ³⁹	Research methods
Knowledge-based Regional Development theory (K-bRG)	Study knowledge-based regional development in four linear phases: genesis, implementation, consolidation and adjustment, and self- sustaining growth and renewal	- Government - Academia - Industry	Government	Government- led	Economically useful knowledge	Place-based	HIC	Exogenous	Qualitative research
Triple Helix System (THS)	Investigate the nature, relationships, and functions of triple helix components (or actors) in their spheres (academia, industry, and government) for knowledge creation, dissemination and use, in a regional setting within the national science and innovation systems boundaries.	- Government - Academia - Industry - Hybrid actors	Academia	Government ⁴⁰ - led Participatory (through consensus space)	Economically useful knowledge	Place-based	HIC (USA)	Exogenous	Qualitative research (neo- institutional and neo-functional approaches) Case-study approach
National/Regional/Sectoral System of Innovation (NS/IRS/SSI)	Study innovation as 'an interactive learning process' amongst actors through DUI- and/or ST&I-modes of learning. Innovation can be studied on a national, regional, or sectoral scale.	- Government - Academia - Industry - Civil society, NGOs - End- users/consumers	Industry (firms)	Government/ Industry	Economically useful knowledge	National/Place- based	HIC (Europe)	Exogenous, reconceptualis ed and contextualised	Qualitative research Case-study

³⁷ Theoretical or conceptual frameworks: innovation policy approaches for place-based or national development

³⁸ Contextual radix: indicates geographical context where the concept was initially deployed for empirical research

³⁹ In relation to contextual concept radix

⁴⁰ Government: central or regional, or else local government

Theoretical/ Conceptual frameworks ³⁷	Aim/Principle	Actors	Central actor (s)	Governance and/or coordination structure	Type or mode of knowledge and innovation flow pathways	Spatial dimension	Contextual radix ³⁸	Contextual relationship with SSA ³⁹	Research methods
Knowledge System Innovation (KSI)	Support the mapping of interactions between the research system, the wider innovation ecosystem, and diverse development outcomes.	- Government - Academia - Industry - Civil society - Community (the poor)	Government	Government- through any of the four perspectives	Socially- relevant, environmentally meaningful, and economically useful knowledge depending on respective perspectives.	National	LIC (SSA)	Endogenous	Qualitative research, Case-study
Innovation Ecosystem (IE)	Study how actors interact and engage with each other to seize new opportunities, support innovation and strengthen the overall business environment for entities at different stages, sectors, and geographical locations. Identify new domains for innovation and market opportunities.	- Government - Academia - Industry - Civil society - NGOs - End-users/ consumers	Dependent on IE aim	Dependent on IE aim	Socially relevant, environmentally meaningful, and economically useful knowledge depending on respective perspectives.	Regional	HIC (Europe)	Exogenous	Qualitative research, Case-study approach
Smart Specialisation Strategy (S3)		- Government public administration - Industry - Academia - Civil society - Consumer groups (users)	Government	Government-led Participatory (through entrepreneurial discovery process)	Economically useful knowledge (mode-2)	Place-based	HIC (Europe)	Exogenous, contextualised	Case-study
Transformative Innovation Policy (TIP)	Mobilise innovation to address the societal and environmental challenges, leading to economic performance.	- Government - Industry - Academia - Civil society - Deprived communities	-	-	Socially relevant, environmentally meaningful, and economically useful knowledge, stemming from any of the actors, and taking any direction with the Sociotechnical system	National, and/or place-based	HIC and LIC	Exogenous and endogenous	Conceptual analyses
Political economy analysis (PEA)	Analysis the PE co-productive categorises of ideas, interests, and institutions, and how the	- Government - Industry - Academia - Civil society	Dependent on PEA aim	Dependent on PEA aim	Socially and economically relevant knowledge	International/Place-based/organisational	HIC	Exogenous, contextualised	Qualitative/Quantitative/Case-study

Theoretical/ Conceptual frameworks ³⁷	Aim/Principle	Actors	Central actor (s)	Governance and/or coordination structure	Type or mode of knowledge and innovation flow pathways	Spatial dimension	Contextual radix ³⁸	Contextual relationship with SSA ³⁸	Research methods
	influence (or not) interrelation between political and economic systems in a specific context.								
Multi-level Perspective (MLP) and Social-Technical Systems (STS)	Investigate the conditions for successful technology transitions (TT) to occur from niches (micro level) through to regimes (meso level) to landscapes (macro level).	- Industry - Government	Industry	Regional/local government	Legal, regulatory and techno- scientific knowledge	Organisational, place-based, national, and/or international.	-	Exogenous	Qualitative/Quantitative/Case-study
Science Diplomacy (SD)	Investigate the interconnectedness of science diplomacy, in all its three dimensions, with internationalisation of research.	- Government - Academia - Communities of practice (networks)	Government	Government through the ministry of foreign affairs	Knowledge flow through diplomatic/international cooperation and negotiations.	International, national	HIC	Exogenous	Case-study Qualitative
Urban Innovation (UI)	Deploy a spatial dimension to explore physical spaces providing proximity, enabling social interactions or access to key amenities or technologies.	- Government - Industry - Academia - Civil society - Communities (citizens)	Dependent on UI study aim	Dependent on PEA aim	Socially-relevant, environmentally meaningful, and economically useful knowledge, stemming from any of the actors, and responding (or not) to the needs, expectations, and values of urban - including citizens	Regional (urban)	HIC	Exogenous	Case-study Qualitative

Source: Author's compilation

6.3.2 Centrality of actor interactions for research and innovation

The descriptive analysis of the aims and objectives of the conceptual frameworks investigated in this research, revealed that actor interactions hold a central position in relation to the characteristics of these concepts. This is irrespective of whether (or not) individual framework scope focuses on a geographical or sectoral setting or else otherwise. As illustrated in Table 6.1 and Fig. 6.1 below and as presented in chapter two of this thesis, the analysed frameworks were deployed to investigate innovation policy from a systemic and/or sectoral perspective, and at regional (or place-based), national, and international levels. The analysis of system actors and their respective roles demonstrated that the government played a central role across a range of conceptual frameworks. While these concepts were developed for academic and policy purposes in a wide range of contexts, this thesis' author would argue that whether a public policy intervention attains (or not) its intended outcome is partly contingent upon the extent to which the government interacts with other actors who have a direct or indirect stake in that policy intervention. Notwithstanding the role of government as a central actor facilitating or leading onto interactions for RIL across most of the conceptual frameworks, the policy or academic implications of these frameworks might be determined by research design (Ramirez, 2021). Notwithstanding all other conditions, the identification of a central actor(s) that facilitates interactions with other actors might also be a function of the type of knowledge being sought to be generated. For instance, an economically useful knowledge is often generated through entrepreneurial universities through a THS perspective (M. Ranga and Etzkowitz, 2013; Kruss and Visser, 2017) or through industry in NIS (Nsanzumuhire and Groot, 2020; Yongabo and Göransson, 2020). Moreover, some socially relevant knowledge can be generated by developmental universities through inclusive NIS or KSI perspectives (Ramirez, 2021; UKaid, 2020). Interactions for both socially relevant and economically useful knowledge creation could also be facilitated by government entities such as science granting councils (SGCs). Fig. 6.1 illustrates a simplified presentation of the central role of actor interactions as recognised in a range of system-based theoretical or conceptual frameworks relevant to this research.



Figure 6.1. Centrality of actor interactions for RIL in selected conceptual frameworks
Source: Author's compilation

The distinctive features of KSI and TIP frameworks, with respect to their contextual relationship with SSA, are presented in sub-section 6.3.3. below.

6.3.3 Contextual radices of theoretical concepts and application to innovation policy research

'All that is conceptual elsewhere is empirical somewhere, and likewise, all that is global elsewhere is local somewhere' (Mugwagwa, UCL, 2022).

Abundant studies on innovation policy in developing countries, and particularly in SSA, often have associated perpetual innovation policy failure with a range of factors including whether the designs of policy interventions were based or not on any recognised concepts or were conceptualised based on concepts that had been empirically developed and tested elsewhere, usually within Euro- or HIC contexts. Hence, over the past few years, scholars in innovation policy in SSA have attempted to reconceptualise some of the mainstream analytical frameworks such as NIS to make them inclusive of SSA-specific dynamics, such as informal sector actors (Chataway et al., 2014) and non-governmental actors (Daniels, 2017). As part of

descriptive analyses of selected conceptual frameworks, this thesis attempted to identify which theories or concepts were endogenous, and which ones were exogenous to SSA. This study thus found that 11 out of 13 conceptual frameworks had been developed based on empirical data, values, and assumptions from social, economic, and political contexts outside SSA, and mainly in Europe as detailed in Table 6.1 above. KSI was the only endogenous concept to SSA (UKaid, 2020) as highlight in light blue in Fig. 6.1 above. TIP framework, highlighted in green in Fig. 6.1 above, represented a peculiar case, being both partly exogenous and endogenous. One the one hand, this concept was developed by a university based in the global North. One the other hand, unlike the previous frameworks such as NIS and THS, the research team that developed TIP framework included African researchers with technical expertise and contextual understanding of science and innovation system dynamics in SSA. TIP was advanced as the latest evolution of NIS, which does indeed possess some conceptual potential for studying a broad range of innovation policy issues, as well as for exploring related policy research questions across a range of environmental, economic, and social contexts. This framework has been critiqued for not resting on any empirical evidence (Diyamett, 2021).

The links between the various scientific concepts and contextual realities indicated above triggered the question: *why and how might it be helpful for [developing] countries to learn and adapt exogenous concepts developed elsewhere?* The Introduction chapter of this thesis made reference to the question as to how *Asian Tigers aka Tiger economies* of Eastern Asia (Hong Kong, Taiwan, Singapore, and South Korea) had leveraged NIS, as an exogenous Euro-centric concept, to inform their ST&I policies and hence led to rapid and major economic growth over the second half of last century (Kim, 1998; Khondker, 2021; Stockton and Yeh, 2022). Abundant studies associated Asian Tigers' fast and major economic transformation with a range of factors including 'developmental state' and public policies aimed at 'rapid industrialisation' (Toma, 2019), policy alignment – linking innovation policies and strategies with overarching government development agendas, and adequate actor interactions for innovation and technology development enabling absorptive capacity (Wonglimpiyarat, 2011). Moreover, NIS intermediaries, *aka* hybrid actors from a THS perspective, were thought to have played a central role in facilitating the acquisition of imported technologies to strengthen local capabilities (Chen et al., 2015). Earlier

studies suggested that, unlike in high-income countries (HICs), Asian Tigers' economic growth had demonstrated proven compatibility with improved quality of health amongst the population (Siddiqi and Hertzman, 2001) and income equality (Fontana and Srivastava, 2009). Learning from the success of Asian Tigers, the emerging economies of BRICS (Brazil, Russia, India, China, and South Africa) are seeking to follow pace by adopting public policies that enable innovation for inclusive and transformative development (Daniels et al., 2017b; Iqbal, 2022). BRICS' recognition of the role of civil society in the ST&I policymaking process is thought to be paramount if economic growth in these countries is align with key societal challenges in the global South, such as reducing poverty and unemployment, addressing gender and income inequality, and improving health and education systems (Sarkar, 2014).

Drawing on Asian Tigers' success and BRICS' potential, this thesis' author argues that an exogenous analytical framework might be adapted to inform ST&I policy in SSA through two approaches: (i) using them [exogenous frameworks] as constructs to understand and (or) measure the performance of science and innovation (eco)systems and policies in response to international metrics and standards such as OECD' indicators on Innovation and R&D performances; and (ii) Interrogating the concepts with empirical and context-driven data from SSA, adjusting or integrating them, or else creating new ones depending on SSA contextual imperatives as continental, countries, and regional levels. By adopting these approaches to innovation policies, SSA countries could arguably leverage the successes registered by Asian Tigers and BRICS and draw lessons from these countries to form coherent and functional science and innovation (eco) systems. This thesis partly aimed at contributing knowledge to this policy problem, as presented in sub-sections below.

6.4 Towards conceptualising actor interactions for research and innovation in an ecosystem

In the quest to respond to this research objective, a critical realist approach did not only guide the methodological approach, but it also underpinned the conceptual perspective. As such, this work sought to conceptualise actor interactions as a capability, in response to this being one of the core causes of perpetual innovation policy failure in a developing country context (Kruss and Visser, 2017), and in Rwanda

in particular (Yongabo and Göransson, 2020; Nsanzumuhire et al., 2021; Twiringiyimana et al., 2021). It is thus hoped that, additionally to responding to this main study question, the proposed multi-staged integrated analytical or conceptual framework would serve as a rigorous tool to generate empirically based and contextually grounded evidence for policymaking and scientific enquiries. For the purposes of this research, and as highlighted in the empirical chapters, the framework in Fig. 6.2 below was deployed to explore the creation and development of a knowledge-based innovation ecosystem on a regional scale, *aka* in this research at micro- and meso-level, and across all THS spheres – academia, industry, government, and hybrid. Given the importance and complexity of actor interactions in policymaking and governance processes, the same framework may well prove adaptable and deployable when exploring place-based innovation ecosystems at micro-, meso-, and macro levels, and/or within each of the THS spheres aforementioned.

Research stage and purpose	Stage-1: Actors and interaction mapping	Stage-2: Delineating conditions for actors' interactions	Stage-3: Exploring pathways for actor interaction fostering
[Policy] research question	<i>Who are the actors and how do they interact for R&I?</i>	<i>Why would actors need (or not) to interact?</i>	<i>What possible pathways to foster actor interactions, and how might these interactions enable (or hinder) change at micro-, meso-, and macro- levels?</i>
Areas of analysis	- Types of actors - Nature and types of interactions	- Social proximity - Geographical proximity - Cognitive proximity - Organisational/regional/national policies and strategies	- Organisational/regional/national/international policy (mis-)alignment - National/regional/sectoral funding mechanisms for R&I - Skills development, technology flows, and knowledge exchange programmes - Physical and social infrastructure development
Analytical lenses	IE, KSI, MLS-STs, NSI, PE, RIS, S3, SSI, THS, UI	IE, KSI, PE, S3, TIP, UI	KSI, MLS-STs, SD, TIP
Research methods	Qualitative/Quantitative/Mixed-method	Qualitative	Qualitative

Figure 6.2. Multi-staged integrated analytical framework for actor interactions for research and innovation in an innovation ecosystem setting

Source: Author's design

As indicated in Fig. 6.2 above, the process of actor interactions for RIL study appears to be carried out in a logical and linear manner across three stages. The starting point or stage might be contingent on a range of factors including whether (or not) an innovation ecosystem being studied is at its embryonic, emerging, or advanced stage of development. Also, a range of conceptual or theoretical lenses could be deployed concurrently in response to the specific policy or scholarship RQ being explored,

taking into consideration the political, social, and economic contexts of the system in which the study is being carried out. While a particular RQ regarding a particular facet of a multifaceted complex policy problem might be framed distinctively through the most relevant lens and viewed through a mono-disciplinary perspective in a particular knowledge system, the meaningfulness of such a question would ultimately influence (and be influenced by) other specific questions targeting other facets of the same problem, hence resulting in integrated knowledge creation. Contemporary epistemic efforts to re-conceptualise existing frameworks to accommodate specific elements of an innovation ecosystem, such as the inclusivity of more actors in mainstream NIS (Daniels et al., 2017b; Kruss and Gastrow, 2017) or of adding a Funding Space (FS) as a dimension to contextualise THS (see chapter four of this thesis), have failed to provide a compelling option to address or mitigate the perpetual innovation policy underperformance from an actor interaction perspective in developing countries (see details in chapter one of this thesis). Such a holistic framework as in Fig. 6.2 above, draws on contemporary epistemological efforts of re-conceptualising individual frameworks, to provide for the integration of multiple knowledge bases in a logical manner within an innovation ecosystem setting. This is essentially in part what this research has endeavoured to contribute knowledge to the realm of scholarly and policy research. By way of a recall, and as mainly presented in the introductory and methodology chapters of this thesis, this research problem was presented as a multifaceted, complex, that is, wicked policy problem requiring a rounded approach to knowledge creation, significantly implicating a range of disciplines, sectors, and involving a broad range of actors with a range of varied skills-sets, expertise, and experience. Moreover, the dual nature of the case study, namely, KIC being at the same time an ST&I policy intervention, and an urban innovation initiative, made the study more complex, hence the work required a two-phased methodological approach: pilot- and post-pilot phases. Drawing on the pilot phase findings – presented in chapters five and six above, the newly developed analytical framework was employed to guide the post-pilot research design as depicted in the sub-section below.

6.5 New concept deployment for the post-pilot research phase

The pilot study phase of this work provided insights into to actor interactions in relation to RIL within KIC's Knowledge Space as this ecosystem was transitioning from the

implementation to the consolidation and adjustment stages of its development (see details in chapter four). However, gaining a deeper and more detailed understanding of the dynamics of actor interactions – within the existing KIC’s Innovation Space and KIC’s Consensus Space, and the proposed KIC’s Funding Space, and their implications for KIC development - remained an essential subject for investigation beyond the scope of the pilot study and outside of the THS remit. Drawing on the review of a range of theoretical frameworks, this research made the case for why it became imperative to deploy multiple lenses to approach this study’s main RQ fully. The newly developed integrated framework in Fig. 6.2 above, was thus deployed to guide the framing of post-pilot research questions and to analyse post-pilot research empirical data and related findings. Three research questions were thus explored:

5. *How do KIC’s Knowledge Space academic actors interact with industry for RIL?*
6. *What is the role of government agencies including foreign offices in supporting the development of KIC into a knowledge and innovation ecosystem?*
7. *What specific characteristics define Kigali Innovation City as an urban smart city initiative, and to what extent do Kigali Innovation City Knowledge Space actors interact with adjacent communities in their geographical setting?*

As described in the methodology chapter and as presented in this chapter, these research questions were mainly designed on the basis of the empirical and conceptual gaps identified from the pilot-study phase of this work. With these research questions embodying multiple realms of knowledge systems, their design was thus guided by the newly proposed context-specific and multi-phased conceptual framework in Fig. 6.2. The detailed RQ checklist – showing the main research, related research questions, and corresponding analytical lenses – are presented in Appendix_3.6. Table 6.2 below illustrates the critical analysis of post-pilot research questions through the multi-staged integrated conceptual framework lens.

Table 6.2. Analysis of post-pilot research questions considered through a multi-staged integrated conceptual framework lens

Analytical lens	Total occurrence in research questions	Occurrence in RQ5		Occurrence in RQ6		Occurrence in RQ7		Research questions through integrated framework lens in Fig.7.2
		Main Question	Sub-questions	Main Question	Sub-questions	Main Question	Sub-questions	
IE	6	0	3	0	2	0	1	Stage-1
KSI	3	0	0	1	0	0	2	Stage-2
MLS & STS	2	0	0	0	0	0	2	Stage-2
PE	10	0	2	0	6	0	2	Stage-3
S3	8	0	2	0	5	0	1	Stage-2
SD	3	0	0	0	3	0	0	Stage-2
THS	1	1	1	0	0	0	0	Stage-3
TIP	1	0	0	0	0	0	1	Stage-1
UI	8	0	0	0	0	1	7	Stage-2

Source: Author's compilation

Table 6.2 above sheds light on the extent to which this study's research questions, highlighted in yellow, and corresponding sub-questions, highlighted in grey, were deeply embedded in diverse conceptual frameworks. For instance, RQ5 "*How do KIC's Knowledge Space academic actors interact with industry for RIL?*" was designed based on THS, its sub-questions encompassed features of various frameworks, including IE, PE, and S3. This approach aimed to empirically unpack the complexity of actor interactions for RIL within a contextually grounded case study.

6.6 Chapter summary

This chapter presented the conceptual aspects of this research as it expanded – in scope and scale – from the pilot research phase onwards. Viewing KIC as a complex socially constructed phenomenon comprising a range of actors (government – central and local – academia, industry, civil society, and community) with different levels of power, interests, capabilities, and capacity to influence the creation, use, and dissemination of knowledge and innovation for KIC development, and based on the empirical and conceptual gaps identified in pilot research phase, the post-pilot research took a dual-conceptual approach to KIC: *KIC as an ST&I policy flagship intervention* – a science and innovation system perspective as was the case for the

pilot study phase, and *KIC as an urban smart city initiative* – an urban innovation perspective. While both perspectives were distinctive, they were complementary to each another as described in the Methodology chapter (see details in chapter three). A context-specific and multi-stage integrated analytical framework in Fig. 6.2 was thus developed, guided by CR's epistemological foundations and ontological assumptions. The newly developed framework was thus deployed to guide the post-pilot research design to fulfil the post-pilot research aim of developing an in-depth understanding of KIC's Knowledge Space actor interactions with other actors and of exploring different pathways towards creating new or fostering existing interactions for RIL, for KIC's development of an inclusive place-based innovation ecosystem in a regional setting. This chapter provides a detailed descriptive analysis of why and how the integrated conceptual framework came about.

The post-pilot phase research findings – emanating from the Research questions and integrated conceptual framework presented in this chapter - are presented in the empirical chapters eight to eleven of this thesis.

Chapter 7. KIC's transition from knowledge space to innovation space: Exploring policy options beyond supporting university-based innovation incubation centres

7.1 Introduction

The first empirical chapter of this thesis, chapter five, presented university-based innovation incubation centres³⁷ as one of the main entrepreneurial features and interactive capabilities of KIC's Knowledge Space academic actors. Drawing on the findings from the pilot phase of this study, and using Triple Helix Systems (THS) and Knowledge-based Regional Development (Kb-RD) theory, this thesis argued in chapter five that identified university-based innovation incubation centres constituted the potential for KIC to expand from a contemporary KS to an Innovation Space as the place-based innovation ecosystem transitioned to the consolidation and adjustment phase of its development. In response to RQ5 – *How do KIC's Knowledge Space academic actors interact with industry and other actors for RIL?* – and using Kb-RD theory and an integrated analytical framework lens as outlined in the preceding chapter (chapter six), this chapter unpacks KIC's Knowledge Space university-based innovation incubation centres at functional, organisational, and institutional levels. Moreover, in response to part of RQ6 – *What is the role of government agencies and other actors in supporting the development of KIC into a knowledge-based innovation ecosystem?* – this chapter interrogates the role of the university-based innovation incubation centres as a policy innovation pathway. Moreover, this chapter explores other policy innovation options for KIC to transition from KS to IS. Drawing on Adu's (2019) descriptively and interpretatively-focused approaches to the thematic analysis of empirical data addressing the aforementioned RQ5 and RQ6, the findings presented in this chapter are organised in four themes: (i) Describing the structural and funding models of university-based innovation or (incubation) centres, (ii) Identifying university-based innovation centres' approaches to interactions, (iii) Supporting university-based innovation incubation centres' potentials and pitfalls, and (iv) Assessing the relationships of innovation centre programs with KIC's development,

³⁷ The concept of Innovation Incubation Centre is used interchangeably in this thesis with other similar terms such as Business Incubation Centres and Innovation Hubs. These concepts are used interchangeably in the context of the Rwandan innovation system.

addressing RQ5, and one theme: (v) Exploring further policy options for KIC's transition to an Innovation Space, addressing RQ6. Guided by an integrated analytical framework, key findings are interrogated in the penultimate section, with the last section giving a summary of the chapter.

7.2 Describing university-based innovation incubation centres' structural and funding models

Fig. 7.1 below provides an overview of demographical information about five research participants, whose anonymised identifications are P_PPS01, P_PPS02, P_PPS03, P_PPS06, and P_PPS13. These participants contributed insights and perspectives with significant information addressing RQ5 under this theme. It is worth noting that only two out of the seven participant demographic data, namely, organizational type, and gender, are presented in this chapter, and indeed the other empirical chapters eight, and nine. This is mainly for illustration purposes, linking the demographics maps in the figures with corresponding narratives. The process of participant identification anonymisation, and details of demographics were provided in chapter three of this thesis - Research methodology.

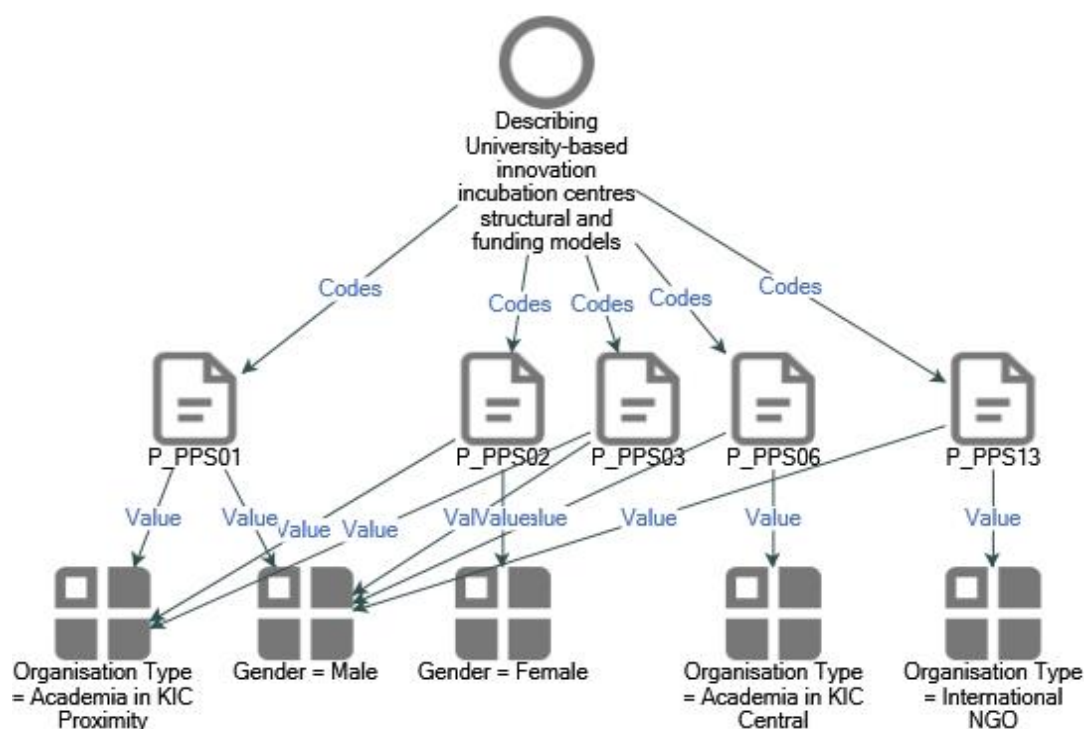


Figure 7.1. Mapping of participant demographics for theme 7.2

Source: Author's design with NVivo based on empirical data

Drawing on participants' insights under this theme, the features of KIC's Knowledge Space academic actors or university-based innovation incubation centres are presented below based on their respective organisational architectures, governance, and funding models.

7.2.1 Organisational models of university-based innovation incubation centres

When discussing whether (or not) respective organisations possessed innovation incubation centres and whether (or not) these centres were embedded within the organisational structures several participants reported that several central and in proximity KIC's Knowledge Space academic actors possessed innovation incubation centres, and that these centres varied in their missions or purposes, and the ways in which they were governed and staffed.

For instance, research participant P_PPS06 from KIC's Knowledge Space's central actor stated that Industry Innovation Lab (IIL) was an innovation incubation centre being created at CMU-Africa. Modelled according to and working very closely with the Swartz Centre for Entrepreneurship in CMU's main campus in Pittsburgh in the United States of America, IIL's main goal was to speed up the entrepreneurship process, for technological innovation and job creation, emanating from research and innovation projects from CMU-Africa students and graduates. As the same participant put it: *"CMU-Africa has a number of project-related courses, and therefore some of the students become candidates for joining IIL upon completion of those projects"* (Research Participant P_PPS06, 2022). This view was echoed by another participant, P_PPS13 from an international NGO operating in technological sectors, who indicated that the relationship being established between his current organisation and CMU-Africa was based on his previous and current experience and connection with IIL. In addition to CMU-Africa students and graduates, IIL was open to other entrepreneurs and innovators from Rwanda and across the African continent, with the purpose of making IIL an inclusive, robust, and cohesive organisation. Inasmuch as IIL emulated the Swartz Centre for Entrepreneurship, which was co-located in same innovation ecosystem as CMU main campus in Pittsburgh, USA, Research Participant P_PPS06 highlighted one fundamental difference between the two centres based on how they were each strategically positioned within their respective innovation ecosystems. Commenting on this issue, the participant said: *"Here what the Swartz Centre [for*

Entrepreneurship] has done is really it provided physical space, lot of mentors, you know the magic of being there in that ecosystem physically helps, and then a year later or whatever, people grow and get on their own office space, sometimes more out of the region as well, which is not a preferred outcome for Pittsburgh definitely. But for Kigali, again, one of the goals of CMU-Africa is to have impact across the continent. So, after some incubation, as they are growing, if they end up moving into Lagos, or one of the larger cities there, that might be okay... But again, this needs to be done systematically” (Research Participant P_PPS06, 2022). Notwithstanding this variation in the missions of CMU innovation incubation centres, the participant went on to recall that ‘the goals [of IIL] are really profitable technology, entrepreneurship, but also keeping impact in mind, job creation and so on, in the region and in the continent’ (Research Participant P_PPS06). This view was echoed and expanded by another participant who stressed IIL’s inclusive support for young innovators and entrepreneurs, saying that: “IIL supports startup businesses that are developing and commercialising technology-enabled products. It addresses really well-defined market opportunities with potential for profitability inclusively. It actually runs a 12-month business incubation programme exclusively focused on helping smart African students within the campus, graduates, but also alumni who can actually be willing to come up with some business ideas, in order to succeed, to help them succeed with their entrepreneurial ventures” (Research Participant P_PPS13, 2023).

Commenting on the innovation incubation centre hosted by the African Centre of Excellence in Energy and Sustainable Development, located in the University of Rwanda College of Science and Technology, Research participant P_PPS03 said that Grid Innovation and Incubation Hub (GIH), aka ‘research translation hub’, aimed to translate research into innovative solutions through entrepreneurship. Besides UR students and graduates, GIH also welcomed incubates from the business sector, making it open to non-academic actors. From governance and functional points of view, the innovation centre was managed by an appointed expert, a lecturer from UR College of Business and Economics, with expertise and a background in entrepreneurship and commercialisation. The centre manager was supported by a product manager, with the team’s main role being to manage the incubator selection process and coaching. On successful completion of coaching, beneficiaries from innovation incubation centres were provided with ‘seed funding’ by the ACE in Energy

and Sustainable Development to develop their prototypes. Commenting on the embeddedness of the innovation incubation centre within the university's institutional and organisational framework, the participant thought that *"...it is actually partly the importance of having a need [for the centre] to be established at University of Rwanda, to be an entity that is embedded, not an island. So, as we are doing the same for the Centre for Energy itself, we also assist, we are also there to support the innovation hub to do their job"* (Research Participant P_PPS03, 2022).

Unlike the UR ACE-based innovation incubation centres such as GIIH, which are mainly technological innovation-oriented, University of Rwanda's institutional framework comprises a Centre for Innovation and Entrepreneurship which is centrally located at the University's headquarters with the mandate to coordinate, support, and facilitate technological and non-technological innovation and entrepreneurship activities across University of Rwanda's colleges. Commenting about the role of UR-CIE, participant P_PPS02 indicated that UR Centre for Innovation and Entrepreneurship's scope included interacting with social enterprises across the country. Although the UR's contemporary functional structure did not include any innovation incubation centres at college level, this study found that the UR colleges were embedding entrepreneurial innovation approaches in the way they delivered education and research in their respective academic specialisms. For instance, talking about innovation incubation at UR College of Arts and Social Sciences, participant P_PPS02 stated that the University was collaborating with one local social enterprise to support first-year students' integration into the university ecosystem environment. As participant P_PPS02 put it: *"The firm helps students in the university right from the beginning to support them in getting into university system, thinking about their projects, working on projects, and maturing the projects as they go along in order to be part of the university ecosystem, to be entrepreneurs, future entrepreneurs and to be their own bosses. Also, in line with that, there is a similar interaction with staff"* (Research Participant P_PPS02, 2022).

Commenting about the state of innovation incubation centres at Rwanda Polytechnic (RP), one of KIC's Knowledge Space academic actors in proximity, participant P_PPS01, reported that RP comprised eight colleges, with innovation centres, *aka* business incubation centres forming part of the organisational structure for each college. At the time this study was conducted, RP had four functional innovation

incubation centres across four colleges, *aka* Integrated Polytechnic Regional Centres (IPRCs), namely: IPRC Kigali, IPRC Tumba, IPRC Musanze, and IPRC Huye. On the subject of the aim of innovation incubation centres at PR, participant P_PPS01 said: *“The purpose of these innovation centres or incubation centres, we call them either way, is to facilitate our researchers, mainly our graduates, to be able to present their early stage innovative ideas and to get guidance where different researchers or innovators can nurture them – be it academic or the other people from industries”* (Research Participant P_PPS01, 2022). The participant went on to indicate that the centres also provided financial and/or technical support for RP graduates and staff to be able to realise their innovative ideas with the potential to be transferred to the relevant industry for implementation. Moreover, the participant highlighted that the overarching goal in embedding innovation incubation centres within RP was to facilitate the process of students, graduates, and staff translating their innovative ideas into technological products or processes, and nurture them until they reached their final stages of development. Commenting about staffing issues, the participant said that innovation incubation centre staff were either internally recruited or identified by experts through the technical support offered by international development partners. The participant went on to suggest that for the colleges devoid of an innovation incubation centre by the time this research was conducted, this may have been due to lack of funding. Nonetheless, the participant felt that it was anticipated that those centres would be equipped and staffed, ready to run in the next one or two years.

7.2.2 Funding modes for university-based innovation incubation centres

When asked about the funding methods for university-based innovation incubation centres, several participants indicated that there were variations in the ways the centres were funded. For example, one participant from KIC's Knowledge Space central academic actor indicated that IIL was co-funded by CMU-Africa, with CMU-Africa student interns being exclusively recruited by IIL incubator startups. What was striking about this funding mode was that CMU-Africa students taking part in IIL activities as interns were supported with funds jointly provided by CMU-Africa and startups. When discussing GIIH's funding approach, participant P_PPS03 revealed that, out of 24 ACEs, ACE_ESD had been among four ACEs that had successfully won a World Bank grant to host such a centre, alongside ACEs hosted at Nelson

Mandela University in Tanzania, Mbarara University of Science and Technology in Uganda, and Moi University in Kenya. The same participant went on to claim that, for sustainability purposes, since the creation of GIIH, UR-ACE ESD had been able to strengthen the capacity of the centre staff through technical support in writing competitive grant applications and in networking. In doing so, the aim had been twofold: (i) helping the innovation incubation centre to obtain funding opportunities from as many sources as possible to complement the mainstream funding from World Bank to run the centre, and (ii) raising more funds to support incubates with seed funding. When discussing the issues of funding and envisaged self-reliance of the innovation incubation centre, participant P_PPS03 said: *“However, it is good to mention that after we established this incubation centre, they [incubation centre itself] are also trying to search for calls to raise funds and secure funds elsewhere to also emulate what we have started. And we are happy for this. We are proud of this, and we tried to work with them. And we do not see it as a competition. We are all in the same university. It is good. We all work together to have a proper innovation ecosystem within our UR”* (Research participant P_PPS03, 2022). Commenting on the awareness of innovation incubation centres in other ACEs hosted by UR and their relationships with GIIH and/or ACE in Energy and Sustainable Development , the same participant indicated that other ACEs hosted by UR had learned from ACE in Energy and Sustainable Development ’s experience and were following pace in establishing innovation incubation centres. These included the Centre of Excellence for the Internet of Things, co-hosted with UR ACE in Energy and Sustainable Development at UR College of Science and Technology, and the Centre of Excellence in Data Science hosted at UR College of Business and Economics. When talking about funding modes of innovation incubation centres hosted by RP, participant P_PPS01 reported that the innovation incubation centre hosted at IPRC Kigali was partly funded by the GoR, but was also enjoying receiving funding from international development partners such as German Development Bank (KfW) and German Development Agency (GIZ) from Germany. Whilst the former solely provided financial support, the latter was providing both financial and technical support to the centre. Asked about how innovation incubation centres in other colleges of RP were funded, the same participant P_PPS01 indicated that the innovation incubation centre in IPRC Tumba, in the northern province of Rwanda, was funded by the Japanese International

Cooperation Agency (JICA) and the French Agency for Development (AFD); he added that the said innovation incubation centre specialised in ICT and mechatronics technology (robotics and automation).

7.3 Identifying the approaches to interactions of university-based innovation centres

The preceding sections of this chapter presented the features of interactions for RIL of identified university-based innovation incubation centres hosted by KIC's Knowledge Space academic actors. As can be seen from Fig. 7.2 below, three participants: P_PPS01 and P_PPS03 from KIC's Knowledge Space academic actors in proximity, and P_PPS11 from a government entity, shared insights and perspectives on the ways in which the identified university-based innovation incubation centres interacted with firms and other organisations. Moreover, these participants talked about the conditions that enabled (or would have enabled) university-based innovation incubation centres to attract actors for RIL.

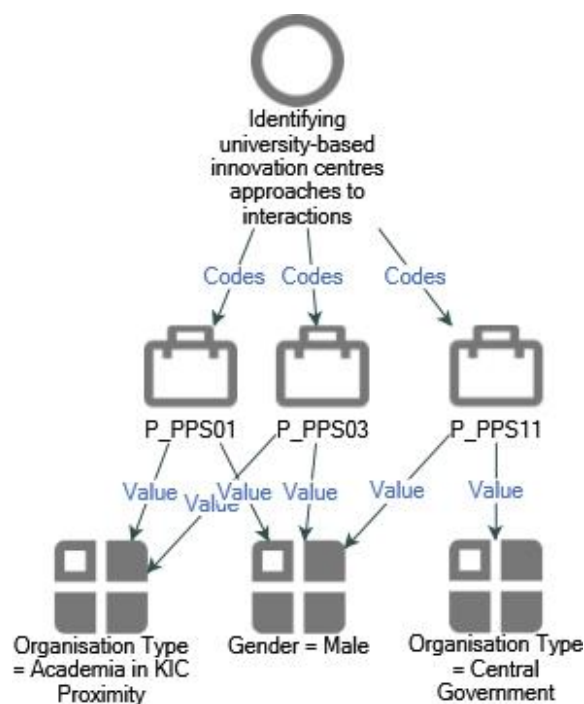


Figure 7.2. Mapping of participant demographics for theme 7.3

Source: Author's design with NVivo based on empirical data

7.3.1 Modes of interaction of university-based innovation incubation centres

A few participants indicated that university-based innovation incubation centres across KIC's Knowledge Space academic actors had adopted (or were adopting) different approaches to interacting with actors for RIL purposes. For instance, participant P_PPS01 stated that the Innovation incubation centre hosted by RP's IPRC Kigali had mainly adopted showcase technological innovations developed by students, graduates, and staff as one the main approaches to interacting with relevant actors. Commenting on the geographical proximity of IPRC Kigali in an urban environment and how this might influence the formalisation of collaborations with other actors through signing memoranda of understanding (MoUs), the participant said: *"Since IPRC Kigali is in the city, there are a lot of firms, other government agencies, which normally visit or want different services from our graduates... The innovations in IPRC play important role because we have a lot of different MoUs that we sign with the public and private institutions which need to get facilitated across various innovations from our college"* (Research Participant P_PPS01, 2022). When talking about this approach, the participant reported that actors from industry or private sector and government delegates attending the showcasing or exhibition events used the opportunity to learn what sorts of ideas and innovations were being developed, and how these ideas could be integrated in their work to improve businesses or services outcomes. The same participant thus suggested that the outcome of showcasing activities was more often than not twofold: (i) firms used this as an opportunity to identify students with good ideas and promising innovations with potential solutions to their business problems, and thus went on to recruit them on completion of their incubation, in order for these innovations to be implemented in their businesses for greater profitability; and (ii) firms or mostly government entities signed MoUs with RP to formally guide their collaborations on various projects of mutual interests. Commenting about a practical example of the outcome of such an approach, participant P_PPS01 reported that RP had an MoU with the Rwanda Agricultural and Animal Resources Development Board (RAB), a public research and innovation agency affiliated with Rwanda's Ministry of Agriculture and Animal Resources (MINAGRI), to collaborate on a range of research and innovation projects. When talking about how the RP-RAB collaboration had come about, the same participant indicated that the MoU was proposed and eventually signed after RAB officials had

visited and appreciated the ideas and innovations being developed at IPRC Kigali's innovation incubation centre. The participant went on to report that students at the innovation incubation centre had developed a range of agriculture tools for maize harvesting and processing, with technological capabilities that superseding those of RAB's imported machines in terms of performance. Commenting about the impact of RP-RAB's interaction with Rwanda's industry or made in Rwanda's policy outcomes, the participant suggested that the MoU has not only facilitated RAB to leverage RP's technological innovation to improve their maize processing efficiency, but it had also saved the government from importing that category of agricultural processing machines.

Neither being located in KIC's geographical proximity nor forming part of the actors in KIC's cognitive proximity, the RP innovation incubation centre in IPRC Tumba presented an interesting finding. Funded by JICA and AFD, the centre was emerging with a specialisation in mechatronics, as part of the new department of mechatronic technology. Commenting on how the centre interacted with other actors, participant P_PPS01 suggested that it has followed IPRC's Kigali-based innovation incubation model of exhibition events, with several firms starting to approach the centre to learn how mechatronics ideas could facilitate their businesses. This was followed by the signing of the MoUs, particularly in two sub-areas of manufacturing, namely food and agriculture processing. This view was echoed by participant P_PPS11 from a central government agency who, talking about the role of university-based innovation incubation centres with expertise in innovations, in providing technical support to government, said: *"We have an MoU with University of Rwanda [UR] that is very nicely working. We have also an MoU with Rwanda Polytechnic [RP] (...) So, once we need technical support, now we are outsourcing intermediators from Rwanda Polytechnic [RP] and University of Rwanda"* (Research Participant P_PPS11, 2022).

UR-ACE ESD's GIIH emerged as an interesting finding as it had adopted a relatively peculiar approach to interactions with other actors. When discussing this mode of interaction, participant P_PPS03 indicated that the centre mainly targeted professional networks and umbrella organisations of variable sizes and scopes, for networking, capacity building, strengthening, and fundraising purposes. He went on to state that the actors whom the centre interacted with included, *inter alia*, public, private, and local and international institutions. When discussing the example of actors whom the centre

interacted with and the purposes of those interactions, the participant reported that, from local collaborators' perspective, the centre interacted with Rwanda's Energy Utility Corporation Limited – a government parastatal establishment mandated to manage energy utility services countrywide, from electricity generating power stations to end-users. The participant went on to say that the GIIH also collaborated with Rwanda's IT Chamber – representing ICT firms in Rwanda's private sector federation, and Energy Private Developers (EPD) – the countrywide umbrella for all private firms in the energy sector. The most interesting aspect of the GIIH mode of interaction was that the centre also collaborated with other university-based innovation incubation centres. Asked about whether there had been or were any interactions with actors from outside Rwanda, participant P_PPS03 indicated that the centre collaborated with several centres or hubs with a similar mandate, such as Nairobi's Innovation Hub in Kenya. Moreover, the centre had registered for membership of the African network of innovation hubs. When discussing the benefits of UR-ACE ESD's and GIIH's strategic and peculiar mode of interacting with foreign actors, participant P_PPS03 claimed that from attending previous meetings held in Nigeria and Zambia in the previous year, for instance, the centre was expecting to host the African network of innovation hubs' annual general meeting in Rwanda. Aside from networking, the UR-ACE ESD Innovation incubation centre interacted with other actors with the aim to learn from other centres' experiences and measure their capacity to absorb what they had acquired from elsewhere. Commenting on the anticipated benefits from interacting with other innovation incubation centres with similar mandates, the participant said: *"Now we are still growing, we are still a small hub. So, we go slowly, but making sure that we keep our networks, and making use of what we get out of the network. We should always end up with the ability [capacity] to improve how we do things or just [how] we raise funds as well"* (Research Participant P_PPS03, 2022). Inasmuch as UR-ACE ESD and GIIH were benefiting from interaction through networking, participant P_PPS03 was particularly critical about the centre's criteria setting decisions as to whom to interact with from an organisational capacity perspective. The same participant believed that, although such a networking approach might sound slow, it helped the centre in two ways: (i) ensuring the networks created were maintained, and (ii) being certain that what was gained from the networking efforts did translate into strengthening the centre's capability [capacity] to deliver quality services

and to facilitate RIL. Moreover, this study found that since 2021, through GIIH, UR-ACE ESD had been organising and running the annual event ‘GIIH Innovation Week’ aimed at fostering dynamic ecosystems while showcasing ‘student-led innovations’. The technological innovations supported and exhibited during innovation week coincided with those aimed at addressing local societal needs while preserving sustainability and inclusivity³⁸. Table 7.1 below illustrates the various characteristics of the interaction approaches of KIC Knowledge Space university-based innovation incubation centres.

Table 7.1. Characteristics of KIC Knowledge Space university-based innovation incubation centres’ interaction approaches

Actor	Interaction approach	Purpose	Targeted collaborators	[Expected] Outcomes
RP	Tech Innovation showcase or exhibition events	Greater awareness and networking.	- Individual local industry - Government agencies - Development Partners - Other universities	- More collaborators are formed. - More MoUs signed. - Acquisition of innovations for processes and services improvements in firms and government. - Innovative students are recruited.
UR-ACE ESD	Bespoke networking through attending events and meetings	Co-learning Fundraising	- Local and international professional networks - Umbrella organisations	- Organisation capacity strengthened. - More funds raised - Greater influence.
	Tech Innovation showcasing events	Supporting young entrepreneurs and innovators Strength collaborations	- Academic actors - Government - Hybrid actors - Industry actors - Innovators and entrepreneurs	- New startups are formed. - Existing collaborations are strengthened with new ones formed.
CMU-Africa's IIL	Support R&I projects from students, graduates, and non-students.	Speed-up entrepreneurship process for tech innovation and job creation	- Academic actors - Hybrid actors - Industry actors - Innovators and entrepreneurs	- New startups are formed - New jobs are created - New collaborations are forged

Source: Author’s compilation based on empirical data.

³⁸ UR-ACE-ESD GIIH Innovation Week 2023
<https://giih.ur.ac.rw/> [Accessed: 31 January 2024]

7.3.2 Conditions for KIC's university-based innovation to attract other actors.

When asked about, in their experience, what conditions might persuade firms to want to engage with KIC KS university-owned innovation centres, several participants' views converged onto five main conditions:

The first condition was to provide innovative students with more space and time to develop their innovations. When discussing this issue, participant P_PPS01 from KIC's Knowledge Space academic actor in proximity argued that it would be imperative for universities to grant students more space and time than they were currently receiving. As the same participant P_PPS01 put it: *"We need more space for students to develop [their innovation ideas], show what they can, give them time, facilitate them, make sure that those innovations reach the maximum [outcome possible in terms of maturity]"* (Participant P_PPS01, 2022). This view was echoed by another participant P_PPS03 from KIC's Knowledge Space academic actor in proximity who felt that an appropriate space, different from the mainstream classroom setting, would attract the attention of people wanting to engage with the incubation centre. When talking about this issue of space, the participant P_PPS03 said: *"Innovation hubs [centres] should really have an attractive, not very fancy, but [a] proper space (...) that is appropriate where people can discuss around the coffee, that is a typical space for innovation hub"* (Participant P_PPS03, 2022).

The second condition that was suggested would persuade firms and other actors to want to interact with KIC KS university-based innovation incubation centres, was to raise public awareness of the innovation activities produced by innovative students and graduates. To this end, participant P_PPS01 argued that innovation incubation centres might not be satisfied with MoUs already signed but may rather seek to expand their horizons of interaction through expansion campaigns to showcase the types of innovations the centres were able to contribute to the industry, or else, promote the types of inter-actor collaboration that might be generated as a result of any additional interaction. Moreover, the expansion of the showcasing activities might provide the innovation incubation centres with the opportunities of exploring the various types of collaboration that individual innovative and entrepreneurial students, graduates, and staff might initiate.

The third condition put forward by several participants, was for KIC KS university-based innovation incubation centre managers to possess the necessary entrepreneurial capabilities and negotiating skills to persuade industry actors to invest in research and innovation development, instead of relying on targeting nearly finished products or services. One participant commented that industry actors usually aimed for profitability, that is, making money rather than investing in long-term research and innovation projects. Notwithstanding this caveat, the same participant argued that by investing in research and innovation and in the students and graduates working on these projects, the industry would be complementing the government in this effort.

The fourth condition for firms and actors to want to interact with KIC KS university-based innovation incubation centres was to develop and strengthen the institutional or organisational capacity in terms of intellectual property rights. Referring to this condition, participant P_PPS01 indicated that one of several reasons the knowledge, innovation, and technology-based programs or projects failed to mature from incubation or prototype stage to becoming marketable products was partly the lack of understanding of intellectual property rights as well as the institutional capacity to support that process. This view was echoed by another participant who suggested that institutional and organisational support for innovation incubation centres was essential for the sustainability of the latter, beyond any project-based funding mechanisms. Commenting about this issue, participant P-PPS03 said: *"It [the innovation incubation centre] has to be also equipped in terms of staff (...) as a very important part of the institution. For example, we are paying one of the staff (...) under auspices of the project funds. But if the project were to end, we would have to make sure that our university understood the importance of the hub and kept supporting the position beyond the project"* (Participant P_PPS03, 2022).

Preserving the identity, values, and uniqueness of innovation incubation centres was also reported as the fifth condition for a university-based innovation incubation centre to thrive. Commenting on this, participant P_PPS03 said: *"It is like if you are in competing business and are in the acceleration stage, with all your processes working properly, as an innovation centre, this will attract others"* (Participant P_PPS03, 2022). Commenting about potential risks associated with lack of effective networking strategy and how these might jeopardize the intended outcomes of interactions, participant P_PPS03 argued that: *"There are a lot of things that are happening in the networks. If*

you really do not pay attention, you can deviate easily, and you do not keep what makes you unique...We discuss this to make sure that we do not lose our uniqueness because the uniqueness of the University-based hub [centre] is probably what also is making the other centres to say, oh maybe we should do the same as them” (Participant P_PPS03, 2022). On the subject of uniqueness, the same participant believed that it would also be good to focus on and hold onto the objective the centre had started with, and that the best way possible to avoid the tendency to absorb anything or endeavour to raise significant funds just for the funds’ sake.

7.4 Supporting university-based innovation incubation centres – potentials and pitfalls

The views presented in this section under this theme surfaced mainly in relation to specific RQ as to how university-based innovation incubation centres were supported to deliver to their mandates. From Fig. 7.3 below, it can be seen that this theme had emerged from the insights and perspectives of seven participants, P_PPS02, P_PPS03, P_PPS04, P_PPS05, P_PPS06, P_PPS07, and P_PPS013, spanning a wide range of actors that constituted KIC’s ecosystem. Drawing on the participants’ insights, this section presents the potentials and challenges faced by KIC KS university-based innovation incubation centres in association with the efforts put in place to support the centres.

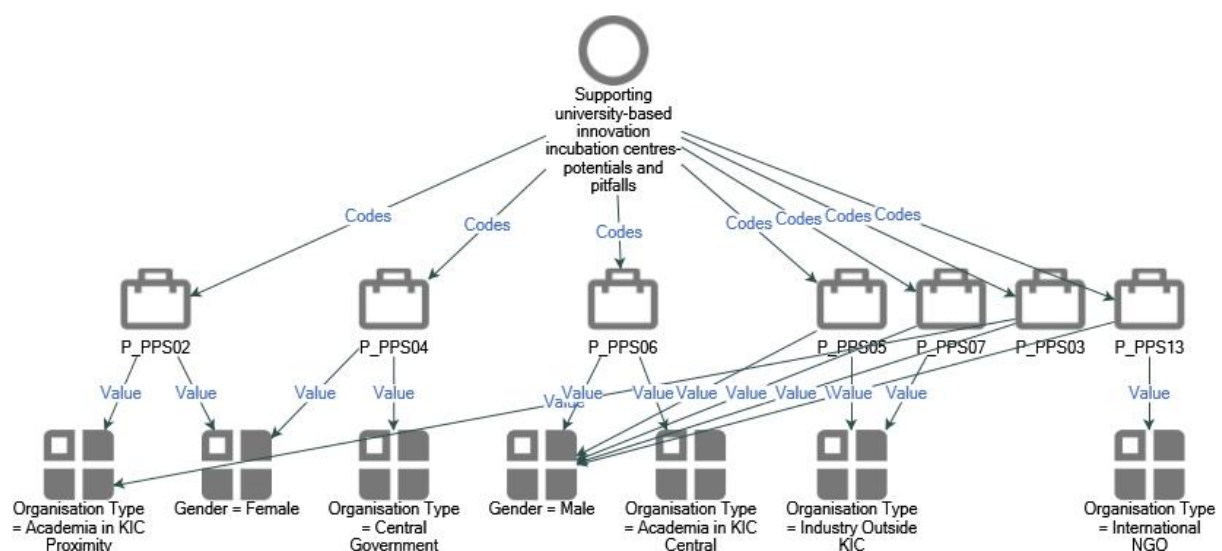


Figure 7.3. Mapping of participant demographics for theme 7.4

Source: Author’s design with NVivo based on empirical data

7.4.1 Unpacking the potential of university-based innovation incubation centres

As presented in a previous section of this chapter, a number of participants reported that university-based innovation incubation centres enjoyed tremendous support from respective host universities, with the backing spanning administrative, technical, and financial dimensions of the centre's activities. From an administrative point of view, several participants reported that host universities were playing a leading role in a range of activities such as the recruitment of staff for the centres and/or the allocation of existing staff with relevant expertise to manage them. From a technical perspective, several participants reported that the host university's role was central to a range of activities such as the selection of ideas with innovation and entrepreneurship potential, and the allocation of experts for coaching or mentorship of selected incubates. From a financial perspective, the role of host universities was reported to include, *inter alia*, the administration of the centre's staff salaries – whether from the university's own funds or from external funding, and the provision of seed funding for prototype and/or start-up development.

In line with the support mechanisms presented above, several participants indicated that the capabilities of the university-based innovation incubation centres presented the potential for generating respective universities' drivers of knowledge-based innovation ecosystems. For instance, commenting on the successful interaction with a university-based innovation incubation centre, one participant from KIC's hybrid actor and an alumnus of KIC's Knowledge Space central actor said: *"As somebody who was there [at CMU-Africa], it is even helping me today. So today, my organisation works with the CMU students, and that is because I know it and I know what it provides. So, whenever I need technical talents, I go to CMU, and I approach this Industry Innovation Lab [IIL] where you can find people wanting to do professional internships or people who are searching for a full-time position. And I have been successful in working with them, which is actually good"* (Research Participant, P_PPS13, 2023). This view concurred with an interesting finding suggesting that IIL incubates exclusively hired CMU-Africa students or graduates as interns. Commenting on the role of the innovation incubation centre, another participant from KIC's Knowledge Space actor in proximity said: *"The institution [University of Rwanda] now interacts with different innovation ecosystems. It doesn't only interact, but it also contributes to driving innovation ecosystems because we also have different innovation centres at*

the university. We have not just innovation centres, but we also have different innovation hubs at different colleges” (Research Participant P_PPS02, 2022).

7.4.2 Exploring the pitfalls of university-based innovation incubation centre

Notwithstanding the aforementioned potentials of the university-based innovation incubation centres, concerns were expressed mainly about sustainability in terms of funding, inadequate mentorship, and policy. For example, asked about their strategy to maintain the centre and keep it operational beyond the existing World Bank project funding, one participant from KIC’s Knowledge Space academic actor in proximity said: *“You have to raise funds, but also you have the pillars that you will focus on. It is not only funds. Also, it is a must to have good partners, reliable partners that you trust and have been with you since and where a common interest was created. The other thing is the strategic plan (...) It is a matter of looking in your own capacity”* (Research Participant P_PPS03, 2023). The participant went on to suggest that greater involvement of centre’s graduates and the harnessing of the host universities’ capabilities might play a central role in preserving the centre’s sustainably beyond the funded project’s life cycle. Asked whether (or not) the centre had its specific policy and strategy, the participant indicated that the innovation incubation centre neither had a specific policy nor a strategy, as the centre was part of the broader organisation. Its mission and priorities were thus embedded in the organisation-wide policies and strategy. In relation to this issue, another participant alluded to the notions of incubate and centre or funder’s goal misalignment, saying: *“There is another challenge for what on one hand the entrepreneurs want to achieve, and on the other, what the supporter wants the researcher(s) to achieve. So, if that can be also addressed, maybe a combining the two, because I cannot say entrepreneurs should not be in the framework or working under the government framework”* (Research Participant P_PPS05, 2022).

Speaking from an innovation incubation centre’s beneficiary entrepreneur viewpoint, one participant stressed the importance of inter-actor interactions for mentorship of incubates for innovation creation within an ecosystem. Commenting on this issue of inadequate mentorship, the participant thought that *“(...) innovation is supported by the ecosystem. If policymakers, government, these [other] organisations are not willing to give support to us entrepreneurs, it is really hard to succeed. We needed some*

people who are willing not only to give money, because the government and these organisations can give money if you prove that you have innovative ideas. But as I said on the capacity building, when it comes to mentorship, it is not practical as it should be” (Research Participant P_PPS05, 2022). Commenting on his lived experience of being an incubate, the participant was particularly critical of the mentorship in the capacity building in the technological innovation sector. He went on to attribute deficiencies in coaching or mentorship to an inadequate understanding of new technology amongst policymakers, decision-makers, and mentors. Talking about this issue, the same participant said: *“The other time we faced the same challenge when the university [UR] was allocating mentors working with the students. Because teachers might have those experiences, but they need new knowledge, they need new ways of how things can be done. At the same time, students need someone who can accompany them to see if they are in the right direction. I think is also applicable when it comes to interactions between entrepreneurs and these actors including policymakers. That is why I feel like there is a need for capacity building, but at the same time, not only young people, even those ones who make decisions”* (Research Participant P_PPS05, 2022).

Commenting about the issue of funding incubates’ innovation projects, several participants were unanimous in the view that existing funding mechanisms were inadequate and disjointed as they only helped incubates develop prototypes in the early stages of the innovation process. For example, one participant from KIC’s Knowledge Space central actor reported that *“(…) again what I have seen here at the main campus, as well as some other innovation ecosystems, is universities are good at developing some of the deep tech to solve that initial innovation phase, but then innovation needs to be harden a little bit, made more robust, and then you need to figure out the product market fit or the service market fit, which is the job of the entrepreneurs, who help to recognise the right space in the market, and they try to convert that to green. Deep tech provides a moot from an entry standing point, and it is hard, right? You need research to be funded by entities like KIC”* (Research Participant P_PPS06, 2022). The participant went on to indicate that building on seed grants from CMU-Africa, many of IIL’s incubates ended up applying for funding from external agencies such as the Gates Foundation, the National Institute of Health (NIH), and the National Science Foundation (NSF) in the U.S.

7.5 Assessing how the innovation centre programmes relate to KIC's development

The aim of exploring participants' views under this theme was to examine whether and how the university-based innovation incubation centre's programs related to KIC's development activities and planning. The goal was also to seek participants' perspectives about whether, and if so, how the university-based innovation incubation centre programs might be better aligned to KIC's development priority areas. As shown in Fig. 7.4 below, this theme emerged from the insights and perspectives of four participants, including three participants, P_PPS01, P_PPS03, and P_PPS012 from KIC's Knowledge Space academic actors in proximity, and one participant, P_PPS04, from central government actor.

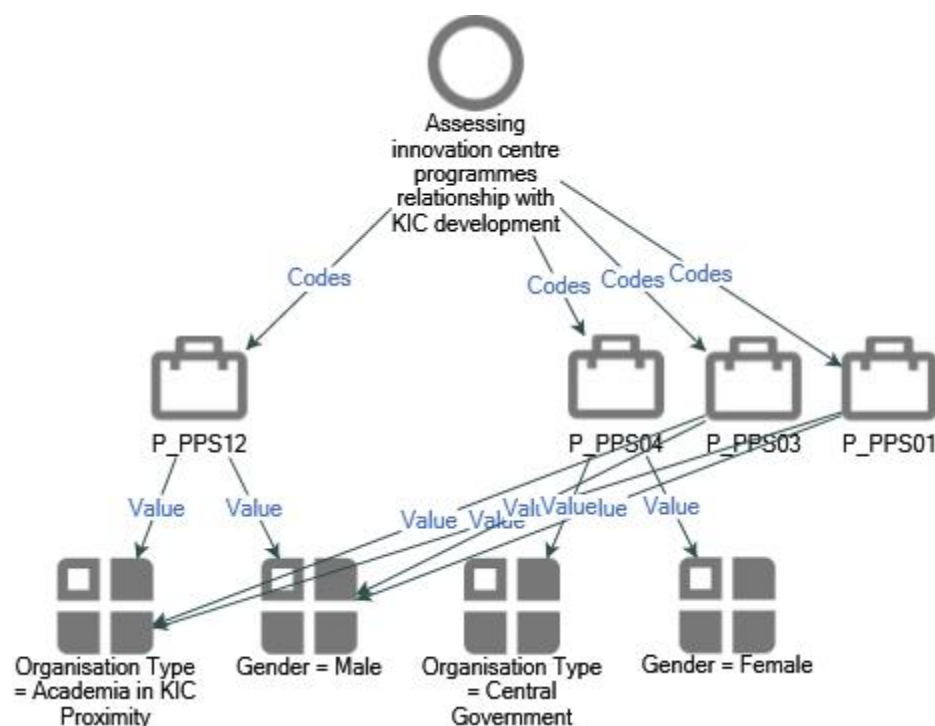


Figure 7.4. Mapping of participant demographics for theme 7.5

Source: Author's design with NVivo based on empirical data

Talking about the centres' relationship with KIC, several participants indicated there was a program alignment, although these views were expressed from varied perspectives. For example, one participant from KIC's Knowledge Space academic actor in proximity said: *"Yes, I think they are quite closely related because our programs are much more engineering-related. More than 95 percent of our programs*

are STEM- [Science, Technology, Engineering and Mathematics] related, and these are the programs where our students can continue to bring change in terms of innovations, I would say scientific innovations, which is in line with the Kigali Innovation City. So, be it in agriculture, be it in engineering, ICT, most of our programmes are quite closely in line with what Kigali Innovation City” (Research Participant P_PPS01, 2022). Another participant from KIC’s Knowledge Space academic actor in proximity, when asked about same issue, said: “*There is alignment... Of course, we have engaged Carnegie Mellon University that is in the premises of Kigali Innovation City, and then I have to mention that they attended our Innovation Week we have organised at the University of Rwanda*” (Research Participant P_PPS03, 2022). This view was echoed by another participant from a public research and innovation agency who stated that: “*we [NCST] delivered together [with KIC] during Innovation Week that took place at University of Rwanda, and it was a very big event which was sponsored by ACE-ESD*” (Research Participant P_PPS04, 2022).

When asked about the ways in which university-based innovation incubation centre programs could be better aligned with KIC’s priority development areas, a number of participants were unanimous in the view that a greater alignment of their respective innovation centre programs with KIC’s mission would necessitate working very closely with KIC. For example, one participant from KIC’s Knowledge Space academic actor in proximity said: “*Will see what type of strength [in terms of capability and capacity] that we have, [and] what part we can play in fulfilling the objective of Kigali Innovation City*” (Research Participant P_PPS01, 2022). Commenting on the importance of attaining a cognitive and geographical proximity of actors as a way towards achieving a greater program alignment with KIC, another participant from the same KIC’s Knowledge Space academic actor in proximity stated that “*(...) there are some ideas that the innovation hubs already being established [at UR] could go to the Kigali Innovation City, physically. It is a possibility, but maybe not only physically, but in a way of operating*” (Research Participant P_PPS03, 2022). Talking about this issue however, another participant from KIC’s Knowledge Space academic actor in proximity expressed a contrasting view, stressing that a move to KIC should be done systematically and be determined by mission, purpose, and need of the individual centres hosted at UR. For example, the same participant said: “*Our mission entails not just developing science and technology, but building capacity. And the capacity*

we want to build most of them are here at CST [College of Science and Technology]. So, we have to plan carefully how we move to the Kigali Innovation City” (Research Participant P_PPS12, 2022). To justify his view, the participant felt that most of the people the centre aimed to reach were in the University of Rwanda – College of Science and Technology, and that it was important for the centre to maintain that link with them. He went on to indicate that although, when KIC expanded in future and more people moved there and capacity building needs arose, then the centre would be able to expand the task of developing capacity there. The same participant went on to make the suggestion that “(...) as CMU-Africa grows, and, say AIMS moved there, then we would be able to say, ok we can have some activities there to help develop capacity there. Let us say we have just a technology company, just doing research and developing things. Then we could move it anywhere. For capacity building is best to be maintained close to the people whose capacities do need to be developed” (Research Participant P_PPS12, 2022).

7.6 Exploring further policy options for KIC's transition to an Innovation Space

The majority of participants thought that KIC's transition from a KS to an IS might be realised through policy options other than just supporting university-based innovation incubation centres. As can be seen in Fig. 7.5 below, the emerging theme presented was the most dominant theme with the highest number of case counts (participants) and code counts (significant information from empirical data) (Adu, 2019). The eight participants, P_PPS04, P_PPS06, P_PPS08, P_PPS10, P_PPS11, P_PPS12, P_PPS13, and P_PPS14, who contributed their insights to this theme came from all the strands of KIC's Knowledge Space, with central government being the most represented sector with three participants. Drawing on the participants' perspectives and insights in addressing RQ5 and RQ6 under this emerging theme, two policy options were identified and are respectively presented in this section: (i) harnessing state-based innovation support centres and programmes and (ii) attracting locally and internally established tech firms within KIC.

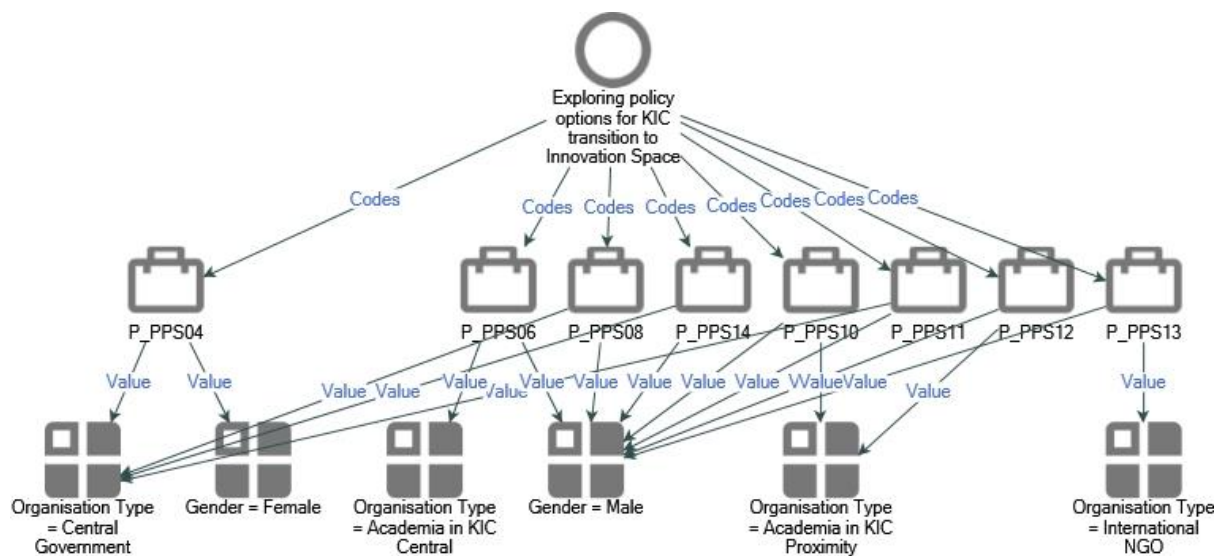


Figure 7.5. Mapping of participant demographics for theme 7.6

Source: Author's design with NVivo based on empirical data

7.6.1 Harnessing state-based innovation support centres and programs

When discussing the potential roles of state-based innovation incubation centres and programs in attaining KIC development outcomes, one participant reported that the National Industrial Research and Development Agency (NIRDA) hosted an innovation

hub that supported innovators and entrepreneurs in STEM, known as the ‘NIRDA Innovation Hub’. Commenting on NIRDA’s overview, the participant indicated that it was a public research and development institution under the Ministry of Trade and Industry (MINICOM)³⁹. When discussing the way in which NIRDA’s Innovation Hub supported young innovators in STEM, the participant said: *“Every year, we conduct a hackathon, and we organise competitions, and we select the most promising projects that come to stay with us for three months, then they graduate, and they become startups. And we also empower those startups to become established companies”*. (Research Participant P_PPS11, 2022). The participant went on to state that NIRDA’s Innovation Hub, in collaboration with its partners, has administered three funding calls:

- Innovation for industry hackathon: the first call was launched in 2019, targeting university students and academic staff aged below 55, with innovative and entrepreneurial ideas. No innovation for industry hackathon was held in 2020 due to the COVID-19 pandemic.
- Innovation for Cow-bio hackathon: the second call took place in 2021-22, also targeting the same category as the 2019 innovation for industry hackathon. Commenting on the eligibility criteria for the Cow-bio hackathon, one participant said: *“Even university graduates who were still below 35, who can find the mentors at university are also eligible... for people who are no longer students, we wanted [them] to have some kind of official affiliation so that we can communicate with them easily”* (Research Participant P_PPS11, 2022).
- Innovation for smart agro-processing call: launched in 2022, and unlike the previous calls, the innovation for agro-processing call was made more inclusive, targeting applicants beyond university students and staff, and with no age limit⁴⁰. When discussing the peculiarity of the innovation for agro-processing call, the same participant said: *“It is open, it is no longer restricted to universities or university students. Even any innovator in the domain. We want to try this*

³⁹ NIRDA is conducting research to support Rwandan enterprises through product development and innovation in STEM and life sciences. From a structural point of view, NIRDA possesses two branches: one in Kigali and another one in the Huye district, Southern province of Rwanda. NIRDA’s branch in Huye comprises a laboratory of life sciences in which the agency works with the established enterprises, and also with the innovators in product development, particularly in agro-processing, phytomedicine, and biotechnology. <https://www.nirda.gov.rw/> [Accessed: 22 January 2024]

⁴⁰ https://www.nirda.gov.rw/home/news-detail?tx_news_pi1%5Baction%5D=detail&tx_news_pi1%5Bcontroller%5D=News&tx_news_pi1%5Bnews%5D=29859&cHash=160f46752ff8827494f69ba091c4aae2 [Accessed: 19 January 2024]

thing to see how it works. It is a kind of trial. We want to see if this can work as well' (Research Participant P_PPS11, 2022).

The same participant reported that each one of NIRDA's Innovation Hub calls had had its own funder, with a diversity in sources of funding, including both donors and state funding. For instance, commenting on this phenomenon, the same participant revealed that the first 'innovation for industry hackathons' that was organised in September 2019 had been funded by UNDP, through the Ministry of Youth (MINIYOUTH) to NIRDA. The 'innovation for cow hackathon' had been funded by Morocco Cooperation (OCP), with the latest call 'innovation for agro-processing' having been entirely funded by NIRDA through the government's ordinary budget. Asked about his awareness of any other government ministry or agency running an innovation incubation centre or programme, the same participant said that the Rwanda Information Society Authority (RISA) had run the INNOVATE4 Disability Inclusion Hackathon in 2019. Launched by RISA in collaboration with Rwanda's Ministry of ICT and Innovation (MINICT), MINIYOUTH, and National Council of People with Disability (NCPD), and funded by the United Nations' Development Programme (UNDP), INNOVATE4 the Disability Inclusion Hackathon had been designed as a nation-wide scheme targeting innovations to address the needs of persons with disabilities, using digital solution-enabled assistive technologies. The overarching goal of the call was to contribute to the UN Sustainable Development Goals' (SDGs) and Rwanda's National Strategy for Transformation's (NST_1) anticipated outcomes of leaving no one behind⁴¹. Hanga Pitch,⁴² run by MINICT in collaboration with the Rwanda Development Board (RDB) and UNDP, and the TVET Youth Challenge,⁴³ run by MINIYOUTH in partnership with MINEDUC, RP, Korea International Cooperation Agency (KOICA), and UNDP, were two significant initiatives aimed at supporting technological innovations and entrepreneurship among the youth in Rwanda. While the former was open to all, the latter particularly targeted young innovators from TVET tertiary education. The Government of Rwanda's support for hackathons and pitching competitions as innovation policy instruments to leverage technology for aspired policy outcomes dates back to 2013, when "the Ministry of Agriculture ran several

⁴¹ <https://www.ndangira.net/innovate-4-disability-inclusion-hackathon-2019/> [Accessed:17 January 2024]

⁴² <https://www.hangapitchfest.rw/>

⁴³ <https://www.miniyouth.gov.rw/1-1/services-1/youth-ecobrigade-program-1>

hackathons at kLab, seeking mobile applications that could be used by Rwanda's farmers" (Friederici, 2018, p. 9).

Participants also reported that the Rwanda Innovation Fund (RIF) constituted part one of state-based innovation support programs for KIC's development. As an early-stage venture capital fund with an investment size ranging between \$250,000 and \$2M, the RIF aimed to support technology or technology-enabled startups at their growth stage in the environmental, social, and governance (ESG)-friendly areas, namely: health-tech, agri-tech, edu-tech, fin-tech, SME productivity and digitisation, clean mobility, and clean energy, with a geographical focus on Rwanda and the East African region. Stemming from an AfDB loan to the GoR, the RIF is presently administered by an international investment management organisation named Angaza Capital on behalf of the Rwanda Development Board (RDB). It is hosted at Norrsken House Kigali, in central Kigali⁴⁴. Commenting on the various innovation funding mechanisms specific to KIC development, one participant from a public research and innovation funding agency said: *"Kigali Innovation City is actually there to support or to promote research and innovation output towards the market. So, there is Rwanda Innovation Fund [RIF] that is managed by Kigali Innovation City and RDB. This is one innovation fund that has been put in place to support those who are ready to go to the market. That is like a capital investment. It is not at early stage of conducting research, testing, and prototyping. No, if you have the output and the innovation is already registered that you have your copyright or IP, and you are ready to [put your innovation to] market. Then the Innovation Fund comes at that stage to support you"* (Research Participant P_PPS08, 2022). The same participant went on to draw parallels between the variations in scale and scope in the ways in which various actors funded innovation saying: *"(...) you know there are nine levels of technology readiness (...) For us [National Council for Science and Technology, NCST], we are just at the concept note, at the early stage of conceptualisation, of idea development, until the prototype is designed. For us, we support research and innovation at that level. So, there is also the Ministry of ICT and Innovation there to support some startups. So, they are planning also to put what is called the Seed Fund (...) to see how they can support some startups towards market level. So, in summary, for us, we are supporting those*

⁴⁴ <https://www.angazacapital.com/the-rwanda-innovation-fund> [Accessed: 23 January 2024]

developing ideas, research, testing and prototypes, while KIC is there to scale up at market level, but through capital investment” (Research Participant, P_PPS08, 2022). Talking about the same issue, another participant from the same public research and innovation funding agency said: *“NCST also supports innovators to go through the incubation centres, but what we have realised is missing is an update from the innovation to startups. Yes, there are startups being created, but we need to have a continuous process where from the academia, everything will end in startups”* (Research Participant, P_PPS04, 2022). As reported by the research participant and can be seen from Table 7.2 below, the NCST created several funding calls through one policy instrument named the National Research and Innovation Fund (NRIF). Based on individual call-specific objectives and targeted beneficiaries, these calls fully or partly focused on R&D-based innovations or non-R&D-based innovation outcomes, and with and without an international dimension. Below are examples of these grants:

- Rwanda Innovation Challenge’ (RIC)⁴⁵: launched in 2020, the call aimed to support up to 36 projects – with funding ranging from five to 10 million Rwandan Francs (Rwf) per project. The call targeted the youth, individual scientists, researchers, and entrepreneurs, aiming to overhaul their skills and develop commercial products and form businesses with a societal impact including job creation. Under the RIC, the NCST collaborated with one private research organisation and RP’s innovation incubation in providing incubates with mentorship services for the duration of twelve months.
- Rwanda Innovation Challenges for Academia-Industry Research and Development Collaboration (RIC-R&D): Launched in 2021, the RIC-R&D was a two-phased call aimed at supporting R&D-based innovations, up to and beyond proof-of-concept level, in Rwanda’s national main priority sectors. The call stressed collaborations involving researchers from local academic actors, experts from industrial actors, and international actors with ‘at least one globally renowned expert in the field’⁴⁶.

⁴⁵ <https://www.ncst.gov.rw/1/rwanda-innovation-challenge> [Accessed: 22 January 2024]

⁴⁶ https://www.ncst.gov.rw/nrif?tx_news_pi1%5Baction%5D=detail&tx_news_pi1%5Bcontroller%5D=News&tx_news_pi1%5Bnews%5D=30164&cHash=6745e4d2fb163c059704e73da81a346a [Accessed: 22 January 2024]

- Women in Science Research and Innovation Grant⁴⁷: Launched in 2021, the call aimed to support woman-led teams of innovative researchers with entrepreneurship and job creation aspirations. The grant funded up to five R&D-based innovations with product or service commercialisation potential.
- Academia-Industry Collaboration: launched in 2021, the call's objective was to support 19 search projects aimed at overhauling industrial performance in specific priority areas including: agriculture, manufacturing, energy, the environment, and ICT⁴⁸. The successful projects were led by relevant researchers from academic actors and implemented in collaboration with relevant industrial actors, with funding ranging between 50 million to 150 million Rwf per project.
- Research and Innovation Mobility Grant (RIM)⁴⁹: specifically created to support researchers and innovators – with R&D-based innovation ideas with the potential to lead to products or services – to travel and conduct research at a reputable international research institution such as university, laboratory, or centre of excellence.

⁴⁷https://www.ncst.gov.rw/nrif?tx_news_pi1%5Baction%5D=detail&tx_news_pi1%5Bcontroller%5D=News&tx_news_pi1%5Bnews%5D=30160&cHash=28b9aa1af1591cc00ff273b62230a3a0 [Accessed: 22 January 2024]

⁴⁸<https://www.ncst.gov.rw/1/academia-industry-collaboration> [Accessed: 22 January 2024]

⁴⁹<https://www.ncst.gov.rw/nrif> [Accessed: 22 January 2024]

Table 7.2. Mapping of Rwanda's State-based innovation funding mechanisms

Call name	Fund name	Fund/Call manager	Collaborating actors	Funding actor	Level of technology	Project funding range in USD (\$) ⁵⁰	Areas of focus	Innovation type	Innovation model	Target applicants
Innovation for industry hackathon	-	NIRDA's Innovation Hub	- MINICOM - MINICYOUTH	UNDP	Innovation idea	-	STEM related innovation	Product/Process	DUI	- University students - University staff
Innovation for Cow-bio hackathon	-	NIRDA's Innovation Hub	MINICOM	OCP	Innovation idea	-	- Agri-tech	Product/Process	DUI	- University students - University graduates - University staff
Innovation for Smart agro processing RIF	-	NIRDA's Innovation Hub	MINICOM	NIRDA	Innovation idea	800–5,500	Agri-processing value chain	Product/Service	DUI	- Teams - Startup firms
RIF	RIF	Angaza Capital	RDB	AfDB ⁵¹	Growth-stage startups	250,000-2M	- Health-tech - Agri-tech - Edu-tech - Fin-tech - SME productivity and digitisation	Product/Service/Process	STI-based/DUI	Startup firms
RIC	NRIF	NCST	- LEAP Applied Research Labs - RP	NCST	Innovation project	4,000 – 8,000	- Clean mobility - Clean energy - STEM related R&I	Product/Service	STI-based/DUI	- Individual-based: - Youth

⁵⁰ National Bank of Rwanda exchange rate: 1USD (\$) = 1,288.10 Rwf, as of 5th February 2024. Figures in Table 7.2 above are approximates in USD (\$). <https://www.bnr.rw/currency/exchange-rate> [Accessed: 5 February 2024]

⁵¹ RIF is AfDB Loan to Rwanda

Call name	Fund name	Fund/Call manager	Collaborating actors	Funding actor	Level of technology	Project funding range in USD (\$) ⁵⁰	Areas of focus	Innovation type	Innovation model	Target applicants
										▪ Scientist ▪ Researcher ▪ Entrepreneur ▪ Researcher ▪ Industrial expert ▪ International expert
RIC-R&D	NRIF	NCST	-	NCST	R&D-based innovation project	-	STEM related R&I	Product/Service	STI-based	▪ Researcher ▪ Entrepreneur ▪ Researcher ▪ Industrial expert ▪ International expert
WSRI	NRIF	NCST	-	NCST	R&D-based innovation project	-	STEM related R&I	Product/Service	STI-based	▪ Researcher (Female) researcher
AIC	NRIF	NCST	-	NCST	R&D-based innovation project	40,000-120,000	- Agriculture - Manufacturing - Energy - Environment - ICT	Product/Process	STI-based	▪ Researcher ▪ Industrial expert
RIM	NRIF	NCST	-	NCST	R&D-based innovation project	-	STEM related R&I	Product/Service	STI-based	▪ Researchers
GCR	GC	NCST	-	BMGF	R&D-based innovation project	95,000	Climate change and health	Product/Service	STI-based	Collaboration: ▪ Academia ▪ Industry ▪ International actors
INNOVATE4 Disability Inclusion Hackathon	-	RISA	- MINICYOUTH - MINICT - NCPD	UNDP	• Innovation idea • Solution prototype • Finished product.	400 - 3,000	Assistive Technologies development with digital solutions.	Product	DUI	▪ Individuals ▪ Teams ▪ Startup firms ▪ NGOs

Source: Author's compilation based on empirical data

As indicated in Table 7.2 above, besides NRIF, Rwanda's NCST also funds R&D-based innovations through Grand Challenges Rwanda (GCR): launched in 2023 with support from the Bill & Melinda Gate Foundation, the call emphasised multisectoral and multi-disciplinary research leading to technological innovations with a societal impact at the interface of climate change and health. In addition to academia/industry collaborations amongst local actors, the GCR specifically encouraged international collaborations.

Aside from the aforementioned state-based innovation support programs, participants reported that there were emerging non-state-based innovation incubation and acceleration ecosystems being developed in Kigali, with mandates partly related to that of KIC. For example, talking about other initiatives similar or related to KIC, one participant from an international NGO operating in the areas of technology, entrepreneurship, innovation, and youth in Rwanda said: *"There is ICT Innovation Centre funded by the [Rwanda] government and KOICA. It is an Innovation Centre. It provides free space allowing startups to find a professional space for their employees. And it is also specialised in equipment like computers, some software, printers and labs basically helping, skilling businesses in their infancy. They have also experienced mentors who help entrepreneurs stay focused throughout planning and decision [making]. It is basically like a k-Lab, but that is bigger than k-Lab"*. Commenting on other examples of non-state-based innovation support programs, the same participant said: *"there is also Norrsken Foundation. Norrsken Foundation is another one, really connecting funders with the knowledge capital and network. Basically, if you have a business or if you have a startup and you need a place to sit and work and be able to meet potential investors, whether actual investors or angel investors, it is a great place to be"* (Research Participant, P_PPS13, 2023).

7.6.2 Attracting established local and international tech firms – to KIC

Aside from supporting university-based innovation incubation centres and harnessing state-based innovation accelerators and related programmes, several participants believed that attracting established (tech) firms – local and international – might offer a viable and complementary policy option that would see KIC transition from KS to IS, and hence become a place-based knowledge-based innovation ecosystem. When asked about what policy option or model should take precedence between leveraging university-based start-ups and spinoffs across KIC's Knowledge Space or attracting established (tech) companies in creating KIC's Innovation Space, a number of participants were unanimous in the view that both policy options should be explored concurrently as each comprised its own potentials and pitfalls. Talking about the two policy options from the perspectives of times scale, investment, uncertainty, risks, experience, and expertise, one participant from KIC's Knowledge Space central actor said: *"It is like a rainforest analogy. If you need those hundred-year-old trees, you need a lot of things at the bottom of the rainforest. A lot of innovation, and there is a lot of stuff that die out. There are some plants that do not make it to large trees (...)"* (Research Participant, P_PPS06, 2022). Building on this analogy, the same participant indicated that, on the one hand, the large companies provide the experienced product managers, providing a natural workforce environment. On the other hand, the young people with the connections to the universities tended to work on contemporary problems such as block chain, quantum, AI, or newer remote-sensing technologies. The same participant thus said: *"I think you need the combination of the younger folks with new ideas who will be trained in top tier institutions, along with sort of product management and marketing expertise"* (Research Participant, P_PPS06, 2022). The participant went on to suggest that realising both short-term and long-terms options would require setting priorities and having strategic partners with a strategic funding interest through a public/private partnership (PPP). This view was echoed by another participant from a government ministry responsible for KIC's development, who contended that science and technology industries and sectors were still nascent, and therefore on the one hand, through KIC's Knowledge Space academic actors, the government was creating a foundation for skills and research environment where innovative ideas could emerge and grow. On the other hand, the country needs to

keep up with the trends of development, and in so doing to leverage advanced technologies and bring in foreign startups and established industries that would be able to provide the solutions to contemporary society's needs. As participant P_PPS14 put it: *"I do not think you can do one versus the other (...) if you only wait for some of these ideas to mature, and then you are probably going to lag behind, because you also need to respond to some of the needs that are immediate. But at the same time, you cannot also only bring mature companies or solutions, because with that innovation, you miss out on the opportunity to create even better contextualised solutions (...) Whether you look at it from education or corporate perspective, I think is important to do both now"* (Research Participant, P_PPS14, 2022). Commenting on Rwanda's strategy to attract foreign technology companies, KIC's Innovation Space using the example of a successful PPP between Rwanda and Zipline – a USA-based technology startup, the same participant said: *"Our strategy is to try to be a proof-of-concept hub in line with recognising that Rwanda has a lot of competitive advantages when it comes to having the right environment for policy generation and regulatory frameworks that exist, but also the will of government to work with innovations or innovators. And so, the proof-of-concept strategy looks at health-tech, fin-tech and agri-tech. The idea is that we attract talent investors and people that are really wanting to try ideas in Rwanda and they can go globally"* (Research Participant, P_PPS14, 2022). With the same example of Zipline, the participant attributed the success of Rwanda's proof of concept strategy to the country's agility in adapting policy and regulatory framework in response to the technology push. Commenting on this issue, the participant said: *"When Zipline came, we did not necessarily have everything in place, but because there was the willingness, I think we were able to adapt and create a regulatory and policy interventions that were needed. I think the outcome was positive and so the challenge would be, if you did not have a government that is going to move fast enough to keep up with the pace for innovation"* (Research Participant, P_PPS14, 2022).

Echoing other participants' views, participant P_PPS12 from KIC's Knowledge Space academic actor in proximity thought that it would be a good idea to create both university-based incubation centre startups and spinoffs, and established industries within KIC's premises. Talking about these issues from an actor's point of view, the same participant stated: *"I think this is a good idea to have the industries and not just*

the academics that are close together, but also the industries. So that can cause factorisation and people can work together” (Research Participant, P_PPS12, 2022). However, commenting on this issue from the perspectives of local contextual imperatives such as job creation and KIC neighbouring local community engagement, one participant from an international NGO collaborating with KIC’s Knowledge Space central academic actors was particularly critical of foreign companies importing experienced staff from elsewhere while creating their bases at KIC. For instance, this participant said: *“They [established companies locating to KIC] should be targeting local resources and the local community around them. If they do not have probably the skill set that they expect, that is an opportunity to give them the training so that they become their future human capital that is cheap and that is able to produce what they expect in the local context”*. (Research Participant, P_PPS13, 2023).

7.7 Discussion

As presented in previous sections of this chapter, the present study was in part designed to explore the ways in which KIC was transitioning from KS to IS as part of its development into a place-based knowledge-based innovation ecosystem. The findings presented in this chapter drew on RQ 5 – *How do KIC Knowledge Space academic actors interact with industry and other actors for RIL?* and part of RQ6 – *What is the role of government agencies and other actors in supporting the development of KIC into a knowledge-based innovation ecosystem?* In this section, the findings are interrogated through the lens of the context-specific and multi-staged Integrated Analytical Framework.

7.7.1 Describing University-based innovation (or incubation) centres’ structural and funding models

Under this theme, the study found that KIC’s Knowledge Space academic actors’ university-based innovation incubation centres constituted universities’ entrepreneurial features or capabilities and potential for KIC’s transition to IS. This finding broadly supported the previous studies in this area linking entrepreneurial universities and their spillover effect into innovation ecosystem development (Yongabo, 2021b; Nkusi et al., 2020; Cele et al., 2020; Ranga and Etzkowitz, 2013). Most striking were the substantial differences in the university-based innovation incubation centres’ organisational models; inclusivity, openness levels, interaction

strategies, and funding models, across KIC's Knowledge Space academic actors – central and in proximity.

From an organisational point of view, this study found that university-based innovation incubation centres varied largely depending on the institutional and organisational architecture of the university in which the centre was hosted. The variations were observed across a range of dimensions including centres' embeddedness, and inter- or trans-disciplinarity. For instance, while innovation incubation centres constituted RP's organisational structures at college levels, UR's Centre for Entrepreneurship and Innovation was strategically located at the university headquarters 'with innovation coordinators' at each of the six university colleges. Nonetheless, UR's structure was flexible in such a way that colleges possessed the autonomy to host innovation incubation centres as well as research centres. For example, GIIH was embedded in UR through ACE-ESD at UR College of Science and Technology. Despite the variations in university-based innovation incubation centres, it is somewhat striking that the operation of all centres relied almost entirely on existing academic staff from host actors being, who were assigned to additional duties. This finding raised the possibility that, despite all gains that may have arisen from the university hosting innovation incubation centres, the contemporary staffing model may have exacerbated the existing issues of learning outcomes attainment due to inadequate teaching capacity. This suggestion concurred with Tan et al. (2021) who found that academic staff in SSA were often overwhelmed with the task of teaching, leaving them with limited time and capacity to focus on research and innovation activities.

This study also identified variations among innovation incubation centres based on the extent of their inclusiveness and openness in scope. For instance, whilst innovation incubation centres at CMU-Africa and RP exclusively admitted students and graduates from respective host universities, the GIIH at ACE-ESD was found to be more open, admitting incubates from within and outside UR. Another important related finding was that, for most centres, the scope of interventions was limited to supporting technological innovation in STEM areas, with the exception of GIIH, which adopted a trans- and inter-disciplinary approach to support innovation in both STEM and Non-STEM areas.

From a funding model perspective, this study found that, with the exception of IIL, which was partly funded by CMU-Africa and incubate startups, the innovation incubation centres at UR and RP were largely funded by international development partners or NGOs, viewed through the THS lens in this study as hybrid actors. For example, the innovation incubation centres at RP IPRC Kigali and IPRC Tumba were partly funded by the German institutions GIZ, KfW, and JICA, and the French AFD, while the UR's Centre for Entrepreneurship and Innovation was fully funded by the Swedish International Development Agency (Sida) through the UR-Sweden programme for research, higher education, and institutional advancement⁵⁰. Interestingly, unlike other international development partners with support focusing on a single programme and single local actor, the UNDP was found to be supporting sustainable and inclusive technological innovations and entrepreneurial startups across a range of actors in Rwanda's innovation ecosystem. In accordance with these findings, previous studies found that international development actors, viewed in research through THS as part of the 'hybrid actors', played a central role in science and innovation funding in developing countries and in SSA in particular (Atuhaire et al., 2022; Chataway and Daniels, 2020; Chataway et al., 2017). This also concurred with earlier observations which showed that international development actors played a vital role in shaping and influencing the ways in which innovation ecosystems operated in SSA (Washbourne et al., 2021; Mugwagwa et al., 2021). One interesting finding was that the GIIH was hosted at UR-ACE ESD, that is, it was funded based on a grant secured competitively. That GIIH was funded was partly attributed to the entrepreneurial and innovative capabilities of the centre's management team who, viewed through a THS lens, could be denoted as 'innovation organisers' and 'entrepreneurial scientists' (Ranga and Etzkowitz, 2013; Twiringiyimana et al., 2021). Another important finding related to the above was that, learning from the experience of ACE-EDS in creating GIIH through competitive funding opportunities, other ACEs hosted at UR, such as ACE-DS and ACE-IoT, followed suit through interacting with ACE-ESD, with the former viewing the latter as collaborators and not competitors. In accordance with the present result, earlier studies in the area of innovation systems demonstrated that innovation is a process of learning through interacting (Georgiou,

⁵⁰ UR Centre for Entrepreneurship and Innovation Impact Magazine: UR Sweden programme https://ur.ac.rw/IMG/pdf/magazine_of_march_2023_for_print.pdf [Accessed: 1 February 2024]

1993; Pavitt, 1995; Lundvall, 2010; Yongabo, 2021b) . Based on this finding, this thesis would therefore argue that, with a collaborative and co-learning attitude amongst entrepreneurial scientists, innovation might thrive, and the process of forming intra- and inter-university-based innovation ecosystems may thus be expected. A contrasting phenomenon often appeared within innovation ecosystems in non-academic settings whereby incumbents often viewed the newcomers as competitors (Juma, 2016).

Another interesting finding closely associated with the innovation incubation centres being embedded in their host universities, was the centres' lack of specific policies and strategies, which may hamper the effectiveness of those centres' interactions with other actors within the ecosystem. Viewed from a critical realist perspective, this discovery corroborated the earlier research which had found a link between the lack of, or inadequate policy alignment amongst underperforming actors from Rwanda's NIS (Nsanzumuhire et al., 2021; Nsanzumuhire and Groot, 2020; Yongabo and Göransson, 2020). Drawing on a systems thinking approach, this author therefore argues that it is paramount for a university-based innovation incubation centre to possess a strategy with a clear vision and priorities, all aligned with the development strategy of the host actors and (or) the niched ecosystem in which the innovation incubation centre is located. He moreover contends that, for a greater outcome and societal impact, innovation incubator centre policies and strategies should be flexible enough to accommodate incubates' goals and aspirations. One possibility of realising this might be by engaging as many actors as possible – including incubates and intended users – primarily in co-creating, co-learning, and co-shaping the centres' policies and strategies relevant to the people in the centre's location. Multi-actor connectedness through policy alignment at place-based ecosystem level might spur societal transformation while contributing to a greater NIS performance outcome.

7.7.2 Identifying university-based innovation centres' approaches of interactions

As part of RQ6, this study sought to explore the ways in which KIC's Knowledge Space university-based innovation incubators interacted with industry and other actors. It also aimed to unpack the conditions that (might) make firms and other actors inclined to interact with the identified innovation incubation centres. Under this theme and as indicated in Table 7.2 above, this study found that showcasing student-led innovations

was the most dominant approach to interaction. Drawing on the example of ‘Innovation Week’ organised by GIIH at UR-ACE-ESD, these showcasing events brought together a wide range of actors including academia, government, industry, and international development actors including NGOs. The events thus generated numerous outcomes including, *inter alia*, the potential for creating more collaborations with existing or new partners through signing memoranda of understanding (MoUs) or otherwise, possibilities of recruiting innovative students via firms or other actors, acquiring technological innovations being exhibited, and also creating tech- startups with seed funding for selected innovations. In accordance with these findings, a recent work on Rwandan universities and how they interacted with other actors highlighted the MoU as one of the important policy instruments used in Rwanda to facilitate inter-actor interactions (Ransom, 2023). As Ransom (2023) puts it: ‘MoUs could be considered as an example of an early-stage direct path as they can lay the ground for further work and consultancy projects, which are an example of later stage direct path, given it involves a concrete exchange of knowledge or services’ (Ransom, 2023, p. 164) between universities and other actors such as, *inter alia*, government, industry, NGOs, and communities. For example, this research found that the MoU signed between RP and RAB not only facilitated RAB to leverage RP’s technological innovation to improve their maize processing efficiency, but it also saved the government from importing that category of agricultural processing machines, while contributing to the attainment of ‘Made in Rwanda’ policy outcome.

These findings may thus be taken to indicate that KIC’s Knowledge Space academic actors leveraged their innovation incubation centres to exhibit their entrepreneurial nature and embeddedness in society and their effort to respond to locally relevant issues through entrepreneurship and innovation. From a niche level, these findings were contrary to those of previous studies which broadly suggested that universities in SSA were still operating under the Humboldtian siloed mode and questioning their relevance to contemporary social and local needs (Brundenius et al., 2008; Cloete et al., 2018; Tan et al., 2021). Another important factor in making innovation showcasing events the most dominant and popular, was its use of an ‘avenue’ for different actors such as the Government and international development partners – notably UNDP, to advance their development agendas and interests embedding inclusivity and sustainability in technologies and innovations developed in incubation centres.

An interactive approach through targeted bespoke strategic networking, although less popular, was a particularly valuable finding. This research found that this approach to interaction yielded positive outcomes leading to incubation centres strengthening their organisation capacity. For example, through this mode of interaction, one innovation incubation centre engaged in collaborations transcending niche ecosystems and national boundaries, thereby creating the opportunities for co-learning and co-creating knowledge and innovation from different perspectives and contexts. Through these types of interactions, the centre also explored the fundraising opportunities to support both the centre's operations and incubates. A possible explanation of this phenomenon might be that successful interactions through targeted bespoke networking are largely contingent upon the actors' agendas and interests, and the extent of entrepreneurial and interactive capability of the individuals managing or leading the centre. In accordance with the present finding, previous studies demonstrated the link between place-based innovation ecosystem performance and ecosystem actor leaders' interactive capabilities (Cele et al., 2020; Daniels et al., 2021).

On the question of exploring the conditions that (might) make firms and other actors want to interact with the identified innovation incubation centres, this study found five main factors that participants thought would make firms and other actors inclined to interact with university-based innovation incubation centres. Drawing on the participants' insights and perspectives presented in section 7.3.2 above, Table 7.3 below provides a summary of factors which this author argues would, if addressed, place KIC KS university-based innovation incubation centres in a position to attract firms and other actors for collaboration. Table 7.3 also illustrates the actors who this thesis suggests would lead the realisation of the corresponding factor and the potential implications that this would present for the centre and/or host university or host entity.

Table 7.3. Conditions for KIC Knowledge Space university-based innovation incubation centres to attract collaborators

Condition/Factor	Responsible lead actors	Implications
Creating sufficient and decent physical space	▪ Host university/entities ▪ Incubation centre	Financial investment in infrastructure development.

Condition/Factor	Responsible lead actors	Implications
Allocating sufficient time to incubates and staff	▪ Host university/entities ▪ Incubation centre	▪ Changes to mainstream academic curriculum. ▪ More innovative solutions (products or services) created.
Increasing public awareness of innovation activities	▪ Incubation centre ▪ Host university/entities	Expanded engagement opportunities.
Building/Strengthening the capacity of centre managers and staff in entrepreneurship, innovation, and negotiation skills.	▪ Incubation centre ▪ Host university/entities	Improved ability to: (i) raise funding, (ii) attract and nurture more incubates, and (iii) influence industry and other actors to invest in R&I and learning.
Building/strengthening the capacity of centre managers and staff in intellectual property rights.	▪ Incubation centre ▪ Host university/entities	Normalised institutional or organisational capacity in R&I management.
Defining and maintaining identity and values.	▪ Incubation centre	Potential for creating relevant networking opportunities.

Source: Author's compilation based on empirical data

As can be seen from Table 7.3 above, capacity strengthening of innovation incubation centre managers and staff was reportedly significant in having the greatest and most varied implications for the centres, host universities, and the broader innovation ecosystems the centres belong to. In accordance with this finding, previous studies demonstrated that in a STEM-dominated innovation ecosystem, it was imperative for STEM 'scientists and engineers to acquire business skills or gain access to skilled personnel' (Etzkowitz, 1996; Ranga and Etzkowitz, 2013; Twiringiyimana et al., 2021) through collaboration with non-STEM universities or with schools, centres attached to a university, or else other actors who might possess these capabilities and expertise.

7.7.3 Innovation incubation centre programme alignment with KIC's development – proximity matters

With respect to RQ6, this study investigated whether, and if so, how university-based innovation incubation centre programs related to KIC's development activities and

planning. Under this theme, the study found that cognitive proximity, in terms of related academic programme, research, and innovation activities of common interest, encouraged the innovation incubation centres from KIC's Knowledge Space academic actors and those from the government sector to interact with KIC's Knowledge Space central actors, and other actors. The GIIH Innovation Week in Box 7.1 below exemplifies the alignment with KIC through cognitive proximity. This finding broadly supports other studies in this area linking proximity with propensity for interaction (Mattes, 2012; Marrocu et al., 2013; De Fuentes and Dutrénit, 2016).

Box 7.1. GIIH Innovation Week 2023

Created in 2021 and hosted by UR ACE-ESD's innovation incubation centre, GIIH, Innovation Week is an annual innovation exhibition event aimed at influencing Rwanda's innovation ecosystem by bringing together several actors with interests in entrepreneurship and innovation support for development. The fundamental aim of the week is to seek to showcase student-led technological innovations that address the most pressing societal challenges in Rwanda and Africa, most specifically in the ACE-ESD priority research areas: energy, food, and water, with a deliberate emphasis on sustainability and inclusivity. The 2nd edition of the event, Innovation Week 2023, was held at UR, bringing together several actors from Rwanda's science and innovation system. The event was officiated by senior officials including Rwanda's Minister of Education, Minister of ICT and Innovation, the UNDP Resident Representative for Rwanda, and UR's Vice Chancellor⁵¹.

In response to the hypothetical question as to whether moving innovation incubation centres from host entities to KIC premises would (or not) lead to a better alignment of their programs with those of KIC, this study found that geographical proximity would enable KIC KS university-based innovation incubation centres to be better aligned with KIC's priority development areas. Several factors could explain this observation. For instance, the co-location and concentration of university-based innovation centres in KIC may increase the population of talented students, graduates, and academics, creating opportunities for active engagement in innovation and entrepreneurship activities through interactions, co-learning, and co-creation. Additionally, with funding

⁵¹ UR ACE-ESD GIIH Innovation Week 2023
<https://giih.ur.ac.rw/innovationweek/> [Accessed: 14 February 2024]

and investment opportunities like the aforementioned ones, some of the innovations developed by these students, graduates, and academics may translate into viable businesses, thereby creating knowledge-based and technology-driven jobs. Moreover, the increase in university-based innovation centres would imply the development of further amenities, thus creating additional opportunities for small-scale businesses and both skilled and non-skilled jobs. However, a contrasting finding from one participant from KIC's Knowledge Space academic actor in proximity suggested that the alignment with KIC should be viewed not only in terms of meeting KIC's development goals, but also of whether the alignment corresponds to the mission, purpose, and needs of the individual innovation incubation centres currently hosted elsewhere. The same participant claimed that these systematic factors should determine whether or not it is suitable to move the centre to KIC.

7.7.4 Supporting innovation incubation centres – potentials and pitfalls

This study found that both university-based and state-based innovation incubation centres enjoyed the hosting by a university or government entity, and support in a range of domains including administration, finance, infrastructure, and technical activities. From a technical standpoint, the results of this study showed that coordination of innovation and entrepreneurship activities and mentoring of incubates were the most important aspects where centres leveraged the capacity and expertise of host universities and/or government agencies. As mentioned in the Literature Review, chapter two of this thesis, these findings in part concurred with previous studies which delineated the characteristics of entrepreneurial universities and entrepreneurial states, and how these capabilities, collectively and often co-existentially, contributed to the formation and support of knowledge-based innovation ecosystems (Audretsch et al., 2019; Wadee and Padayachee, 2017).

While mentorship of incubates was identified as one of the fundamental activities in supporting incubates, the study found that there was adequacy of mentorship capacity and capabilities across the university-based and state-based innovation incubation centres studied in the research. One interesting finding that was found to be significantly associated with incubate mentors' capability was that despite having a STEM background, some of the mentors from KIC' KS actors in proximity lacked or possessed limited communication skills using modern digital technologies and

platforms, thereby jeopardising interactions with assigned incubates. A possible explanation for this might have been that some of the mentors may have been old-school scientists and/or engineers lacking communication skills with modern technologies. This thesis thus contends that the capacity strengthening needed for the university-based and state-based innovation incubation centre mentors spanned innovation and entrepreneurship support to include skilling, re-skilling, and/or up-skilling in communications using modern digital technologies. Most striking also was the expanded meaning of mentorship in state-based innovation incubation centres. In addition to its technical dimension of incubate coaching, mentorship had adopted a further meaning named in this thesis as ‘trust stamp’ for incubates. For example, this study found that for NIRDA’s bio-hackathon, university graduates who were not yet employed were required to identify a mentor from their previous university as a sign of official affiliation. Several factors could explain this rather intriguing finding. Firstly, state-based innovation incubation centres viewed universities as trusted partners and guarantors for graduates. Secondary, there may have been mistrust in whether, and if so, how selected incubates would use the funds for their intended purposes. Thirdly, this may have been a way of encouraging and facilitating interactions between universities and alumni, which may have yielded further outcomes beyond incubation.

Moreover, these findings corroborate previous studies that have highlighted the contextual and practical realities underpinning the functioning of innovation hubs in Rwanda, extending beyond abstract visions and technical considerations. Drawing on grounded empirical case-study research of two innovation hubs in Kigali, Friederici (2018) revealed that while clear policy missions, goals, targets, and aspirations, along with the availability of knowledge capabilities and physical infrastructure, are important, they are neither necessary nor sufficient conditions for determining the success or failure of an innovation hub. The research identifies four practical factors underpinning the implementation of an innovation hub in Rwanda: (i) the hub community – setting the conditions and boundaries for inclusion and exclusion of hub members; (ii) community dynamics and the associated tensions for growth – such as choosing between inclusive and diverse or selective approaches to hub stakeholders, and how these interrelate with the hub’s goals and targets; (iii) organisational culture and identity, ‘resulting from overlaps in values, demographics and interests of community members at a given point in time’; and (iv) funders’ and founders’ personal

visions – their maintenance and adaptation in alignment with the hub’s missions. (Friederici, 2018, p. 17-18). Embedding awareness of these contextual factors – and an understanding of the possible tensions and contestations associated with them – into capacity-strengthening efforts for innovation hub leaders, managers, and stakeholders may contribute to the hubs achieving their intended goals while responding to diverse stakeholder needs and interests.

On the innovation funding front, this study found that the majority of funding mechanisms or instruments focused on STEM areas of Rwanda’s ST&I policy, partly indicating the extent to which Rwanda’s government believed in technological innovation being central for the country to attain its development outcomes (Chataway et al., 2017; Mugwagwa et al., 2020a; Twiringiyimana et al., 2021). As one of the main goals of this research underpinned by a critical realistic view was to explore *in-situ* the constructs of Rwanda’s science and innovation ecosystem, it dived deeper to explore the nature and possible causal factors of the inadequacies in the innovation funding mechanisms in KIC KS university-based and state-based innovation incubation centres as well as other R&I funding mechanisms on a national and/or sectoral scale. As indicated in Table 7.2 above, the innovation funding mechanisms or instruments ranged from (i) as basic sector-specific innovation incubations as the INNOVATE4 Disability Inclusion Hackathon by RISA, and the Innovate for Smart Agro-processing, run by NIRDA’s Innovation Hub, with funding ranging from about \$400 to about £5,000 per project to support innovation ideas. This level was similar to the funding range for university-based innovation incubation centres, through (ii) the National Research and Innovation Fund (NRIF) run by NCST to support R&D-based innovation projects with a maximum funding of up to approximately \$120,000 per project, to (iii) the Rwanda Innovation Fund (RIF) run by RDB, supporting growth-stage startups with funding ranging from \$250,000 to \$2 Million per project. As can be seen from Table 7.2 above, innovation funding instruments at stage (i) supported innovations developed mainly through the DUI model, while those at stages (ii) and (iii) supported innovation through R&D or the ST&I-based model (Yongabo, 2021b). In addition to the existing innovation funding mechanisms being insufficient to support the new technological innovation development life cycle from innovation idea stage to market readiness (Washbourne et al., 2021; Martínez-Plumed et al., 2021), what was surprising was the lack of any coordination mechanism amongst actors to support innovators and entrepreneurs

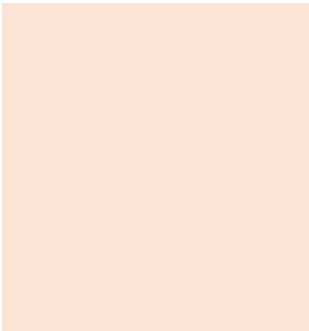
through these stages, which may have caused stagnation of the innovation development process, and hence undermined the ecosystem growth. This finding broadly supported the work of other studies in this area, linking actors' siloed mode of functioning with the underperformance of innovation ecosystems (Suominen et al., 2018), particularly in the context of funding scarcity (Friederici, 2018; Mugwagwa et al., 2021).

In its search for a conceptual framework through which to analyse the funding mechanisms for innovation activities through the DUI model, this work adopted a systemic approach to the Technology Readiness Levels (TRL) framework (Martínez-Plumed et al., 2021) to assess Rwanda's contemporary funding system for ST&I-based product innovation development, through the nine technology readiness levels, with the focus on contemporary funding mechanisms and leading actors within Rwanda's science and innovation systems. To cast the net wider and deeper with a critical realist's standpoint, and building on Martínez-Plumed (et al., 2021) and Washbourne (et al., 2021), this study drew parallels between the TRL framework, the R&D-based innovation financing theory, and the technological innovation venture growth, in a quest to uncover any gaps in Rwanda's mainstream innovation funding system, as illustrated in Table 7.4 below.

Table 7.4. Contemporary Rwanda ST&I-based model innovation funding system through a TRLs lens

Goal	TRLs	Product	Description	Theoretical funding estimates in \$ ⁵²	Funding Instrument	Lead actor
Deployment or implementation	or TRL9	Deployed product	Actually system proven in operational environment	25M		

⁵² R&D-based innovation financing theory and technological innovation venture growth suggest eight stages of an R&D-based innovation development, with corresponding funding mechanisms, from basic research when an R&D-based innovation firm is created, through applied research, proof of concept, working prototype, engineering prototype, production prototype, product introduction, to revenue grow. From a funding perspective, R&D-based innovation financing theory defines stages three (proof of concept) through to final stage eight (revenue growth) of firm lifecycle as the '*valley of death*', and this is partly due the amount of funding required at these stages and systemic complexities of actors and processes involved. See details in (Washbourne et al., 2021, p. 26).

Goal	TRLs	Product	Description	Theoretical funding estimates in \$ ⁵²	Funding Instrument	Lead actor
Development	TRL8	Commercial (certified) product	System complete and qualified	2M-50M	RIF (250k-2M)	RDB
	TRL7	System prototype	System prototype demonstration in operational environment	500k-2M		
	TRL6	Engineering prototype	Technology demonstrated in relevant environment	50k-500k		
	TRL5	Working prototype	Technology validated in relevant environment			
	TRL4	Early prototype	Technology validated in Lab			
					NRIF/RIC-R&D Phase I; GCR; NRIF/RIC-R&D Phase II (95k -?)	NCST
Research (basic and/or applied)	TRL3	Proof of concept	Experimental proof of concept	5k-50k	NRIF/RIC (4k-8k)	
	TRL2	Concept	Technology concept formulated			
	TRL1	Early innovation idea	Basic principles observed			

Source: Adapted from Martínez-Plumed et al. (2021) and Washbourne et al. (2021).

As shown in Table 7.4 above, this study found that Rwanda's ST&I policy was geared towards supporting R&D-based technological innovation with two mainstream innovation funding instruments: RIF and NRIF, with the former being managed by RDB while the latter was coordinated by NCST. This study also found several funding instruments supporting the DUI model of innovation as shown in Table 7.2 in the preceding section of this chapter. In accordance with these findings, relevant literature

has demonstrated that Rwanda's contemporary innovation policy approach spanned frame 1 and frame 2 of the innovation policy models (Chataway et al., 2017; Twiringiyimana et al., 2021; Yongabo, 2021b);. However, from a technology readiness level and funding, and structural perspectives, as can be seen in Table 7.4 above, this study found that the NCST NRIF fund supported the R&D-based technological innovation from TRL1 (research from early innovation idea) to TRL4 (early prototype), with RDB RIF serving as an early-stage venture capital to support technology-enabled firms, *aka* startups, at approximately TRL7 and TRL8. However, this study found that there was a funding, institutional, and organisational gap in supporting technological innovations at development stage (TRL5 and TRL6), and at deployment stage (TRL9), as highlighted in orange colour in Table 7.4 above. A possible explanation for this striking finding might be the absence of institutional and organisational alignment to unlock this process and enable the systematic transition of technological innovations across TRLs. An implication of this innovation policy phenomenon is that, with a contemporary innovation funding architecture, it might be cumbersome to adequately assess R&D-based technological innovation readiness in Rwanda from a public innovation funding and systems perspective.

Perhaps the most interesting finding in the present theme was the PPP model of a public innovation fund management. The delegation of power for RIF to be managed by an international organisation on behalf of Rwanda's RDB raised a policy question on how the absorptive capacity of local innovation management actors was to be achieved within Rwanda's NIS. This finding was contrary to previous studies which suggested that NIS was shaped and strengthened by, and thrived on embedded local capabilities (Feinson, n.d.; Mugwagwa and Eaton, 2021). A possible explanation for this might nonetheless be in part an indication of the extent to which Rwanda's contemporary innovation space was open to international actors. Another striking finding was that the RIF call framework fell short of indicating the policy's intention to incentivise potential applicants to locate their startups in KIC premises (GoR, 2023a). Moreover, this study found that the RIF management firm was located at the time at Norrsken House, Kigali⁵³, an emerging non-governmental entrepreneurial and innovation ecosystem being developed in Kigali city centre, not in KIC. There are

⁵³ <https://www.norrsken.org/eastafrica> [Accessed: 10 February 2024]

several explanations for this interesting finding. Firstly, the fact that the RIF was not being managed by KIC contrasted with the views of a number of participants from central government who thought otherwise. This contradiction in part concurred with the earlier findings in chapter five of this thesis about the limited understanding of KIC across KIC's ecosystem actors. Secondly, the hosting of RIF elsewhere than in KIC premises may in part have implied Rwanda's innovation policy shifting knowledge-based innovation ecosystems towards multiplication rather than consolidation. Thirdly, the limited built environment may have made KIC unfit for hosting RIF management, reflecting the state of KIC as an evolving programme in development. Fourthly, RIF management firm not being hosted in KIC may imply a policy shift in the direction of KIC as an evolving flagship policy instrument. The latter proposed implication resonated with one participant from KIC's Knowledge Space central actors who thought that KIC's development should rather be named a '*Knowledge City*' focusing on world-class academic, research, and entrepreneurial education.

7.7.5 Exploring policy options for KIC's transition to an Innovation Space

The preceding section discussed the challenges and opportunities associated with the contemporary innovation policy interventions in supporting both university-based and state-based innovation incubation centres or programs. Drawing on the findings from participants' perspectives and insights in addressing part of RQ6 under this emerging theme, and guided by the integrated analytical framework presented in chapter seven, this section takes the discussion further to interrogate the factors underpinning the proposed policy options for KIC's transition from a KS to an IS. On this question, this study found that attracting established technology firms to KIC might be a viable and complementary policy option in addition to supporting KIC's Knowledge Space university-based start-ups and spinoffs. From the findings, a comparative analysis of both these policy options is presented in Table 7.5 below, showing the policy implications for the success (or failure) of each of the two options against seven factors.

Table 7.5. Comparative analysis of policy options for KIS' transition to an Innovation Space

Factor	KIC University Start-ups promotion and support	Attracting large international tech firms
Strategy in timescale and investment	Long-term investment strategy.	Immediate to short-term investment strategy.
Uncertainty and risk	▪ High uncertainty, with high rate of failure. ▪ Risk often solely borne by government or funding actors.	▪ Low uncertainty. ▪ Financial and operational risk shared between government and partner company.
Technology readiness	▪ Research and early-experimental development: from experimental proof-of-concept to early prototype stages (TRL3-TRL4). ▪ Potential systemic lag: it takes far too long for ideas to mature.	▪ Deployment: from system prototype to deployed product (TRL7-TRL9) ▪ Potential systemic leapfrog: it creates the possibility of leading in newest tech and market trends.
Societal and market needs or demands of response	▪ Exploring future problems and solutions. ▪ Contextually relevant and embedded solutions.	▪ Provides solutions to contemporary societal needs and actors' interests. ▪ Requires adaptation to new context.
Human capital development	▪ Graduates and incubates with no or meagre market experience. ▪ Talented university graduates possess ability to work on newer problems.	▪ Experienced managers, product management and marketing expertise. ▪ Experienced managers create natural workforce environment.
Job creation	Specialised and limited job opportunities	Diversified, technical and non-technical, job opportunities.
Policy and regulatory environment	▪ Robust PPP-model with top-tier entrepreneurial universities ▪ Deliberate effort to strengthen local HE to train talented graduates.	▪ Robust PPP-model with technically-credible companies. ▪ Deliberate effort to enable knowledge and technology circulation for greater absorptive capacity development outcomes. ▪ Government buy-in and agile policy and regulatory systems.

Source: Author's compilation based on empirical data

The empirical findings presented and discussed in Table 7.5 broadly support the work of other studies in science, technology, and innovation areas linking policy and place-based innovation ecosystem performance outcomes (Dosso et al., 2021; Dosso, 2020a). For example, in accordance with the present findings, a recent study on a healthcare innovation system in Rwanda demonstrated that successful disruptive innovation in Rwanda's healthcare supply system by an multinational company (MNC), with flying robots, *aka* drones, was fundamentally contingent upon a range of key factors such as pre-defined social demand, the relevant firm's technical capabilities, governmental buy-in, agility of policy, and regulatory environment (Amaechi et al., 2021). The present findings further accord with previous research, which highlighted that attracting NMCs is part of catch-up strategies aimed at improving the performance of NISs in developing countries (Watkins et al., 2015). A strong relationship between demand and innovation through technological push was also reported in the literature (Di Stefano et al., 2012). However, the findings presented in Table 7.4, challenged the mainstream literature on Rwanda's 'proof-of-concept' narrative as a policy innovation strategy to attract international technology actors (GoR, 2019c; Daniels, 2021, p. 31). As can be seen in Table 7.4 above, particularly with regard to the 'technology readiness' factor, and as demonstrated in Amaechi et al.'s (2021) work, the MNC brought its technological products at deployment stage. However, the policy narrative of Rwanda being a proof-of-concept hub might stand when viewed from the perspective of policy intervention at experimentation stage (Sly et al., 2022). The findings discussed in this section might provide initial evidence to inform policy options regarding KIC's transition from KS to IS. Moreover, the present findings provide the starting point for examining the conditions under which the GoR can attract NMCs in ways that enable technology and knowledge adoption and diffusion (Watkins et al., 2015); GoR, 2019c; Daniels, 2021), as part of catch-up strategy to enhance Rwanda's wider NIS.

7.8 Chapter summary

This chapter set out to explore the policy options underpinning KIC's transition from KS to IS. Based on the findings presented in chapter four, this chapter drew on empirical data to unpack KIC' KS academic actors' university-based innovation incubation centres or hubs in response to RQ5 - *How do KIC's Knowledge Space*

academic actors interact with industry and other actors for RIL? This chapter explored other policy options for KIC to transition to IS in response to part of RQ6 - *What is the role of government agencies and other actors in supporting the development of KIC into a knowledge-based innovation ecosystem?* This chapter identified the existence of innovation incubation centres hosted by KIC KS academic actors. It also discussed the ways in which these university-based innovation incubation centres were structured, governed, and funded. Moreover, the chapter discussed the approaches through which university-based innovation incubation centres could interact with industry and other actors. The chapter furthermore discussed how the geographical and cognitive proximity of university-based innovation incubation centres might (or not) influence the alignment of centres' innovation programs with KIC's development and planning. Aside from the university-based innovation incubation centres, this chapter discussed state-based innovation incubation centres or programs with a similar potential to contribute to KIC's transition to IS. This chapter also debated the potentials and pitfalls pertaining to contemporary support mechanisms for both university-based and state-based innovation incubation centres and programs. Further to interrogating the innovation incubation model, this chapter ended with exploring whether, and if so, how attracting international technology firms might be a policy option for KIC's transition to IS as it evolves into a place-based knowledge-based innovation ecosystem.

Guided by the integrated analytical and conceptual framework underpinning this study, the research found that variations in the governance and funding of university-based innovation incubation centres structures were largely contingent upon the mainstream structural architectures of the universities or KIC KS academic actors the centres were embedded in. The second major finding was that innovation exhibitions and other networking events organised by KIC's Knowledge Space academic actors in proximity or government, were the major avenues for the university-based innovation incubation centres, and to some extent the state-based innovation centres, to interact with KIC's Knowledge Space central academic actors or KIC's management team. The implication of this finding was that there may have been a limited policy framework for these innovation incubation centres to contribute to KIC's development. From a funding perspective, the findings reported in this chapter shed new light on the parallel nature of the innovation funding architecture in Rwanda and its implication for KIC. On

the one hand, the DUI-model of innovations undertaken by incubates at university-based and state-based innovation incubation centres was largely funded by non-governmental organisations, notably UNDP. On the other hand, the R&D-based or ST&I-based models of innovation activities were largely funded by government and were institutionalised, with NRIF being managed by NCST, while RIF was overseen by RDB. However, this study found that there was institutional disconnect in the ways these funds operated, and a framework to reconcile these two ST&I-based model innovation funding instruments was proposed through TRL and R&D-based innovation theory lenses (see details in Table 7.4. on Rwanda's contemporary ST&I-based model innovation funding system through a TRLs lens). Despite both NRIF and RIF focusing on technology-enabled sectors largely similar to KIC's priority sectors, this study found no direct or specific aspect of these funds targeting KIC actors. These findings raised an important question about the nature of Rwanda's innovation funding model and how it was contributing to Rwanda's innovation policy outcomes with regard to national innovation flagship programs such as KIC. This would be a fruitful area for further work.

Another important finding presented in this chapter was the vital role played by international actors in shaping the direction of Rwanda's NIS. In addition to RIF playing a central role in innovation funding, it was found in this study to have been managed by a private international organisation based on the PPP-model of policy innovation. Moreover, this study found that attracting MNCs may be a viable and complementary policy option not only to support KIC's transition from KS to IS as it evolves towards becoming a place-based knowledge-based innovation ecosystem, but also to contribute as a catch-up strategy to enhance Rwanda's NIS. This chapter suggested a framework that might help in developing an understanding of the implications of this policy option for KIC and Rwanda's innovation ecosystem at large.

Drawing on empirical and secondary data, the following chapter further explores KIC's Knowledge Space actor interactions for RIL from an urban innovation perspective.

Chapter 8. KIC as an urban smart city initiative: Unpacking the relationship dynamics between control, contingency, embeddedness, and inclusivity dynamics

8.1 Introduction

The preceding empirical chapters four, five, and seven of this thesis presented and discussed Kigali Innovation City (KIC) from a science, technology, and innovation (ST&I) policy intervention perspective. In addition to exploring KIC's ST&I policy intervention characteristics, this thesis also aimed to investigate KIC from an urban innovation perspective. This chapter thus looks at the importance of KIC's *spatial* dimension – as a physical space providing geographical proximity, enabling social interactions and/or access to key amenities or technologies. In response to the seventh RQ of this thesis – *What specific characteristics define Kigali Innovation City as an urban smart city initiative, and to what extent do Kigali Innovation City's Knowledge Space actors interact with adjacent communities in its geographical setting?* – and drawing on the empirical data collected through expert interviews, this chapter aims to investigate the expert perspectives gained about KIC, how it was characterised as a smart city initiative in the context of its peri-urban geographical locale. As presented in the Literature Review, chapter two of this thesis, although often abundantly cited in policy narratives, the terms 'smart' and 'smart city' can and do mean many different things to different people. This chapter also explores how KIC's Knowledge Space actors, *aka* KIC's citizens and their smartness, may or not influence (or be influenced by), the rest of the City of Kigali's actors including, *inter alia*, the local authorities and communities in proximity. Moreover, this chapter discusses the implications of these interactions for the inclusive urban knowledge-based innovation city that KIC aspires to become.

The findings presented in this chapter were analysed based on Adu's (2019) description- and interpretation-focused approaches to the thematic analysis of empirical data, with significant information addressing RQ7. Chapter three of this thesis provided a detailed account of the methodological approach underpinning this research. This chapter adopted Bulkeley et al.'s (2019) typology of a smart city initiative to analyse and discuss the findings through the lens of this work's multi-staged, integrated analytical framework for actor interactions for RIL – as presented in

chapter five of this thesis. The key findings are presented in five themes constituting the sections of this chapter: (i) *Defining the term ‘Smart’*, (ii) *Describing KIC as a smart city Initiative and its role in relation to the rest of Kigali*, (iii) *Describing the role of smart city tech or platforms for KIC actors*, (iv) *KIC tech project experimentation, sustainability, and inclusivity*, and (v) *Exploring potential areas for collaboration for greater KIC local embeddedness and relevance*. Detailed findings for each of these themes are presented in sub-sections below.

8.2 Defining the term ‘Smart’

The first part of RQ7 aimed to seek expert views on the meaning of the term ‘smart’ as it is understood in the context of urban innovation. Fig. 8.1 below provides a summary of demographics of seven research participants, with anonymised identifications P_PPS02, P_PPS04, P_PPS05, P_PPS09, P_PPS10, P_PPS11, and P_PPS12, who contributed insights about what ‘smart’ meant from their respective perspectives. These participants were drawn from a range of organisations including KIC’s Knowledge Space academic actors – central and in proximity, central government, industry, and NGOs.

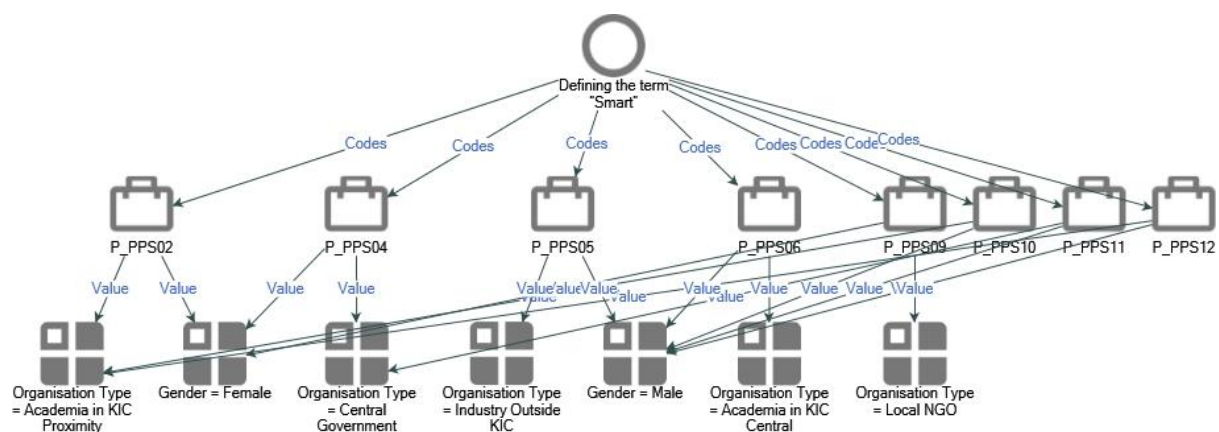


Figure 8.1. Mapping of participant demographics for theme 8.2

Source: Author’s design with NVivo based on empirical data

When asked how they would define the term ‘smart’ in a few words, the research participants presented in Fig. 8.1 above provided a wide range of definitions, as can be seen in Table 8.1 below:

Table 8.1. Research participants' interpretation of the expression 'smart'

Participant ID	Proposed definition of 'smart' from an urban perspective
P_PPS02	"A space for innovation, (...) it brings together smart people in charge of driving the innovation system of the country (...) leading to the well-being of people'.
P_PPS04	'Efficiency (...) accessing information easily, sharing information easily, using technology easily, for the well-being of citizens'.
P_PPS05	'Connectivity (...) access to information, communication in such a way [the] people are able to communicate easily and faster'.
P_PPS06	'Impact for all (...) through digital public goods'.
P_PPS09	'A city which has to improve the life of its residents'.
P_PPS10	'Infrastructure or services that are all designed to minimisation of carbon emissions. They are designed to facilitate the deployment of green energy (...) having spaces that are facilitating environmental protection'.
P_PPS11	'Integration and the adoption of modern technologies such as IoT, Blockchain, data science, embedded systems, software engineering (...) anything that is related to this 4 th industrial revolution leads us into smart something'.
P_PPS12	'Use of technology to improve people's lives or to collect data from them'.

Source: Author's compilation based on empirical data

As can be seen from Table 8.1 above, the term "smart" was given a broad range of definitions interpreting it on the basis of five main distinctive characteristics such as: *people, space – physical or virtual – process, product, digital technology, infrastructure, service, and activity*. Interestingly, irrespective of the variations in their characterisation of what 'smart' meant, all the participants were unanimous in the view that smartness was (or should be) leading to the well-being of the people and facilitating protecting the environment.

8.3 Describing KIC as a Smart City Initiative and its role to the urban setting

Drawing on previous sub-question, the next past RQ7 aimed to understand the characteristics of KIC as a smart city initiative and its role to urban development of City of Kigali. Fig. 8.2 below presents an overview of demographic information on nine research participants, with anonymise identifications P_PPS01, P_PPS02, P_PPS04, P_PPS06, P_PPS09, P_PPS10, P_PPS11, P_PPS13, and P_PPS14, who shared perspectives about the perceived determinants of KIC characteristics as a smart city initiative in the context of urban innovation and development. These participants were drawn from a range of organisations including KIC's Knowledge Space academic actors - central and in proximity, central government, NGOs – local and international.

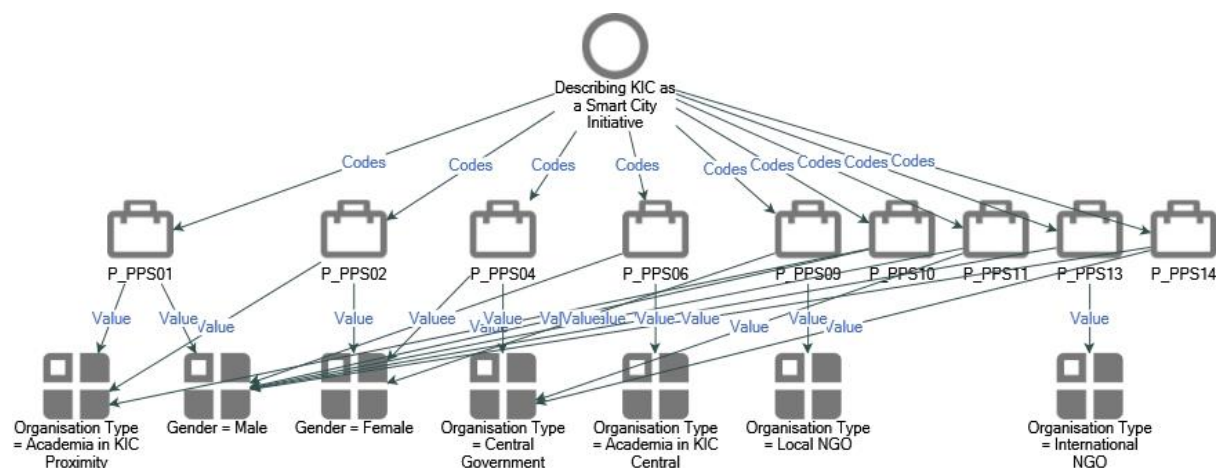


Figure 8.2. Mapping of participant demographics for theme 8.3

Source: Author's design with NVivo based on empirical data

Drawing on their respective expertise, roles, and experiences, nine participants provided varied descriptions of KIC as a smart city initiative as shown in Table 8.2 below.

Table 8.2. Research participants' interpretation of KIC as a smart city initiative with respect to City of Kigali

Participant ID	Perceived description of KIC as a smart city initiative with respect to City of Kigali
P_PPS01	• A space where the innovations and plans of transforming the City of Kigali can be forged, for urbanisation, infrastructure, and/or technology uptakes. • A constellation of spaces where different policy makers and practitioners can go and learn how to implement the changes effectively for the city's development.
P_PPS02	• A space where best quality products are developed fast through innovation, and those products are meant to benefit people.
P_PPS04	• A space for innovations that help the citizens, such as smart transport systems, easy access to public and private services via online platforms.
P_PPS06	• A space for start-ups and laboratories leading on innovations such as carbon off-setting, for urban resilience and sustainability.
P_PPS09	• A city of smart people, quick thinkers, with the ability to respond spontaneously to challenges facing the society.
P_PPS10	• A science ecosystem of universities, with ability and opportunities of interacting with the industry and community in its vicinity.
P_PPS11	• An initiative aiming for (i) no one to be left behind in the era of industrialisation using modern technologies, and (ii) supporting young innovators thereby enabling and enhancing local innovation competitiveness on national, regional, and international markets.

Participant ID	Perceived description of KIC as a smart city initiative with respect to City of Kigali
P_PPS13	• A programme using IT [information technology] to improve operational efficiency, and ways to shape better interactions with the public across the city.
P_PPS14	• A physical space for experimenting several solutions, as part of both Africa continental and Rwanda national smart cities initiative, underpinned by shared infrastructure that is leveraging new technologies, such as electric vehicles, public lighting, going green through carbon emission off-set efforts, and deployment of technology such as Wi-Fi coverage.

Source: Author's compilation based on empirical data

As can be seen in Table 8.2 above, the majority of participants referred to KIC, in relation to the City of Kigali, as a physical space characterised by the smartness of its citizens, the knowledge and technological innovation solutions developed and experimented by its citizens, as well as its amenities and physical infrastructure. They also suggested the ways in which these capabilities benefited (or may benefit) the rest of the City of Kigali's citizens, including the community in KIC's immediate vicinity, and other actors in Rwanda and in the African continent in general. Interestingly, some participants indicated that KIC's perceived role was to ensure Kigali's urban resilience and sustainability. Commenting on KIC's contemporary geographical location as 'a science ecosystem of universities'. In relation to Kigali's urban and peri-urban settings, participant P_PPS10 said: *"Previously, the ideas of science, parks, industrial parks, were traditionally being located outside the city. In the present era the tendency is to have innovation packs or science parks, or innovation hubs clustered within the city."* (Research Participant P_PPS10, 2022). This view was echoed by participant P_PPS06 who stressed the importance of the geographical co-location of actors for such an early-stage innovation ecosystem as KIC. The same participant went on to suggest that co-location offered opportunities for both infrastructural resources and human resources to share, including the faculty, while attracting more actors through the snowball effect. However, the same participant contended that digital technology-

based innovation and business could be located anywhere in Kigali, in Rwanda, or in the continent.

8.3.1 Unpacking KIC's smartness from a peri-urban perspective

The Introduction chapter of this thesis showed the urban context of the City of Kigali with 70% of its territory being rural and only 30% urban. The Gasabo district, where KIC is located, is one of the three districts of City of Kigali. It is also the largest and most rural part of City of Kigali. Given its geographical location, KIC is peri-urban as it is surrounded by a typical rural setting, with the exception of its industrial area, which is located on an adjacent hill (see chapter four for details). Taking a peri-urban perspective of KIC, two participants indicated the importance of KIC's infrastructure such as electricity and internet connectivity for the communities in KIC's vicinity. Talking about the ways in which KIC may have been contributing to promoting inclusive electricity and internet connectivity, participant P_PPS05 indicated that KIC's internet connectivity facilitated access to information and communications in such a way that people were able to communicate easily and faster. This view was echoed by participant P_PPS12 who said: *"you can make it [KIC] smart and use technology to improve people's lives or to collect data from them"* (Research Participant P_PPS12, 2022).

8.4 Describing the role of 'smart city tech' or platforms for KIC actors

The next sub-question of RQ7 was to explore the ways in which smart city technologies or platforms being developed in KIC were utilised or might be utilised at grass roots level by academics and other actors who used (or expected to) use KIC's facilities for learning, research, and/or innovation activities. Fig. 8.3 below shows the demographic information from two participants with the respective anonymised identifications P_PPS02 and P_PPS13, drawn from KIC's academic actors in proximity and an international NGO collaborating with KIC, respectively.

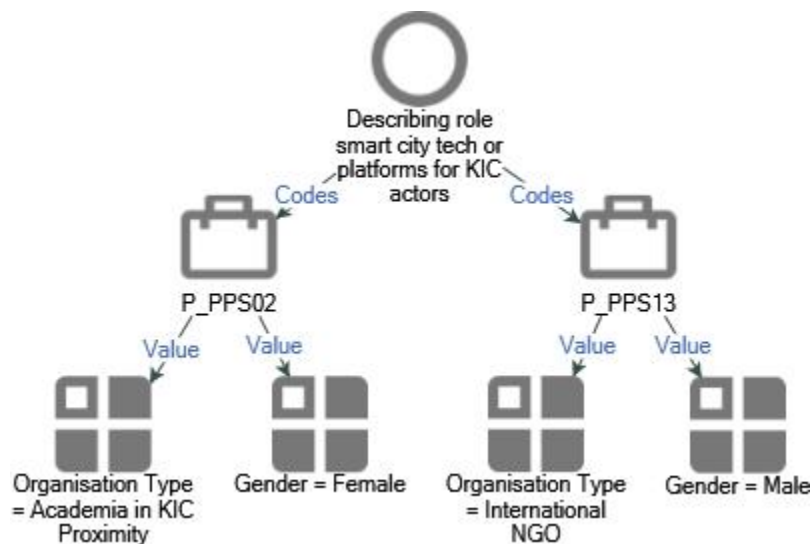


Figure 8.3. Mapping of participant demographics for theme 8.4

Source: Author's design with NVivo based on empirical data

Commenting on how smart technologies and platforms such as the Internet of Things (IoT) and Artificial Intelligence (AI) developed by KIC's Knowledge Space actors might be utilised by academia actors in KIC and other actors, participant P-PPS02 indicated that researchers were categorised into two types: the first category comprised the academic researchers in Science, Technology, and Engineering and Mathematics (STEM), who designed these technologies, with the second category encompassing non-STEM researchers who used these technologies in their scientific research aimed at contributing to societal well-being. Commenting on the way in which these interactions with non-STEM scientists and other actors benefited STEM researchers who developed those technologies, the same participant said: “(...) *academics or even other actors who interact with the technologies, give feedback to the scientists working on those technologies (...) towards improvement*” (Research Participant P_PPS02, 2022). Talking about the same issue from a teaching and learning perspective, participant P_PPS13 indicated that smart city technologies provided the opportunities for KIC's Knowledge Space actors, *aka* universities, to put into practice what they taught their talented students. In addition to teaching and learning, participant P_PPS13 also suggested that KIC technologies and talented students might equally benefit the industries in KIC's vicinity. Talking about this issue from a co-location or physical proximity perspective, the same participant said: “...*even those industries ranging from agricultural technology, also might benefit from*

having this world class students close to them so that they can actually use them to increase the profits, and then make use of their talents that are world class". (Research Participant P_PPS13, 2022).

8.5 KIC tech project experimentation, sustainability, and inclusivity

In response to RQ7, this research sought to explore any technological or non-technological experimentation projects or programmes being or planned to be implemented as part of KIC's development. Fig. 8.4 below illustrates the overview of demographics of two participants, with anonymised identities P_PPS06 and P_PPS07, from KIC's Knowledge Space central and industry actors respectively, who contributed thoughts and perspectives in response to this sub-question.

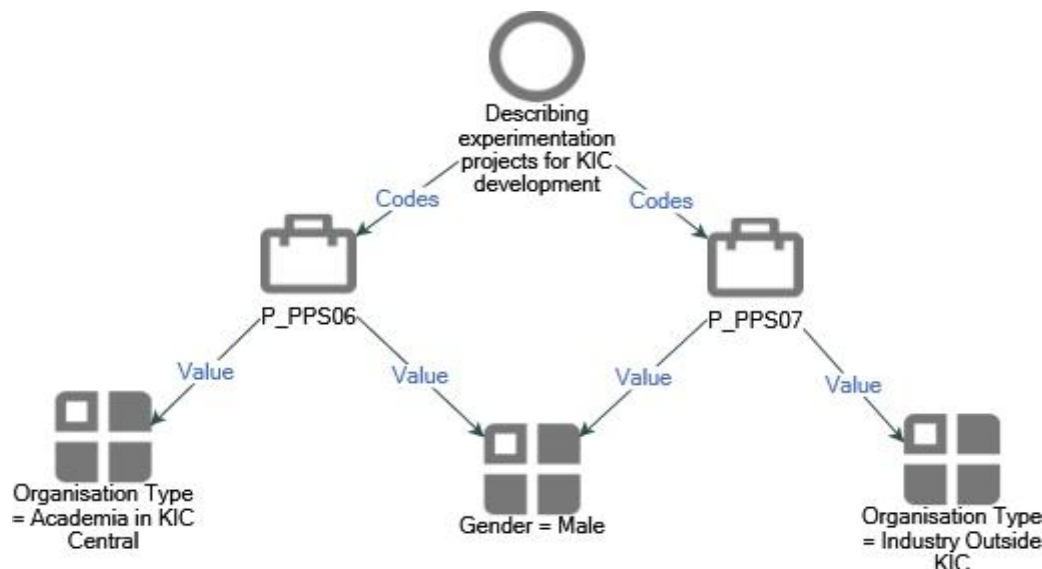


Figure 8.4. Mapping of participant demographics for theme 8.5

Source: Author's design with NVivo based on empirical data

When asked to describe the technological or non-technological experimentation projects or programmes hitherto implemented as part of KIC's development, participant P_PPS06 reported that one start-up initiative was emerging within the Industry Innovation Lab (IIL), with an early-stage business model aimed at working with farmers to plant more trees, which could become the carbon off-set by engaging socially responsible technology users. IIL is a university-based incubation centre hosted at Carnegie Mellon University in Africa (CMU-Africa), one of KIC's Knowledge

Space central actors (see IIL details in chapters 4 and 7 of this thesis). Talking about the proposed IIL-based business model start-up, participant P_PPS06 said: *“They are trying to do the calculus from the farmer side of the thing, so they can go to the airline, they can go to air polluting industrial companies and say, hey, we could provision the off-set that you are seeking (...)”* (Research Participant P_PPS06, 2022). Commenting on the involvement of grassroot communities in big innovative technological development and experimentation schemes, participant P_PPS06 took a global perspective to critique the ways in which several governments such as the United State of America (US), China, the United Kingdom (UK), and India were heavily investing in AI research, working with big producers of AI such as Microsoft, but not conducting this in tandem with consumers, in particular in emerging economies. Talking about this issue, participant P_PPS06 argued: *“We have just hit 8 billion population market two weeks ago. Bulk of the consumers are in emerging economies. They are in Addis Ababa, they are in Lagos, they are in Kigali, they are in Bangkok, they are in Mumbai. So, we really need to co-opt the creation, we need to co-create, otherwise there will be trust and access issues”* (Research Participant P_PPS06, 2022). Of interest here was the way in which the participant was raising the issue of trust and access that had emerged with the COVID-19 vaccine, to advocate for responsible and grounded AI. Commenting on the COVID-19 experience and its implications for technological innovation project development and experimentation approaches in different geographical contexts, the same participant said: *“I think there is a lesson there for co-creation of AI, co-creation of grounded AI. Ground AI is the AI that is relevant to the specific problem in that geography”*. (Research Participant P_PPS06, 2022). The condition for groundedness in KIC experimentation projects was echoed by participant P_PPS07 who said: *“...because one of the goals is to scale it [KIC] up into other African countries, I think it will have [a] meaning, if it goes on to transform the lives of Africans. So, it has to be grounded”*. (Research Participant P_PPS07, 2022). Talking about how KIC was working to address this policy and societal issue of technological innovation development and experimentation in a way that was grounded, aka inclusive and contextually relevant, participant P_PPS06 reported that KIC’s Knowledge Space central academic actor, CMU-Africa, formed part of an emerging the African Engineering and Technology Network (Afretec) network described in Box 8.1 below.

Box 8.1. The Afretec network – a pan-African collaboration of ten technology-focused universities

Afretec is a pan-African collaboration of ten African technology-focused universities. The network, still in its early stages of creation, is driven by CMU-Africa with the aim of creating a platform of member universities ‘to drive inclusive digital growth by collaborating on teaching and learning, knowledge creation, and entrepreneurship activities within the area of engineering and technology’⁵⁴

8.6 Exploring potential collaboration areas for greater local KIC embeddedness and relevance

Part of the aim of RQ7 was to explore the potential areas in which the City of Kigali and local communities in KIC’s vicinity might benefit from and contribute to KIC’s planning and development trajectory. KIC’s local embeddedness and relevance to adjacent communities therefore stood out to be one of the broad themes that emerged from the analysis. Fig. 8.5 below provides an overview of the demographics of the 10 participants who shared their perspectives in response to this theme.

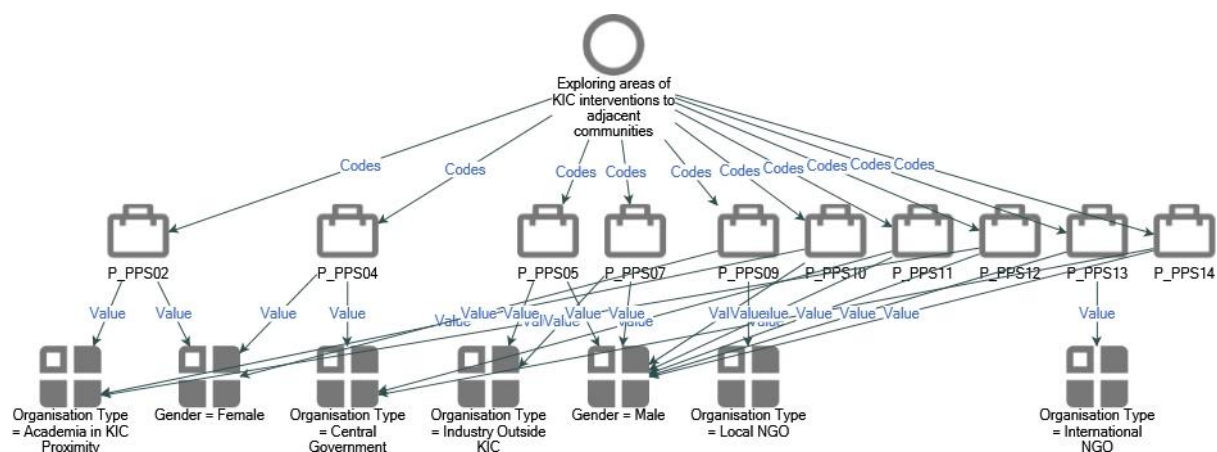


Figure 8.5. Mapping of participant demographics for theme 8.6

Source: Author’s design with NVivo based on empirical data

⁵⁴ <https://engineering.cmu.edu/afretec/about/index.html> [Accessed: 25 April 2024]

When discussing the ways in which KIC could engage in locally relevant interactions with City of Kigali and the community in the KIC vicinity, participant P_PPS07 felt that the City of Kigali and local authorities could invite the KIC coordinators to their regular meetings, thus creating the opportunity to present their plans and activities to the KIC coordinators, thereby drawing collaboration areas for mutual benefit. Suggesting the ways in which KIC interactions with local authorities and communities could be institutionalised, the same participant felt that the Joint Action Development Forum (JADF) might be one of the possible contemporary frameworks for KIC to interact with City of Kigali and Gasabo district and/or Bumbogo sector. As indicated in Box 8.2 below, JADF's organisational and institutional multi-actor nature might increase KIC's embeddedness in and closeness to the community in its vicinity, and hence enhance its meaning and relevance from a community perspective.

Box 8.2. Joint Action Development Forum (JADF)

The Joint Action Development Forum (JADF) is a multi-stakeholder platform comprised of representatives from the public sector, private sector, and civil society. JADF aims 'to promote and facilitate full participation of citizens in the decentralised and participatory governance and improve service provision processes'⁵⁵. All Rwandan local authorities including City of Kigali, districts, and sectors enjoyed JADF as part of their institutional framework, with JADF being nationally coordinated by the Rwanda Governance Board (RGB),

Commenting on the importance of KIC joining JADF of City of Kigali and/or Gasabo district or else Bumbogo sector, participant P_PPS07 said: *"My recommendation would be that Kigali Innovation City be part of JADF. Because that is where they can plan together each year. They even put resources together, and then they set and work together to achieve Imihigo⁵⁶ [performance contracts] for the district"* (Research Participant P_PPS07, 2022). This was echoed by another participant, P_PPS09, who felt that City of Kigali and local authorities were fortunate to have KIC as their geographical constituency, and that they should harness KIC's potential to achieve

⁵⁵ <https://www.rgb.rw/1/governance-and-service-delivery/joint-action-development-forumjadf> [Accessed: 14 May 2024]

⁵⁶ According to Rwanda's Ministry of Local government (MINALOC), **Imihigo** is "a Rwandan tradition, institutionalised to enhance socio-economic development and institutional performance". <https://www.minaloc.gov.rw/reports> [Accessed: 23 May 2024]

some of their respective development plans, activities, and goals. Commenting on this issue, participant P_PPS09 said: “(...) *for some of the milestones that they want to achieve, it is going to be easier for them to achieve because they have already a facility which is nearby, and which is happening without putting much effort*”. She went on to say: “*Things are happening. People are doing wonders, research and innovation... as they are near Kigali Innovation City, they are going to become ahead of others because of those facilities. If they use them wisely*” (Research Participant P_PPS09, 2022).

Talking about KIC’s responsibility for community development, participant P_PPS07 said: “*I think Kigali Innovation City is more than academic. The good thing with all the academic institutions is that they have outreach services, programs. So those outreach programs are for the community*” (Research Participant P_PPS07, 2022). Talking about other ways in which City of Kigali and local authorities might collaborate with KIC for development. The same participant felt that improving communication strategies would be paramount, and that this might be achieved by defining the ways in which KIC actors reached out to the community, how they collaborated, and how they co-created and synergised their activities. This view was echoed by participant P_PPS13 who thought that KIC’s closer collaboration with the local authorities and community in its vicinity would not only pave the ways for KIC to achieve its developmental goals, but would also improve the living conditions of those communities through greater access to job opportunities. In a similar vein and viewing KIC as an expansion of City of Kigali urban, participant P_PP05 suggested that through KIC, the citizens from City of Kigali’s rural areas would have access to technologies and space for innovation activities.

8.6.1 How would KIC’s adjacent communities benefit from KIC’s geographical proximity?

The aim of this chapter was partly to explore the ways in which KIC, in its spatial dimension, was developing (or might develop) into an inclusive knowledge-based innovation ecosystem relevant to adjacent communities. When asked about their perspectives on how KIC was benefiting (or might benefit) the adjacent communities, participants reported a broad range of KIC potential contributions to three main categories of communities in KIC’s vicinity, including the **residential community**, the

industrial community in Kigali's Special Economic Zone (KSEZ), and the broad **City of Kigali urban citizens**. As shown in Fig. 8.6 below, the overwhelming majority of KIC's potential contributions were perceived to benefit the residential community in KIC's geographical proximity. Talking about the ways in which KIC might benefit the adjacent residential community, a common view amongst the majority of participants was that KIC could offer employment opportunities to the community. For example, commenting on the anticipated impact of KIC on adjacent communities, one participant said: *"I would say KIC is a life-giving institution because there are many jobs that are created around (...) I would not see the people who would benefit from that better than those around."* (Research Participant P_PPS07, 2022). Moreover, as shown in Fig. 8.6 below, several participants suggested that KIC would offer access to innovation spaces and available amenities such as internet access, power, and good roads.

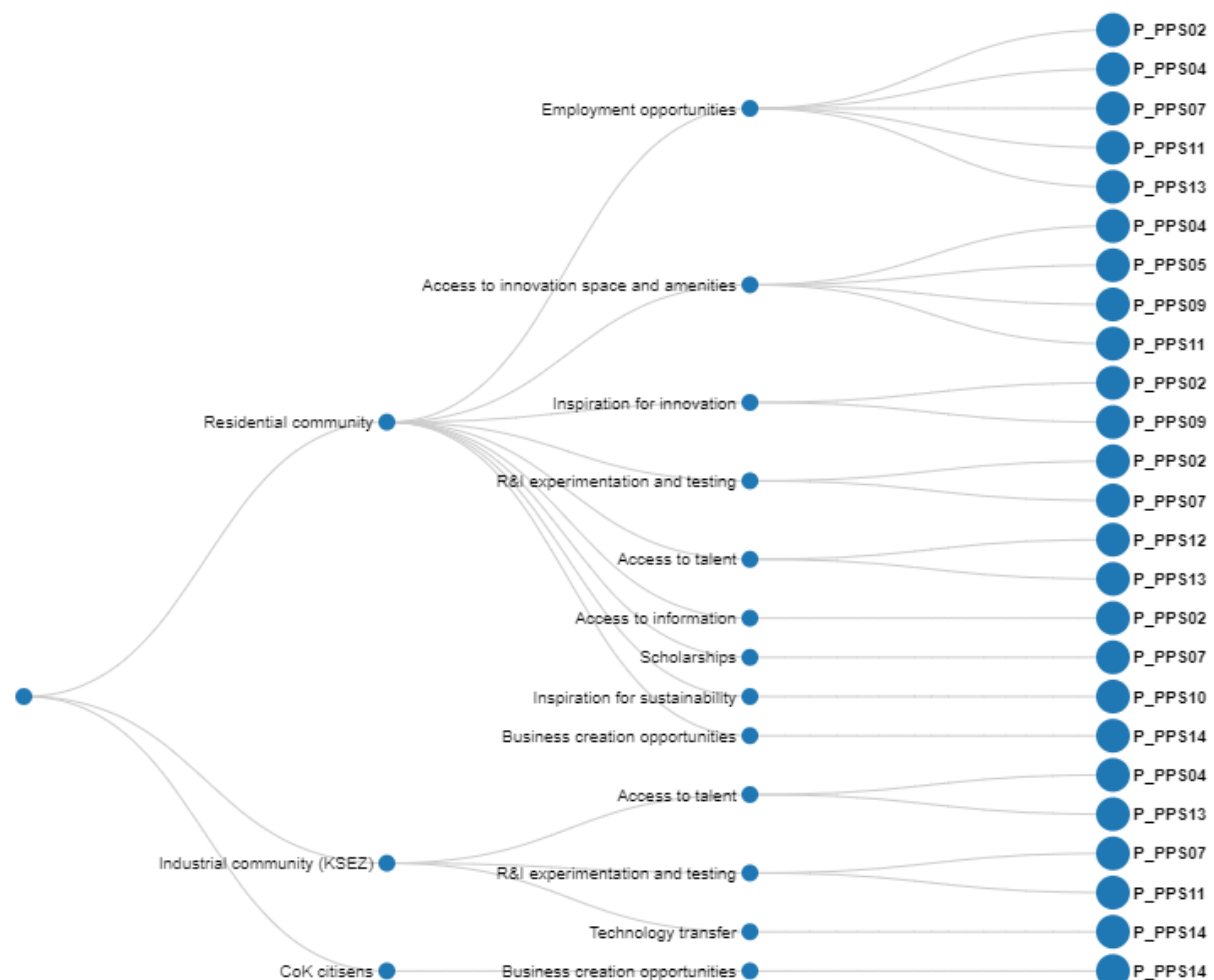


Figure 8.6. KIC's perceived potentials and related beneficiary adjacent communities

Source: Author's design with RAWGraphs based on empirical data

A few participants felt that the presence of KIC, with a talented student body and outstanding international academics and researchers, would serve as an inspiration to the community, particularly the young generation, through community outreach programmes and mentorship programmes. For instance, talking about this issue, one participant said: *“I think that the schools around the place also will gain something by being close to CMU-Africa or to ALU [African Leadership University]”* (Research Participant P_PPS12, 2022). This view was echoed by another participant who said: *“(…) those universities in there [KIC], they have world-class students. So, they should actually think about how their very high skill sets can influence the community around. They could go out there and mentor the young people who are in secondary schools (…)”* (Research Participant P_PPS13, 2022). Of interest was one participant’s indication that KIC would inspire the community from a sustainability standpoint. Commenting about this issue, the participant said: *“the organisations in the Kigali Innovation City are subscribing to sustainability, whether it is in terms of energy, in terms of climate change adaptation, in terms of water resources management, in terms of even mobility. For KIC to inspire the community on how to farm sustainably in small scale holdings but increase the yield through smart agriculture, it is a matter of creating opportunities for people in the surroundings to interact with the people creating knowledge in the various areas there”*. (Research Participant P_PPS10, 2022). One participant argued that KIC’s Knowledge Space actors should amplify their local relevance through scholarship programs. Talking about this issue, the same interviewee said: *“(…) imagine if each [KIC] university offers like one scholarship [to one student] from the neighbourhood, that would be one of impactful interventions”* (Research Participant P_PPS07, 2022).

For some respondents, KIC would benefit the community from the latter being involved in the experimentation and testing of research and innovations being developed by the former. Talking about this, one participant said: *“KIC universities and their partners might want to extend their interventions towards involving or including the community around in different domains such as digital healthcare, smart agriculture”* (Research Participant P_PPS07, 2022). This view was echoed by another participant who said: *“(…) schools or health centres, hospitals, or agricultural activities such as cooperatives around that area, would benefit (…). When they [KIC] even want to test something like*

deploying a system that can be used by farmers, they start with the closest place. So, people surrounding Kigali Innovation City would be the first to be served" (Research Participant P_PPS04, 2022). In this author's view, this finding was somewhat counterintuitive. Much as local communities might benefit from technologies and innovations, equal emphasis would need be put on the potential unintended consequences for people's safety, privacy, risk, and agency as a result of participating in experimental trials of these technologies and innovations.

Commenting on the potential ways in which KIC could benefit the actors in adjacent industrial communities in KSEZ, a number of participants stated that KSEZ industrial actors would benefit from accessing KIC's brilliant students and academics, through R&I and industrial attachment, with one respondent suggesting a knowledge and technology transfer scheme. Talking about this matter, one participant said: *"where KIC is being built, it is not far from the industrial zone [KSEZ]. My imagination is that a lot of these factories and industry will benefit from the talent that is in the research and the innovations that are coming out of the KIC."* (Research Participant P_PPS14, 2022). With KIC being an evolving regional development project, the same participant commented that it would not only benefit the communities in the immediate proximity, but it would also offer business investment opportunities for the broader community of City of Kigali citizens.

8.6.2 Factors hindering KIC's local embeddedness, and proposed ways to improve interactions with adjacent communities

When asked what factors might be hindering City of Kigali and local authorities from engaging with KIC despite its physical location in their geographical constituency and the aforementioned perceived benefits, participant P_PPS07 thought the cause might be a governance and structural phenomenon. Commenting on this issue, participant P_PPS07 said: *"Sometimes I have the impression that Kigali Innovation City is from RDB [Rwanda Development Board], and maybe it is like a ministerial project. Otherwise, they [local authorities] should see it as an opportunity"*. (Research Participant P_PPS07, 2022). This view was echoed by another participant who felt that the fact that KIC was being coordinated by RDB, a central governance actor, might influence its distant position in relation to City of Kigali and local authorities. For example, commenting on possible ways in which this policy, governance, and

coordination gap might be curbed to enable KIC to interact with adjacent industrial communities in KSEZ, the same participant felt that KIC's governance structure was naturally led by its relevant central government actor, RDB, and that its interactions with adjacent communities might primarily need be led by a local government authority of a comparable governance level as RDB. When discussing this, the same participant said: *"I think this can be done by the ministry, the local government first and the MINICOM [Ministry of Trade and Industry] (...) Since there is no immediate collaboration between NIRDA [National Industrial Research and Development Agency] and Kigali Innovation City, I think NIRDA can also be involved because we work with industries on a daily basis"* (Research Participant P_PPS11, 2022). However, another participant from central government argued that KIC was not just being built as a space, but an ecosystem, its management team had the responsibility and mandate to build the infrastructure and initiate interactions with all other relevant actors, including the adjacent communities, to meet KIC's mandate as part of Rwanda's proof-of-concept strategy. As the same participant put it: *"(...) KIC is more than just space. KIC is also importantly building an ecosystem...also creating this kind of a proof of concept and among other things (...) KIC as an institution also have that mandate to create programs that enable this vision to materialise, and so I can see more programs being done to mobilise innovators to bring people together to collaborate on initiatives, and so that is going to continue to be a part of the road for KIC"* (Research Participant P_PPS14, 2022).

8.7 Discussion

The seventh RQ presented in this chapter was *"What specific characteristics define Kigali Innovation City as an urban smart city initiative, and to what extent do Kigali Innovation City's Knowledge Space actors interact with adjacent communities in their geographical setting?"*. Drawing on this work's multi-staged integrated analytical framework for actor interactions for RIL – as presented in chapter six of this thesis – this chapter adopted Bulkeley et al.'s (2019) typology of smart city initiative to analyse and discuss the findings. In doing so, this thesis used the category of situatedness (leading actors, and the relation between the urban and the laboratory), and this category was described and interrogated based on empirical data. Drawing on the five themes presented in the previous section, the findings are discussed in five related

themes: (i) Expanded interpretation of “Smartness” from an urban perspective; (ii) Varied interpretation of KIC as urban smart city initiative – a policy alignment gap and governance issue; (iii) Collaboration, control, and contingency in the context of KIC’s local embeddedness, co-location, relevance, inclusivity, and sustainability; (iv) Anticipation of and reflection on perceived impact of KIC R&I and technologies on adjacent communities; and (v) Unpacking KIC characteristics: a new dimension of smart city initiative typology.

8.7.1 Expanded interpretation of ‘Smartness’ from an urban perspective

This research found that the term ‘smart’, viewed from an urban innovation perspective, was ascribed a wide range of definitions, interpreting it according to eight main distinctive characteristics including *people*, *space – physical or virtual – process*, *product*, *digital technology*, *infrastructure*, *service*, and *activity*. Another important finding was that ‘smartness’ was unanimously associated with societal well-being and environmental sustainability. Perhaps the most striking finding was participants’ broad perspective on people being placed at the core of smartness, with the city’s smartness starting with that of its citizens – the people. Inasmuch as these findings concurred with existing literature, this research expanded the meaning of ‘smartness’ from previous studies that more often than not viewed smartness from a ‘technological solutionism’ or ‘tech-push to urban concept (Nilssen, 2019; Haggart and Tusikov, 2020). The new interpretation of ‘smart’ has often been forgotten or underrated by technology-oriented scientists and technocrats who often think about the notion of ‘smart’ from a technical perspective, usually digital technology (GoR, 2015; Smart Africa, 2017). Indeed, in most cases, the terms ‘smart’ and ‘smartness’ are used interchangeably with technological development, technological solutions, technological tools, platforms, and innovations such as the Internet of Things (IoTs) and AI, providing a very narrow view of what ‘smart’ entails from an urban perspective. One possible explanation for this broad interpretation of ‘smart’ might be the varied expertise and professional and academic background of participants, including STEM and non-STEM experts, who contributed thoughts and perspective to these themes (see details of participants’ demographics in Fig. 8.1 and Table 8.1 in preceding section of this chapter).

8.7.2 Varied interpretation of KIC as an urban smart city initiative – a policy alignment gap and governance issue

Further to the various interpretations of the term ‘smart’, this study also found distinct understandings of what constituted KIC as a ‘smart city initiative’. The variations in the ways participants described KIC as smart city initiative, on the one hand echoed similar observations from the pilot study phase participants’ diverse understandings of KIC as an ST&I policy initiative as presented in chapter four. It is worth recalling that participants in both the pilot and post-pilot phases of this research were key experts and senior officials and administrators from Rwanda’s science and innovation ecosystem whose organisational mandate or individual role were directly or indirectly connected with KIC. This in part explained the extent to which Rwanda’s ST&I policy actors were less attuned to the policy narrative landscape than anticipated, and the implications this might have had on the development and growth of strategic policy interventions such as KIC. Viewing this from an urban place-based regional perspective as observed in the research and as presented in this chapter, a possible explanation for this phenomenon of main actors’ varied understandings and interpretations of such a national and place-based ST&I policy intervention as KIC, might be associated with Rwanda’s state-led and top-down approach to ST&I policy and governance (UKaid, 2020; Twiringiyimana et al., 2021; Yongabo, 2021b), leaving it to limited actor engagement in ST&I policymaking process. Another possible and related factor to explain this observation might be the gap in policy alignment and governance amongst KIC main actors as shown in Fig. 8.7 below.

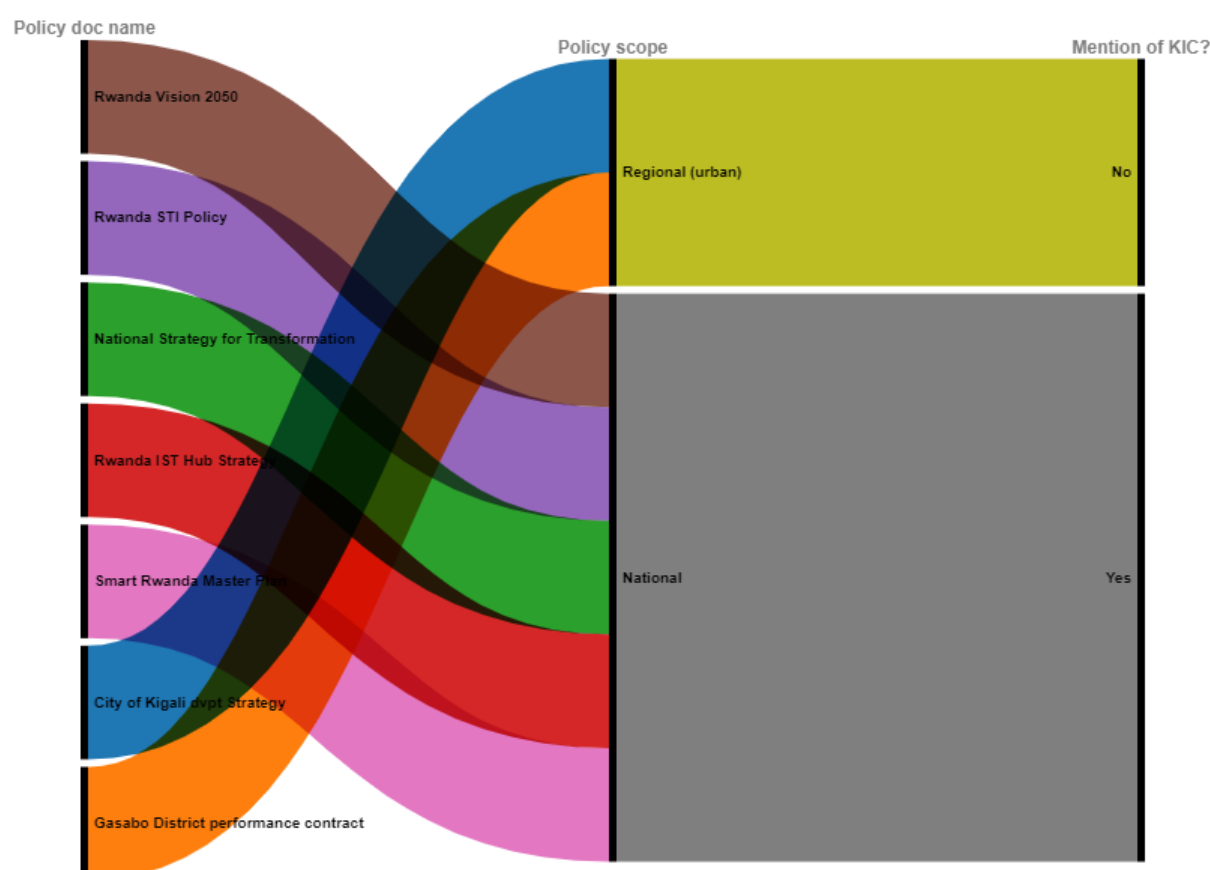


Figure 8.7. Mapping of national and place-based (urban) policy narratives in relation to KIC

Source: Author's design, based on narrative review using RAWGraphs (<https://app.rawgraphs.io/>)

As can be seen in Fig. 8.7 above, for instance, while KIC was viewed as a key element for City of Kigali from urban innovation and urban development perspectives, this study found no mention of KIC in City of Kigali and Gasabo district strategies⁵⁷ where KIC was physically located. However, KIC formed part of strategic policy interventions in national development vision and agenda narratives in key policy instruments such as Smart Rwanda Master Plan (SRMP), Rwanda National Strategy for Transformation (NST-1, 2017-2024); Rwanda ICT Hub Strategy; and Rwanda national ST&I policy (GoR, 2015; GoR, 2017a; GoR, 2019c; GoR, 2020b). As indicated in the Literature

⁵⁷ City of Kigali policies, strategies such as the Rwanda Urban Development Project (RUDP II 2022), and implementation of 'Imihigo' performance contracts. <https://www.kigalicity.gov.rw/publications> [Accessed:15.04.2024]

Review chapter of this thesis, and as viewed through the digital technology-enabled urban development strategy, *aka*, 'Smart city' strategy, KIC was characterised by SRMP as a highly important strategic project with a 'must-have' priority (GoR, 2015, pg. 49, 54). The absence of any reference to KIC in City of Kigali's strategic plan unequivocally implied its absence from City of Kigali action plans and those of associated local entities such as Gasabo district. Hence KIC may have been viewed as a lesser priority by those local urban authorities who may have felt less concerned about it as it did not form part of their organisational goals, plans, and performance contracts – known in Kinyarwanda language as 'Imihigo'⁵⁷.

As mentioned in the Literature Review chapter, an effective innovation ecosystem is one that is characterised by three main properties: resilience, self-organisation, and hierarchical systems evolving from the bottom up with the overall goal of the system reflecting or serving the goals of its actors or subsystems (Meadows, 2008; (Washbourne et al., 2021; Mugwagwa et al., 2021). Viewed through the lens of the hierarchical system, the embeddedness of KIC in national policy documents yet its omission from local policy instruments may be explained from two perspectives: on the one hand, KIC's place in top level policy narratives characterises the Rwandan government's 'entrepreneurial state' capability, allowing the government to seize partnerships and funding from international and private sector actors such as the World Bank, AfDB, CMU, and ALU (see details of interactions with these varied types of actors in chapter four). On the other hand, this entrepreneurial state capability is exhibited in a top-down manner and does not necessarily transcend all the Rwanda policy and governance structures related to KIC development. KIC experience exemplifies that this state-led and top-down approach sometimes misses the opportunities of bottom-up interactions. It may therefore be paramount to instil the culture of entrepreneurial state from the local government authorities as well, for them to be able to take the initial steps for interactions benefiting their local communities. Without entrepreneurial capabilities from a local government perspective, KIC's siloed, and lacking in policy alignment phenomenon may lead to undesirable policy outcomes for all KIC actors, thereby widely hindering Rwanda's science and innovation ecosystem performance. A similar policy alignment gap was also identified in UR strategy as presented in chapter four above.

8.7.3 Collaboration, control, and contingency in the context of KIC's local embeddedness, co-location, relevance, inclusivity, and sustainability

With respect to RQ7, this research was designed to explore the ways in which KIC's Knowledge Space actors (may) have interacted with adjacent communities, and whether, and if so, how these interactions (may have) translated into KIC's local embeddedness, relevance, inclusivity, and sustainability. At a glance, this study found three main categories of communities in KIC's vicinity including (i) *residential community*, (ii) *industrial community* in Kigali's Special Economic Zone (KSEZ), and the wider (iii) *City of Kigali urban citizens*. What was surprising was the absence of either formal or informal interactions between KIC's contemporary citizens, *aka*, KS' academic actors, and the aforementioned adjacent communities, with the exception of temporary noises from manufacturing factories in KSEZ, as highlighted in the previous empirical chapter four. This finding also corroborated the results of the pilot phase of this research in chapters 4 and 5, suggesting that interactions amongst KIC's Knowledge Space actors were found to be predominantly based on or driven by cognitive proximity rather than geographical proximity. The prevalence of cognitive proximity over geographical proximity amongst KIC's Knowledge Space actors offered a new perspective on the knowledge-based innovation ecosystem in a top-down and state-driven ST&I policy regime.

As stated in section 8.7.2 above, the mainstream understanding of innovation ecosystem largely characterised innovation ecosystems as self-organised entities with innovation occurring based on actor interactions – mainly facilitated by geographical proximity (De Fuentes and Dutrénit, 2016; Zhao et al., 2022). It thus transpired in the case of KIC – a government-driven ST&I policy instrument – that each organisation tended to be focusing on responding to the policy goals upwards, with a meagre interest in engaging with horizontal interactions with other KS actors that co-located in same geographical vicinity. With the absence of local communities in the planning and governance of KIC being a significant observation, this thesis suggested that the less KIC's Knowledge Space actors were engaged in inter-actor interactions for RIL, the less they were likely to engage with adjacent communities. As a flagship innovation initiative within Rwanda's NSI and THS-based ST&I policy, KIC “might reflect an assumption that Indigenous peoples are not involved in the types of innovations recognised or promoted by the policy, reflecting their deeper exclusion from such

initiatives” (Jimenez et al., 2025, p.7). These findings further question the practical suitability of these conceptual frameworks for Rwanda context, in spite of their central role in guiding the national ST&I policy framing (GoR, 2020b).

In the instances where KIC was enrichingly governed and managed by central government, the contemporary disconnectedness of KIC’s Knowledge Space actors from a geographical proximity perspective may have been restored with KIC’s coordination unit playing a greater role in facilitating this process. However, this research found that KIC’s coordination unit, officially affiliated to RDB and operationally working closely with RDB and MINICT, was limited in terms of capacity. Moreover, it transpired at the time of conducting this research, that KIC’s coordination unit’s focus was dominated by KIC’s site and estate management. With KIC being an evolving project under development, it was reportedly more interested in attracting more actors to occupy the designated land than facilitating interactions for RIL amongst existing actors.

Given the geographical context of KIC’s locale – in a low-income, peri-urban area – this research found that KIC’s perceived embeddedness would be evidenced by KIC developing into an anchor organisation and institution in the area where it was located. Alternatively, this may have suggested that KIC may contribute to exacerbating exclusivity, moving beyond ‘university silos’ syndrome to embrace the ‘knowledge-based innovation ecosystem silos’, leading to a knowledge-based innovation ecosystem ‘ivory tower’ phenomenon (Stockdill and Danico, 2012; M Rawlins, 2019), which in turn would compromise the relevance of such a policy instrument for society, and specifically jeopardise any ‘co-location advantage’ and attainment of a place-based development strategy (Dosso et al., November 14, 2020b). Scholars have already posited the need for flagship policy instruments such as KIC to be more inclusive for greater impact, particularly in LIC contexts (Yongabo, 2021b).

Based on the hypothetical suggestions from research participants, the involvement of KIC’s adjacent communities in KIC’s development and planning processes should in this author’s view be regarded as a key factor in achieving project inclusivity and sustainability, whilst concurrently contributing to reducing socio-economic disparities. For instance, as highlighted in the previous sections, additionally to KIC forming part of City of Kigali or Gasabo district’s JADF, the presence of City of Kigali Council as an active actor amid KIC’s proposed consensual place-based forum would be essential

(Zhao et al., 2022) in crowning KIC's status as an inclusive and sustainable knowledge-based innovation ecosystem. What is however in no doubt whatsoever in this author's considered assessment of the overall present situation, is that such an inclusive place-based development approach involving all systemic actors through consensual forums would require a fundamental paradigm shift in Rwanda's innovation policy for the development of place-based ecosystems in an urban setting. Actor-level engagement in and commitment to alignment with place-based programs the execution and consolidation are critical imperative if KIC is to mature into a self-sustained ecosystem (Roper, 2021; Ranga and Etzkowitz, 2013). Capacity strengthening of government/public policy actors and public administrators across City of Kigali local authorities within this collaborative⁵⁸ approach would thus be indispensable. Moreover, social proximity might also be paramount in shaping/influencing the ways in which City of Kigali local authorities and communities interact with KIC (Zhao et al., 2022). In line with Rwanda's government Proof-of-concept strategy (GoR, 2019c; Daniels, 2021), and viewed through the lens of pilot project theory (Hughes et al., 2020), the suggested KIC anchored-ness in City of Kigali may constitute a starting point for experimenting or scaling out this type of smart city innovation model of knowledge-based innovation ecosystems in other Rwanda's cities.

8.7.4 Anticipation of and reflection on perceived impact of KIC R&I and technologies on adjacent communities

This research gathered participant perspectives about how KIC's neighbouring communities might become potential beneficiaries of technologies and innovations being developed by KIC universities and research organisations, which might lead to unintended consequences for people's safety, privacy, risk, and agency as a result of participating in the experimentation of these technologies and innovations. As highlighted in the present and previous empirical chapters, this research was shaped with the perception that ST&I was a panacea for Rwanda's socio-economic developmental problems. While KIC was in its early stages of development, STEM universities and research organisations, constituting KIC's Knowledge Space actors,

⁵⁸ This thesis adopted Mulgan's (2019, p.135) definition of **collaboration**: 'acting with, rather than only to or for, a belief in rough equality, a cultural commitment to the idea of equality of commutation...'.

had already started to teach and produce engineers and scientists in the various STEM domains of Rwanda's national ST&I policy priority areas, as well as to conduct research in those areas. This study also found that, with university policy goal alignments put in place, KIC's Knowledge Space academic actors may leverage their academic capabilities and infrastructure to conduct collaborative research and learning, and thus produce technologies and innovations that may generate a positive transformation of the most pressing development sectors such as using digital solutions to improve access to education, securing financial transactions, green energy in rural settings including schools and healthcare facilities. These social-technical and contextual values mainly stem from Rwanda's government belief in ST&I as a driver for national socio-economic transformation, as highlighted in Rwanda's Vision 2050 and ST&I policy (GoR, 2020h; GoR, 2020b).

The interactions of KIC's Knowledge Space academic actors, predominantly the STEM universities and research organisations, were largely driven by their personal and interpersonal values in relation to technological innovations being the sole solutions the societal problems. This were also reflected in the institutional policies that they intended to align. However, the perceived intention of experimenting with their research, technologies, and innovations on the communities within KIC's vicinity, with the latter not being active participants, implied that the values of KIC's adjacent communities would be missing from the equation. Viewed through the UK Research and Innovation (UKRI) Anticipation, Reflection, Engage, Act (AREA) framework⁵⁹ lens for responsible R&I, and drawing on the anticipations and reflections highlighted above, this author suggests that KIC in collaboration with City of Kigali could design public safety policies and regulatory frameworks governing how research, technologies, and innovations developed by KIC actors might be experimented with, within or beyond KIC's vicinity, without causing any unintended harm to the participating communities. For instance, these policies and frameworks could include provisions for the active engagement of these communities in R&I co-design and technological innovation co-creation, as well as providing informed consent guidance

⁵⁹ <https://www.ukri.org/who-we-are/epsrc/our-policies-and-standards/framework-for-responsible-innovation/>

[Accessed: 20 May 2024]

for those participants in these experimentations. While this issue encompassed interesting insights, it was not widely discussed and thus warrants further investigation.

8.7.5 Unpacking KIC's characteristics: a new dimension of smart city typology

In response to RQ7, this research set out with the aim of exploring the characteristics of KIC as a smart city initiative. Drawing on empirical data and secondary evidence from the literature, this study found that as a smart city initiative, KIC comprised three characteristics, namely: *strategic*, *experimental*, and *educational*. As can be seen in Fig. 8.8 below, the three characteristics of KIC were institutionally and organisationally interweaved, making KIC a new typology of smart city initiative (SCI). Each of the three characteristics is explained below:

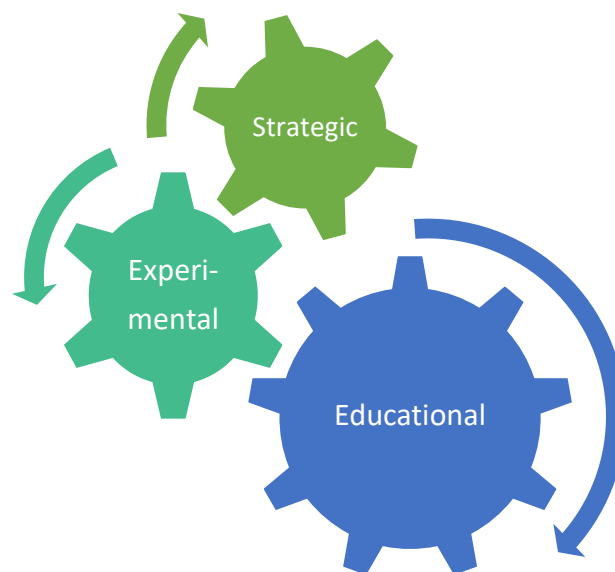


Figure 8.8. Typology of KIC as smart city initiative

Source: Author's design based on empirical and secondary data

KIC as a strategic SCI: As indicated in section 7.8.2 above, KIC forms part of strategic STI policy interventions in Rwanda's national development vision and agenda narratives. Its strategic value is evidenced in several main policy instruments such as SRMP, Rwanda NST-1; Rwanda ICT Hub Strategy; and Rwanda national ST&I policy (GoR, 2015; GoR, 2017a; GoR, 2019c; GoR, 2020b). SRMP, *aka*, national 'Smart City'

strategy, considers KIC as a highly important strategic project with a “must have” priority (GoR, 2015, pg. 49, 54).

KIC as an experimental SCI: Drawing on the empirical data, this study found that KIC is emerging into a knowledge-based innovation ecosystem with innovation spaces where talented students and researchers develop research-based technological innovations. Another striking yet counterintuitive finding was that KIC’s research-based technological innovations may be tested and experimented on KIC adjacent communities, including residential and industrial communities in KSEZ through a range of approaches such as knowledge and technology transfer programs. These findings concur with Rwanda’s policy documents suggesting that KIC had been strategically located next to KSEZ in particular with the aim of acting as an ecosystem to facilitate and accelerate knowledge exchange among academics, entrepreneurs and industry, as well as to -create innovative and transformative technologies and produce research output aimed at addressing societal challenges (GoR, 2015; GoR, 2017a; GoR, 2019c; GoR, 2020b). This also corroborated another study viewing KIC as a knowledge and talent platform for digital technology industry for Rwanda and for Africa (Daniels, 2021). Moreover, viewed through the lens of Rwanda’s Proof-of-concept strategy, this study found that the KIC model may be considered as an experimental model with possibilities of being scaled out to Rwanda secondary cities.

KIC as an educational SCI: Drawing on the empirical findings presented in sections 8.2 to 8.6 above, this study uncovered the importance of KIC’s Knowledge Space actors, *aka*, academic actors as primary producers of knowledge and human capital. It also established the variable ways in which KIC’s Knowledge Space actors, *aka*, KIC citizens might leverage their smartness to influence the rest of City of Kigali citizens, including adjacent communities as well as the broad Rwanda and Africa science and innovation systems. This finding concurred with the pilot study phase of this research that highlighted that targeting education and capacity building was at the core of KIC genesis, as detailed in chapter four above. Given the primary educational mandate of KIC’s Knowledge Space actors, it was striking to find one participant from KIC’s central KS suggesting a name change from ‘Kigali Innovation City’ to ‘Kigali Education City’ to emphasize education over innovation (see details in chapter four).

KIC's educational characteristic is also highlighted in the Rwanda government's ST&I policy narrative. As indicated in the Introduction chapter of this thesis, Rwanda NSTI and the National ICT Hub Strategy 2024 suggested that KIC was being created as a consolidated geographical area to house both international and local universities and research institutions to train and produce highly skilled engineers, researchers, and scientists in the priority sectors of national development (GoR, 2020b; GoR, 2017a; GoR, 2019c; GoR, 2020b).

8.8 Chapter Summary

The main purpose of this chapter was to present and discuss the research findings in response to RQ7: *“What specific characteristics define Kigali Innovation City as an urban smart city initiative, and to what extent do Kigali Innovation City’s Knowledge Space actors interact with adjacent communities in their geographical setting?”*. Drawing on empirical data, this study found that ‘smartness of KIC citizens’ revealed a new interpretation of the expression ‘smart’ that transcended previous studies’ assumptions that often-ascribed smartness to (digital) technologies underpinning smart city initiatives in an urban context. Moreover, this thesis drew on empirical and secondary data to propose a new type of smart city initiative as had been identified in KIC – the interwoven typology of KIC being at the same time strategic, experimental, and educational, offering new knowledge in urban innovation studies. A Critical Realist approach was deployed to explain this typology in the wider context of Rwanda’s state-led and top-down approach to ST&I policy and governance, and in a low-income-country (LIC) context. Despite the contextual dichotomy between KIC and the case studies researched previously, this work expanded on and partly reflected earlier studies by proposing three distinctive types of urban smart city initiatives (strategic, civic, organic) (Bulkeley et al., 2019). Additionally, viewed through a political economy analysis (PEA) lens, the analysis of policy narratives revealed that KIC was institutionally linked to central government whilst being detached from any urban influence, *aka*, the City of Kigali (see Fig. 8.7 for details). Moreover, this study found that KIC’s Knowledge Space actors, KIC’s management entity, and City of Kigali authorities – including local authorities in Gasabo district where KIC is geographically located, constitute key actors with the potential to influence, drive, or facilitate interactions emanating from the social proximity of KIC’s citizens. To achieve this

collective mandate, this author argues that, in addition to government-urban policy alignment, it may be paramount for all main actors to acquire entrepreneurial, developmental, social networking, and collaboration skills, and to apply these capabilities to enhance the governance, R&I, and learning in place-based settings. He further contends that in doing so, these actors would harness the intertwined feature threads of KIC – strategic, experimental, and educational urban smart city initiative, thereby ushering KIC towards developing into an inclusive, locally embedded and relevant knowledge-based innovation ecosystem.

The next and last empirical chapter of this thesis presents and discusses KIC's Knowledge Space actor interactions for RIL with other actors – including international actors and science diaspora, through the lens of science diplomacy.

Chapter 9. Science diplomacy – a pathway towards fostering KIC’s actor interactions for research, innovation and learning? Potentials and pitfalls

9.1 Introduction

The preceding empirical chapters four, five, and seven, discussed actor interactions for research, innovation and learning (RIL) viewing Kigali Innovation City (KIC) from a science, technology and innovation (ST&I) policy intervention perspective, with chapter eight embracing the spatial dimension of KIC as an urban innovation initiative. In all these previous chapters, the role of international actors in influencing KIC’s actor interactions became evident. Considering KIC from both an ST&I policy intervention and an urban innovation initiative perspectives, this chapter deployed a science diplomacy lens, as part of the context-specific, multi-staged, integrated analytical, and conceptual framework, to explore and unpack the ways in which international actors, including the diaspora, influenced (or not) the national and place-based ST&I innovations policy. In response to part of the sixth RQ of this thesis - *What is the role of government agencies and other actors in supporting the development of KIC into a knowledge-based innovation ecosystem?*, in this chapter, the thesis aims to constitute a point of departure for developing an understanding of Rwanda’s model of diplomacy for science and technology, with a particular focus on institutional architecture and actor interactions for RIL, and how this model of cooperation for science offers (or not) an impetus to the development of domestic ST&I policy interventions and flagship programmes, focusing on KIC. The findings presented and discussed in this chapter emanated from a combination of (Adu, 2019)’s description-focuses and interpretation-focused approaches to thematic analysis of empirical data with significant information addressing RQ6. A detailed methodological approach to this thematic analysis was presented in chapter four of this thesis. The findings in the present chapter are organised into two themes, namely: (i) Describing the interactions with international or foreign actors, and (ii) Examining the Ministry of Foreign Affairs’ role in facilitating interactions with international or foreign actors and the scientific diaspora. Guided by this study’s multi-staged integrated analytical framework for actor interactions for research and innovation, and in relation to RQ6, key findings are interrogated in the second but last section, with the final section presenting the summary of the chapter.

Fig. 9.1 and Fig. 9.2 below give an overview of the demographic information about the research participants who contributed insights and perspectives with significant information addressing RQ6 under each of the themes presented in this chapter. As was the case in the other empirical chapters, only two out of seven participants' demographic data were selected: organisational type and gender, are presented in this chapter. This is mainly for the purposes of illustration, linking the demographics maps to the figures with corresponding narratives. Chapter four of this thesis – Research Methodology, presents a detailed explanation of participant identification anonymisation and demographics.

9.2 Describing interactions with international or foreign actors

Part of RQ6 was to understand whether, and if so, how actors who participated in this study interacted with foreign or international actors such as universities, funding agencies, research centres, banks, private firms, NGOs, philanthropists, or entrepreneurs for RIL, and whether these interactions contributed to the development of KIC. Fig. 9.1 below gives an overview of demographic information about five research participants, with anonymised identifications P_PPS02, P_PPS04, P_PPS08, P_PPS10, and P_PPS12, who contributed insights and perspectives with significant information addressing RQ6 under this theme.

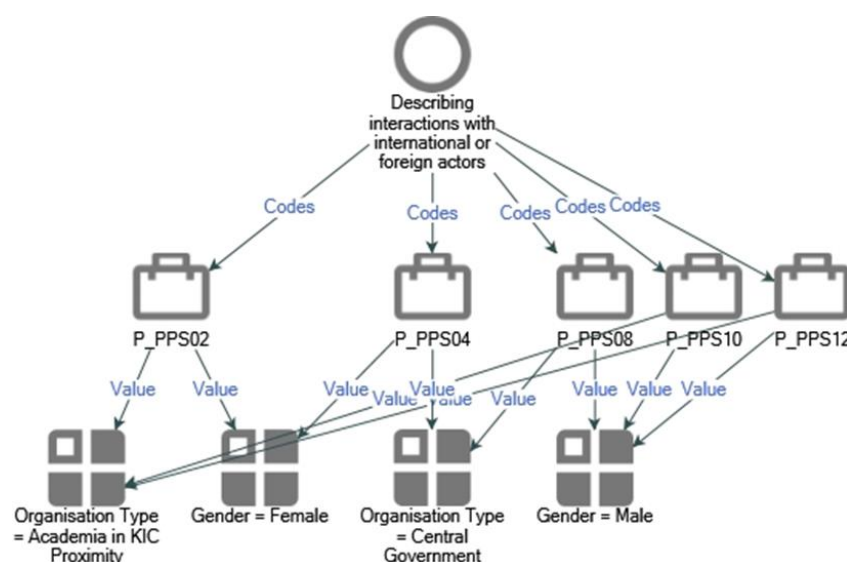


Figure 9.1. Mapping of participants' demographics for theme 9.2

Source: Author's design with NVivo based on empirical data

When asked whether their respective organisations interacted with international or foreign actors such as universities, funding agencies, research centres, banks, private sector entities, NGOs, philanthropists, and entrepreneurs, and if so, how these interactions were initiated, participants in Fig. 9.1 above were unanimous in the view that they did interact, and that the interactions were initiated based on mutual organisational interests and anticipated developmental goals. For example, one participant from KIC's Knowledge Space academic actor in proximity – UR, indicated that their organisation had created International Network for Government Science Advice (INGSA)⁶⁰ chapter (or branch) for Africa in Rwanda, emanating from the evolving interactions between UR and INGSA. Talking about how INGSA-African branch in Rwanda was being operationalised, the participant said that a few senior academics, with relevant experience and expertise, had been appointed to run the initiative in addition to their existing academic duties. Commenting on the prospects of the organisation, the same participant said: *“it is just a small team that is handling the initiative now. But the team is going to grow”* (Research Participant P_PPS02, 2022) (See details of INGSA and INGSA Rwanda in discussion section below).

Another participant, P_PPS04, from Rwanda National Council for Science and Technology (NCST), reported that NCST, *aka* the Rwanda's science granting council (SGC), interacted with the international universities. Giving an example of who the Council interacted with and why, the participant said that NCST had recently worked together with KTH – Sweden's largest technical university – to organise and run a webinar on academic innovation management for science and innovation actors in Rwanda. The participant did not indicate how the INCST-KTH alliance had been initiated and whether (or not) the collaboration between the two organisations has encompassed diplomatic cooperation between Rwanda and Sweden.

Commenting on the relationship between NCST and ACE-ESD, one of the KIC's Knowledge Space academic actors in proximity, participant P_PPS04, indicated that the Council was partnering with ACE-ESD and thought that the latter might have been

⁶⁰ Established in 2014 in Auckland, New Zealand, under the auspices of the International Council for Science (ICSU), INGSA is a network with interest in 'enhancing the role of science in public policy at all levels of government, from local to global', with a deliberate focus 'only on improving the use of scientific evidence in policy formation and implementation across all aspects of government', and not working on the 'development of policies for the public funding of science' (Gluckman, 2016). <https://ingsa.org/> [Accessed:2 March 2024].

providing the former with funds to support some innovations. Talking about this government-academia collaboration, the same participant said: “But *they [ACE-ESD] are emphasising that we should also look at the social innovations, because that one has been left behind while it is very important for the citizens of the country to solve their problems*” (Research Participant P_PPS04, 2022).

Participant P_PPS04 went on to report that NCST had been involved in interactions that had resulted in partnerships with other Science Granting Councils (SGCs) with similar or related mandates in other Sub-Saharan Africa countries, under the Science Granting Councils Initiative (SGCI). The participant also indicated that the Council was intending to be part of the Grand Challenges organisation, an international institution that supported initiatives aimed at ‘fostering innovations to solve key global health and development problems’⁶¹. This finding somewhat corroborated the finding presented in chapter eight of this thesis, which showed that in 2023 Rwanda’s NCST launched the Grand Challenges Rwanda (GCR), an initiative targeting multisectoral and multi-disciplinary R&D-based innovations, with support from the Bill & Melinda Gate Foundation (BMGF). When asked whether the NCST interacted with any foreign philanthropic actors, the same participant P_PPS04 indicated that the Council was in the early stages of engaging with a private Swedish organisation specialising in waste management, with the intention of exploring potential collaboration including funding innovation projects. Commenting on interacting with international development banks, participant P_PPS04 reported that engagements with international development banks focused on knowledge transfer from the banks’ expertise through technical support, and not on financial support. As the participant put it: “*we [NCST] have some experts from World Bank who are working closely with the NCST, not in funding projects, but evaluating the state of our innovation system, to see the state of adoption of innovation and technology and see how we can improve. The experts also participated in the training (...) where the KIC [Kigali Innovation City] was also invited*”. (Research Participant P_PPS04, 2022). This insight was echoed by another participant, P_PPS08 from NCST, who confirmed that the Council’s interaction with the World Bank aimed at technical support through the Bank’s expertise.

⁶¹ Grand Challenges <https://www.grandchallenges.org> [Accessed: 27 February 2024]

Participants P_PPS10 and P_PPS12 from KIC's Knowledge Space academic actors in proximity represented peculiar cases in relation to other participants under this theme, namely, describing the interactions with international or foreign actors. As can be seen in Fig. 9.1 above, and as discussed in chapter four of this thesis, these two participants represented branches of international academic organisations operating on Rwanda. When asked whether their respective organisations interacted with international or foreign actors, and if so, how these interactions were initiated, participant P_PPS10 from Coventry University Africa Hub reported that Coventry University Africa Hub interacted with multiple actors, both local and international, in the areas of R&I, education, and capacity building. When asked to provide examples of these interactions, P_PPS10 stated that Coventry University Africa Hub was collaborating with University of Rwanda (UR) in research and capacity building, including PhD training. Moreover, participant P_PPS10 revealed that Coventry University was establishing a collaboration with the Centre of Excellence for E-health and biomedical engineering. This was one of the African Centres of Excellence hosted by UR, having been constructed within KIC locale, and conceptualised in this research as KIC's Knowledge Space central academic actor (see chapters one, four, and five for details about the Centre). Participant P_PPS10 also reported that the Hub was collaborating with the UR and Rwanda's Ministry of Health (MoH) in the areas of nursing education. Commenting on whether, and if so, how the hub interacted with public sector actors, participant P_PPS10 indicated that the Hub had a Memorandum of Understanding MoU with Rwanda Energy Group Limited (REG)⁶², and through this MoU, Coventry University and REG had submitted a proposal for funding to a UK organisation to develop a solar photovoltaic (PV)-based induction for implementation on cookers. Furthermore, Coventry University Africa Hub was collaborating with the Rwanda Development Board (RDB) on issues of executive training. As presented in chapters one, two, five, and eight, RDB was the main government entity overseeing KIC. Participant P_PPS10 went on to indicate that the Hub was collaborating with the Aviation Transport and Logistics, the umbrella organisation that encompassed state-owned companies such as Rwanda Air and Kagera Aviation. Commenting about Coventry University Africa Hub interactions with international actors from industry,

⁶² REG Limited is a state-owned holding company with seven inter-linked functions: (i) import, (ii) export, (iii) procurement, (iv) generation, (v) transmission, (vi) distribution, and (vii) sale of electricity in Rwanda. <https://www.reg.rw> [Accessed: 28 February 2024]

participant P_PPS10 indicated that Coventry University Africa Hub was mainly collaborating with UK-based or UK-originated firms and charities operating in Rwanda, such as OX, a UK-based e-mobility start-up experimenting electric trucks in Rwanda⁶³, Fair Mobility⁶⁴, Code Box Limited⁶⁵, and Vanguard Economics Limited⁶⁶.

When asked about the value, in terms of expertise, knowledge, or technical contribution, of the addition of the interaction with international actors such as OX, whose R&I activities were conducted in the UK, with OX-Rwanda only managing advanced prototypes at experimentation stages, participant P_PPS10 said: *“I think the value addition of interacting with OX is in terms of supporting research that is going to be contextual, because these trucks are operating in Rwanda. So even if you do research in the UK, there is some information which you need to be able to apply here”*. Commenting on the relevance of research for contextualising UK-based innovation, participant P_PPS10 thought that electric vehicles that were designed to operate in UK would probably struggle to perform in Rwanda because of the mountainous terrain. Therefore, from a technology design perspective, the participant thought that evidence was needed to understand and address the issues of the capacity of the battery, charging station distribution, in such a way that they could reach as many farmers as possible, as well as tackling the issue of refrigeration compartments carrying frozen products. Commenting on the relevance of research from end-user and economic perspective, the participant suggested that it might be vital to examine whether (or not) and if so, to what extent the innovation might be advantageous to the farmers by comparison with other mainstream modes of transport. When discussing the possibility of expanding the UK-based e-mobility innovation beyond Rwanda, participant, P_PPS10 said: *“I believe based on the experience, one can look at extending the OX service to other regions in other countries in the region”* (Research Participant P_PPS10, 2022).

Participant P_PPS12 from the East African Institute for Fundamental Research – a branch of the International Centre for Theoretical Physics (ICTP-EAIFR), hosted at UR

⁶³ <https://www.oxdelivers.com/about> [Accessed: 28 February 2024]

⁶⁴ <https://register-of-charities.charitycommission.gov.uk/charity-details/?regid=1094144&subid=0>

⁶⁵ <https://find-and-update.company-information.service.gov.uk/company/07992273> [Accessed: 28 February 2024]

⁶⁶ <https://www.vanguardoeconomics.com/about-us/#our-team> [Accessed: 28 February 2024]

and focusing on capacity building of UR researchers and students in STEM areas – reported that the institution had not so far engaged in any interactions with international actors other than the parent organisation, the International Centre for Theoretical Physics (ICTP), and associated actors. When asked about the possible reasons for not having been able to collaborate with other international actors, participant P_PPS12 thought that there had been very few opportunities for the said organisation to support capacity building and that they had limited knowledge of such organisations. This was rather a surprising finding. When talking about how ICTP-EAIFR was addressing this issue, participant P_PPS10 said: *“we are trying to build our database to get to know more people, more organisations that can help with capacity building, help fund capacity building (...) we [also] try to get grants for research which is not specifically targeted for capacity building”* (Research Participant P_PPS12, 2022).

9.2 Examining the Ministry of Foreign Affairs’ role in facilitating interactions with international or foreign actors and the scientific diaspora, and implications for KIC

Part of RQ6 aimed to examine whether, and if so, to what extent Rwanda’s Ministry of Foreign Affairs and International Cooperation (MINAFFET) played a part in facilitating interactions between local science and innovation ecosystem actors and international actors, including the Rwandan diaspora. The same question also sought to understand the implications of such interactions facilitated by MINAFFET for national ST&I flagship programs such as KIC. Fig. 9.2 below gives an overview of the demographical information about two research participants, with anonymised identifications as P_PPS04 and P_PPS08, who contributed insights and perspectives with significant information addressing RQ6 under this theme.

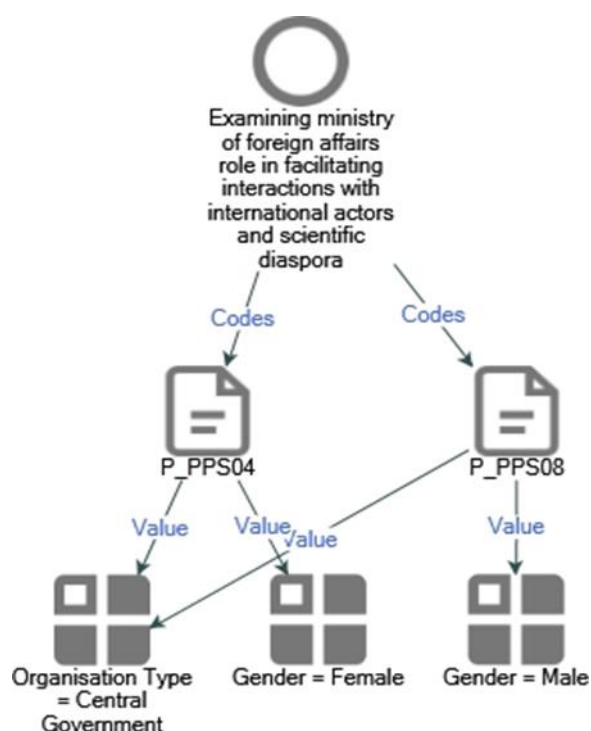


Figure 9.2. Mapping of participant demographics for theme 9.3

Source: Author's design with NVivo based on empirical data

Talking about the role of MINAFFET in facilitating NCST's interactions with international or foreign actors and the scientific diaspora for RIL, participant P_PPS04 stated that MINAFFET's contemporary structure included a department dedicated to handling the Rwandan diaspora affairs. The same participant thought that MINAFFET possessed enough funds to facilitate interactions between Rwanda's scientific diaspora and local actors. Commenting on the genesis of NSCT's strategy to engage with the Rwandan scientific diaspora, participant P_PPS04 stated that a skills assessment study conducted by NCST in 2018-2019 had found that Rwandan expertise in priorities areas of national development was relatively low, and thus the Council was recommended to work with MINAFFET and put in place mechanisms aiming at bringing as many Rwandan experts living abroad as possible to come and contribute to the development of their country. Hence NCST launched an initiative to repatriate the diaspora. Another participant, P_PPS08 from NCST, alluded to the belief of the Rwanda government in the importance of encompassing the diaspora in national development programs as highlighted in three main national strategic policy documents. Talking about key narratives and guidelines in these policy documents,

participant P_PPS08 indicated that one of the priority areas for the National Strategy for Transformation (NST_1, 2017-2024), and one of the resolutions of the 2018 or 2019 National Dialogue Council (Umushyikirano), each pointing to the need to mobilise and facilitate Rwandans living abroad to participate in the country's development programs. The participant went on to state that current Rwanda National Science Technology and Innovation Policy (ST&I Policy 2020) also emphasised the involvement of the diaspora – particularly the scientists, researchers and entrepreneurs – in national programs matching their expertise and interests.

Commenting on the role of MINAFFET in realising NCST's initiative to bring back the diaspora, participant P_PPS04 stated: *"With the Ministry of Foreign Affairs and International Cooperation, we managed to have a meeting with some diaspora representatives, and we distributed the sheet where they were asked to provide some details including their areas of expertise. We found a very good number of diaspora who would come and contribute to the development of our country"* (Research Participant P_PPS04, 2022). Asked whether the aim was to encourage Rwandan scientific diaspora to relocate to Rwanda, the same participant indicated that the intention of the initiative was not to ask them to relocate to Rwanda as they were able to contribute their expertise from wherever they might have been based. The comment on the vital role of MINAFFET in facilitating interacting with the diaspora was echoed by another participant, P_PPS08 from NCST, who unequivocally said: *"you cannot interact with Rwandan community abroad without any channel from Ministry of Foreign Affairs and International Cooperation, MINAFFET"* (Research Participant P_PPS08, 2022).

Shedding further light on the efforts to meet with the aforementioned diaspora representatives, participant P_PPS08 reported that a virtual meeting was held in March 2022 as an initial call encompassing participants from various countries in Africa, and those living in China, Canada, the USA, and Europe, and was facilitated by the directorate in charge of Rwandans living abroad at MINAFFET. Asked what role MINAFFET actually played in making that meeting happen, participant P_PPS08 said: *"we [NCST] drafted a concept note and then shared it with the MINAFFET. Based on the concept note, they [MINAFFET] drafted invitation, and they shared it with our respective embassies in different countries"* (Research Participant P_PPS08, 2022).

Talking about the outcome of the initiative, participant P_PPS04 reported that in October 2022 NCST invited five of the diaspora people who had attended the meeting, to visit a range of organisations including research institutions, academia, startups, and industries in Rwanda with the purpose of the visit being to identify which areas in these diaspora Rwandan nationals could contribute. This view was echoed by another participant, P_PPS08 from NCST who said: “(...) *we had a [one week] visit of 5 people from diaspora as well as one World Bank expert, and one of the discussions was about the collaboration with Kigali Innovation City [KIC]. NCST management facilitated this team to go to the economic zone [Kigali Special Economic Zone] to visit different actors [and explore how they can provide] their support. So, we are in collaboration with them to see how to scale out innovation, in particular innovation not only just at early stage, but at the commercialisation level*” (Research Participant P_PPS08, 2022). Participant P_PPS08 went on to reveal that these five diaspora experts were Rwandan scientists who came from five countries: Canada, Belgium, Finland, China, and South Korea, and in addition to visiting, they had given a public talk to a range of actors from Rwanda’s science and innovation ecosystem, including KIC (see details of the role of KIC in this visit programme in chapter seven). Interestingly, the authorities of the City of Kigali were not mentioned among the actors visited by the delegation, raising the question of the place of urban innovation in Rwanda’s science and innovation ecosystem’ discourses and narratives. This phenomenon partly echoed the findings presented in the preceding chapter eight of this thesis.

The most striking outcome of the aforementioned initial visit and discussions held during the visit was that the Rwandan scientific diaspora expressed a keen interest in and desire to create an association of Rwandan scientists living abroad, and suggested that NCST could coordinate that network. Commenting about this, participant P_PPS08 said that during discussions, it had been recommended that the association be managed by the scientist themselves, with NCST providing support and facilitation as required. When asked about how the activity of bringing the five diaspora experts was funded, participant P_PPS04, 2022 reported that the cost of their travel including flight tickets, ground transport, and accommodation, had all been covered by NCST. The funding issue was echoed by participant P_PPS08, who indicated that, the inability to invite more than five out of the 30 or more participants who had registered on the platform, was mainly due to lack of budget. Commenting on NCST’s plans to

continue expanding this activity, one participant P_PPS04 indicated that NCST was planning to put in place specific funds [budget line] for the diaspora scientists, making this part of NCST's mainstream activities. Moreover, participant P_PPS04 stated that the Council had appointed a focal person for that activity. Interestingly, a significant lack of awareness of science and innovation diplomacy as a scientific lens to guide this 'bringing diaspora experts back' initiative was observed amongst all participants. A similar observation was made during the presentation of this research to officials of the Rwanda High Commission in the UK who, despite showing keen interest to learn more about the concept, exhibited only a partial understanding of what science diplomacy was, and how it might contribute to strengthening the embassies' ability to advance Rwanda's science and innovation agenda, goals, and interests, into a bilateral or international Rwanda-UK cooperation and negotiations (See details of this meeting in Appwndix_3 of this thesis).

9.6 Discussion

As mentioned in the Literature Review in chapter two of this thesis, science diplomacy, despite lacking a universally complete definition, is described in three main dimensions. One original dimension links science with foreign policy, viewing science diplomacy as an 'application of science cooperation to help build bridges and enhance relationships between and amongst societies, with a particular interest in working in areas where there might not be other mechanisms for engagement at an official level' (Ruffini, 2017, p. 11). Another dimension draws on diaspora theory and the transnationalism phenomenon where science diplomacy is deployed as public policy effort to engage with, encourage, and facilitate the scientific diaspora living in host countries or societies, to contribute knowledge and expertise to their home country's development programs as they contribute to host countries or societies (Shuval, 2000; Vertovec, 2009; Seguin et al., 2006). The third and emerging dimension of science diplomacy is being used as a 'science-to-policy interface' focusing on scientific advice to governments, with R&D-based evidence playing a central role to policymaking on at national and international level (Gluckman, 2016). Taking this broad approach to science diplomacy as a conceptual lens, this chapter drew on empirical data to explore whether, and if so, how science diplomacy might be a pathway towards fostering KIC actor interactions for RIL. In a quest to respond to part of RQ6 – *'What is the role of*

government agencies and other actors in supporting the development of KIC into a knowledge-based innovation ecosystem?’, the aim was to unpack any systemic potentials and pitfalls that might be underpinning or hindering these interactions at the interface of science, innovation, policy, and diplomacy on institutional and (or) or actors’ dimensions.

As presented in the sections above, this study found that there was a trichotomy in the approaches through which Rwanda’s science and innovation ecosystem actors interacted with international actors. Firstly, the study found that government agencies and KIC’s Knowledge Space actors engaged in direct interaction with international actors, and did so mainly for RIL, capacity development, and funding. Secondly and surprisingly, in contrast with the first category of actors, this study found that international R&I actors operating in Rwanda leveraged their parent organisations’ capabilities to interact with local actors, thereby influencing and shaping the local science and innovation ecosystem’s dynamics. Thirdly, the study found that government agencies’ and KIC’s Knowledge Space actor interactions with Rwanda’s scientific diaspora were solely channelled through and facilitated by the Ministry of Foreign Affairs and International Cooperations (MINAFFET). Another important finding was that, irrespective of the approach, these interactions were initiated based on the mutual interests of the actors involved. In this section, the findings were interrogated against existing literature, focusing on institutional and actors’ potentials and pitfall, and the implications of these dynamics for KIC’s innovation ecosystem development.

9.6.1 Unpacking KIC’s actor interactions with international or foreign actors

RQ6 of this study partly sought to determine whether, and if so how KIC’s actors interacted with foreign or international actors such as universities, funding agencies, research centres, banks, private firms, NGOs, philanthropists, or entrepreneurs for RIL, and whether these interactions contribute to the development of KIC.

This study found that KIC’s Knowledge Space actors, that is, the academic and research organisations, and government agencies demonstrated an interest in interacting with international actors. The variations in the ways in which these interactions were formed were contingent upon a range of factors including individual actors’ missions, institutional and organisational architectures and capabilities. For instance, on the one hand, this study found that NCST and ACE-ESD leveraged their

interactive capabilities to engage in collaborations with international actors with similar mandates for co-learning and R&I funding mobilisation purposes. On the other hand, it was somewhat surprising to find that the ICTP-EAIFR – with a core mandate of STEM capacity building of UR researchers and students, reported being unable to interact with those international actors providing funding for capacity building, mainly due to organisation's inability to identify those actors. ICTP-EAIFR presented KIC KS actors' organisational pitfalls from an interactive capability standpoint. In accordance with the present findings, previous studies demonstrated that scientists [including those in leadership positions of scientific organisations] were often 'siloeed academically and professionally', and that they needed a range of skills including, *inter alia*, 'negotiation, communication and leadership skills, navigation protocol, building coalitions, partnerships and networking, and heightened cross-cultural and cross-disciplinary awareness' (Mauduit and Gual Soler, 2020, p. 5) in their tasks of identifying and engaging with other actors for collaboration.

Most striking of all findings was the ability of international actors operating in Rwanda in exhibiting the aforementioned capabilities in interacting with local and other international actors for RIL. For instance, contrary to expectations, this study found that the Coventry University Africa Hub was interacting with a wide range of actors spanning government – both public policy and public administration, private sector, academia, and international NGOs working on a broad range of areas and sectors of interest to the Hub. Several factors may explain this observation. Firstly, the Hub was found to be led by people with a breadth of knowledge and experience in academia, public policy, and industry at national and international levels. Secondly, the Hub and its parent organisation may have harnessed their R&D capability to conduct market research and generate evidence that informed the Hub's policies and strategies, including whom to interact with, and why and how to interact with them.

Moreover, this study found that INGSA was establishing its branch on African soil in Rwanda, named INGSA-Africa Hub Rwanda, hosted at UR. It is worth recalling that, as presented in the preceding chapters of this thesis, UR was conceptualised in this research as KIC's Knowledge Space central actor and actor in proximity. In light of INGSA-Africa's mission to provide actors at the 'science-to-policy interface' of networking and capacity development opportunities, INGSA-Africa Hub Rwanda aimed to 'help to understand, coordinate, and strengthen the national and regional

science advice systems by acting as a focus point for training and networking opportunities'⁶⁷. In accordance with the empirical findings presented in the preceding section, the contemporary INGSA-Africa Hub Rwanda comprises a small team of five people, all existing UR staff, including four scientists and one professional officer serving as secretary of the Hub. This study also found that despite INGSA-Africa Hub Rwanda's small stature, it was an evolving Hub enjoying a quadripartite support encompassing four actors namely: INGSA, the Fond de recherche du Quebec (Quebec Research Fund), University of Rwanda, and government of Rwanda. It is important to note here that the INGSA/Government of Rwanda relationship dates back to 2018, when Rwanda hosted INGSA's "Eastern Africa Regional Government's Science Advice Workshop" held in Kigali in August 2018. That event brought together a range of participants including early-career and senior academics and researchers, policymakers, public sector officials, and representatives of regional and international organisations responsible for science and technology governance, policy, and capacity building⁶⁸. According to these findings, it may be inferred that the INGSA-Africa Hub Rwanda represents the institutional and organisational potential for supporting actors in bridging gaps in science diplomacy skills – from 'science-to-policy interface' dimension, not only for Rwanda's and Africa's science and innovation actors broadly, but also and particularly for KIC's development, as the latter evolves into a knowledge-based innovation ecosystem. Moreover, given the central role of UR as a mere public and research-intensive university in Rwanda (Twiringiyimana et al., 2021), and indeed part of KIC's Knowledge Space, it could conceivably be suggested that hosting INGSA-Africa Hub in Rwanda might constitute a point of departure from just conducting capacity building in science advice, to embarking on developing graduate-level academic courses uncovering the broader dimension of science diplomacy (Mauduit and Gual Soler, 2020), as discussed in the earlier Literature Review chapter. These courses would embed African societal, scientific, political, and diplomatic contexts. This thesis particularly argues that graduate-level programmes that dive deep into, and navigate the breadth of the foundations of science diplomacy, are vital for Rwanda's science and innovation actors, including Rwandan diplomats. This is

⁶⁷ INGSA-Africa Hub Rwanda <https://ingsa.org/chapters/africa/hub-rwanda/> [Accessed: 2 March 2024]

⁶⁸ INGSA-Rwanda Workshop 22-24 August 2018 <https://ingsa.org/resources/rwanda-report-2018/> [Accessed: 2 March 2024].

partly due to the fact that Rwanda aspires ‘to become a global centre for AI research and innovation’ (GoR, 2022), and that the country is the home for the World Economic Forum’s Centre for the 4th Industry Revolution (C4IR)⁶⁹. This argument is consistent with that of Mauduit and Gual Soler (2020) who posited that the emergence of such multilateral and multi-stakeholder policy processes and forums with socio-technical dimensions as AI policy and C4IR ‘require skilled professionals capable of navigating the science-diplomacy interface’ (Mauduit and Gual Soler, 2020, p. 3). Gaining these technical capabilities, through up-skilling, would contribute to attaining KIC knowledge-based innovation ecosystem’s development outcomes. Moreover, these technical capabilities would broadly contribute to achieving Rwanda’s Vision 2050 with respect to strengthening ‘international cooperation through trade and other regional and global negotiations’ (GoR, 2020h, p. 42). Furthermore, technical capabilities in science-diplomacy interface would contribute to developing the institutional processes and human capacity for science diplomacy, while raising awareness in MINAFFET and embassies of any required collaborations (Ittelson and Mauduit, 2019).

9.6.2 Examining the Ministry of Foreign Affairs’ role in facilitating interactions with international or foreign actors and the scientific diaspora, and implications for KIC

This study empirically found that Rwanda MINAFFET was playing a vital role in facilitating interactions between actors in the national science and innovation ecosystem, and the scientific diaspora and other relevant science diplomacy actors. The study also showed the perceived nuanced role of the scientific diaspora in contributing knowledge and expertise for the development of their home country. In accordance with participants’ views, harnessing the scientific, technological, and innovation potential of the Rwandan diaspora was highly present in the narratives of contemporary Rwanda government public policy and country’s development agenda. For instance, the Rwanda Vision 2050 recognises the diaspora’s contribution, amongst other actors, in achieving the country’s aspirations of transforming its economy while modernising all Rwandans’ lives (GoR, 2020h). As can be seen in Table 9.1 and Fig. 9.3 below, one of the five objectives of Rwanda’s national ST&I policy objectives – increasing scientific and technology output – aims to be achieved by adopting two intertwined strategies and four policy actions at the interface with the

⁶⁹ Centre for the Fourth Industrial Revolution (C4IR) Rwanda <https://c4ir.rw/> [Accessed: 4 March 2024]

science and technology and foreign policy domains, all funded primarily by government. On the one hand, the policy emphasises the importance of strengthening technology innovation support mechanisms through creating knowledge clusters, R&D-based innovation centres, and innovation incubation centres, to enhance the performance of the NIS (see details of this in chapter eight). On the other hand, the policy stresses the value of strengthening ‘cooperation with Rwanda’s diaspora and international scientists and innovators’ – including technology venture capitalists and entrepreneurs – through (i) establishing an association of Rwandan ST&I diaspora, and (ii) creating and operationalising ‘initiatives that tap into the pool of Rwandan living, studying, and working abroad in an effort to strengthen local knowledge and improve implementation of ST&I activities’ (GoR, 2020b, pp. 38–39). Moreover, Rwanda’s National Umushyikirano Council (NUC)⁷⁰ emphasised the role of the diaspora, *aka*, the Rwandan Community Abroad (RCA) for national development. For instance, one of the seven resolutions for the 18th NUC held in 2023 called for the government to ‘support RCA in scaling up their contribution to national development’ (GoR, 2023b, p. 1). Furthermore, one of the six resolutions of the 19th NUC held in 2024 urged the government to ‘create platforms for the RCA to make secure investments in the country and connect them to job opportunities on the local market’ (GoR, 2024, p. 2).

⁷⁰ The National Umushyikirano Council (or national dialogue council) is an annual event chaired by the president of the republic of Rwanda where the population, residing in the country and abroad, meet, interact with, and ask questions to their leaders. Governed the country’s Constitution, the event partly aims to collectively shape or recalibrate national development programs. <https://www.umushyikirano.gov.rw/about> [Accessed:05 March 2024]

Table 9.1. Mapping of Rwanda ST&I and Foreign policy nexus

ST&I Policy objective	Strategies	Key policy actions	Source of funds	Key actors
Increased scientific and technological output	Strengthen technology innovation support mechanism	Establish knowledge nodes, R&D and innovation centres to boost the performance of the national ST&I ecosystem	National budget	MINICT, MINICOM, KIC, NIRDA, UR, PSF, NCST, MINECOFIN, HLIs, RDB
		Establish and strengthen innovation support systems (incubation and tech transfer centres)	National budget	MINICT, MINICOM, KIC, NIRDA, UR, PSF, NCST, MINECOFIN, HLIs, RDB
	Strengthen cooperation with diaspora and international scientists and innovators	Establish association of Rwandan ST&I diaspora	National budget	NCST, MINAFFET, MINICT, RDB
		Establish and operationalise initiatives tapping into the pools of Rwandans living, studying, and working abroad in an effort to strength local knowledge, and improve implementation of ST&I activities	National budget	MINICT, NCST, RDB, NIRDA, MINECOFIN, MINEDUC, HLIs, MINAFFET

Source: Adapted from GoR (2020b, pp. 38–39)



Figure 9.3. Mapping of Rwanda’s ST&I and foreign policy nexus

Source: Author’s design, based on Table 9.1, using RawGraphs (<https://app.rawgraphs.io/>)

From the actors’ standpoint, Table 9.1 and Fig. 9.3 above show that the national ST&I policy strategy on strengthening cooperation with the ST&I diaspora and international scientists and innovators, is primarily implemented by government ministries and agencies responsible for building and strengthen Rwanda’s innovation system. These include the NCST, the Ministry of ICT and Innovation (MINICT), the Rwanda Development Board (RDB)⁷¹, the National Industrial Research and Development Agency (NIRDA), the Ministry of Finance and Economic Planning (MINECOFIN), the Ministry of Education (MINEDUC), and higher education institutions (HLIs), *aka*, tertiary education and research organisations, with MINAFFET playing a facilitation role. These findings therefore suggested that the anticipated or aspired to interactions

⁷¹ Rwanda Development Board (RDB) – the public sector entity operating at ministerial level (with its CEO attending government Cabinet meetings). RDB mainly serves as Rwanda’s gateway for technological innovation and investment. It is the custodian of KIC (see details in chapter 8). <https://rdb.rw/> [Accessed: 7 March 2024].

between Rwanda's ST&I policy and international cooperation and foreign policy, transcended the boundaries of mainstream *science diplomacy*, aka, diplomacy for science, leading to the emerging *innovation diplomacy*. Partly in accordance with the present results, previous studies demonstrated that there was a 'growing practice in public policy' with countries adopting innovation diplomacy in foreign policies including, but not limited to, 'diplomacy for innovation', to attain national ST&I policy goals and outcomes, and thus strengthen national or regional science and innovation systems (Leijten, 2017; Griset, 2020; Kļaviņš, 2021). However, despite Rwanda's national science and innovation ecosystem characteristics and ambitions aiming for scientific, technological, and innovation gains from innovation diplomacy, this study could not establish whether or not Rwanda's foreign policy had yet attained the capacity to enable the country to fully harness its science and innovation diplomacy potential. Rwanda's MINAFFET possessed a department dedicated to coordinating and supporting RCA, with one of the two main pillars of Rwanda's foreign policy being 'to contribute to wealth creation through development cooperation, investment and tourism promotion, transfer of knowledge and technology, equitable world trade and regional integration'⁷². This institutional capacity might arguably constitute a point of departure towards adequate diplomacy for science and technology, aka, innovation diplomacy. However, the absence of dedicated science and (or) technology offices in Rwanda's foreign offices, including in science- and technology-intensive countries such as the United Kingdom (UK)⁷³, poses a systemic dichotomy of interaction between Rwanda's domestic ST&I policy and its foreign policy. It also creates imbalances within the architecture of domestic science and innovation ecosystem. In accordance with previous studies in this domain, this author argues that attaining Rwanda's domestic ST&I policy aspirations in respect of the scientific [and technical] diaspora and international scientific and innovators potential requires changing the configuration of actors in foreign policy domain (Leijten, 2017). That being said, as indicated in Fig. 10.4 below, this study found that MINAFFET and Rwanda's foreign offices still played a central role in facilitating the interactions between local ST&I actors and international

⁷² Rwanda MINAFFET Foreign Policy pillars: <https://www.minaffet.gov.rw/foreign-policy-1> [Accessed: 7 March 2024].

⁷³ The London diplomatic list: <https://www.gov.uk/government/publications/foreign-embassies-in-the-uk> [Accessed: 7 March 2024].

actors including the diaspora, which has implications for national ST&I policy interventions such as KIC.

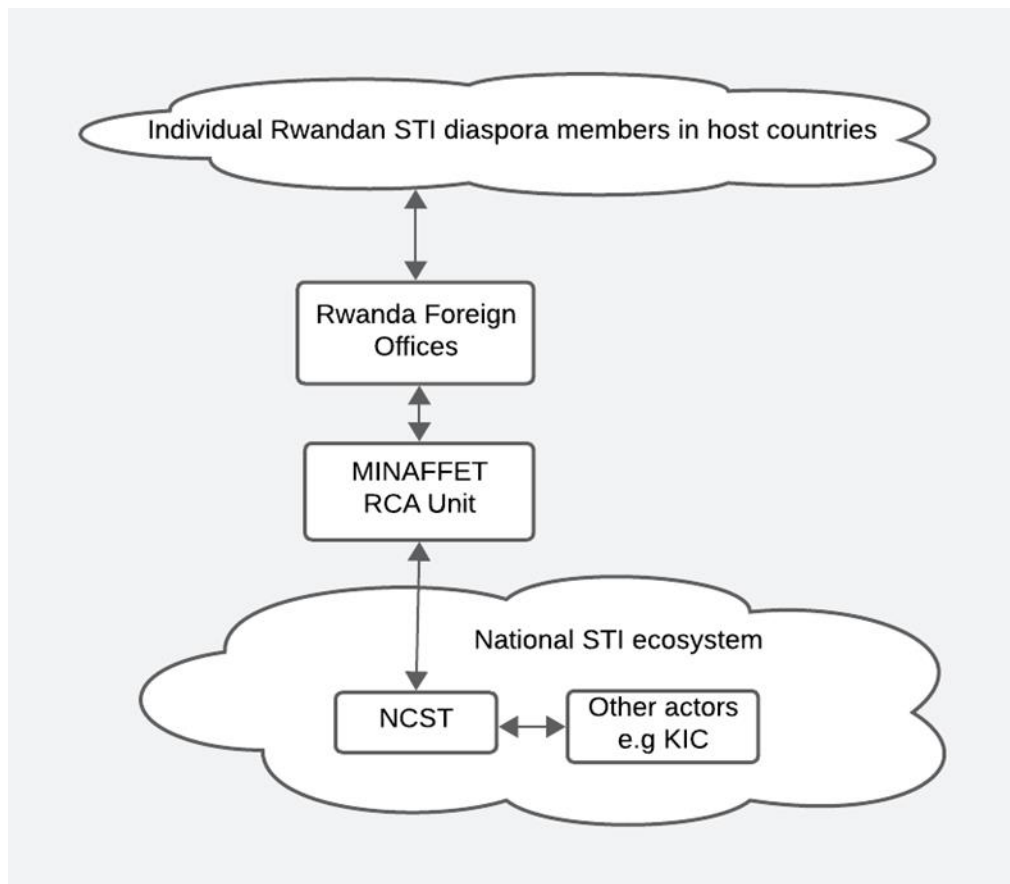


Figure 9.4. Model of state-funded ST&I diaspora-government interactions

Source: Author's design with Lucid chart based on empirical data

Drawing on the initiative started by NCST to engage the Rwandan ST&I diaspora, Fig. 9.4 above show the model of Rwanda's domestic ST&I actor interactions with the ST&I diaspora through state-funded programmes. In accordance with Rwanda's ST&I policy, as indicated in Fig. 9.3 above, the initiative was coordinated through a range of actors, including KIC, as part of the implementation of a science and diplomacy agenda through Rwanda's national ST&I policy. Most striking about the 2023 NCST-led initiative of bringing the ST&I diaspora back was the willingness of diaspora representatives to create an Association of Rwandan ST&I Diaspora, and NCST's and MINAFFET's commitment to facilitate this process. This finding is partly consistent with the recent work of Birka and Wasserman (2023) who, based on an empirical study of diaspora/government engagement in Ireland, proposed a five-level model of

scientific diaspora namely: Absent, Custodian, Midwifery, Husbandry, and Demiurge, each defined based on two factors: level of government engagement and level of diaspora ownership. Viewed through Birka and Wasserman's (2023) model, and according to this finding, it can be inferred that the model envisaged for the association of Rwandan ST&I diaspora would be categorised as a 'Midwifery' where the 'State identifies prospective engagements and potential champions [or leaders] and mobilises and promotes them, with the ownership still staying firmly with the diaspora' (Birka and Wasserman, 2023, p. 7).

However, in accordance with these findings, a previous study on institutional capacity for science diplomacy in Central America revealed that the lack of science and technology ministries might undermine the design and implementation of countries' effective science [and innovation] diplomacy agenda. The study found that in abased science and technology ministries, national agencies such as Rwanda's NCST were mandated to oversee ST&I. Despite the governance mechanisms in place, the coordination role of such agencies was often compromised from two perspectives: on the one hand, the councils did not possess the agency to coordinate other actors including ministries, mainly because 'they [the science councils] do not necessarily carry the same political and institutional weight as ministries' (Jarquin-Solis and Mauduit, 2021, p. 8). Moreover, science council communications and coordination with other actors was limited, mainly because the heads of science councils were usually not cabinet members and hence were unable to participate in cabinet meetings, which in turn may have created 'institutional imbalance'. On the other hand, science councils 'do not have direct access to multilateral and international forums which the ministry of foreign affairs and other ministries usually have under their legal mandate' (Jarquin-Solis and Mauduit, 2021, p. 8). Further research may be needed to gain a better understanding of how science and innovation diplomacy is supported and developed in other developing countries with a ministry of science and technology, and those without. Moreover, drawing on Jarquin-Solis and Mauduit's (2021) work, a further line of enquiry may be to compare the status of and trends in the interface between science and innovation diplomacy on one hand, and the national ST&I ecosystem in the global South. Another interesting study by the International Organisation for Migration (IOM) on Rwanda' diaspora in the UK found an interest on the part of RCA in the UK in investing in Rwanda, particularly in areas of land, property, IT business, and the stock

market. Perhaps the most disturbing finding of that study was the ‘divided nature of the Rwandan community in the UK, in part due to differing migration patterns and history, leading the community to be categorised ‘as being pro-government of Rwanda, anti-government of Rwanda, or ambivalent’ (OIM, 2020, p. 69). Much as the effort might be put in place to strengthen Rwanda’s science and innovation diplomacy in the UK, this undesirable phenomenon might hinder the attainment of science and innovation diplomacy potential for attracting as many Rwandan experts, scientists and innovators, as well as international scientists and innovators, as it would. What was most striking nonetheless was Rwanda’s ST&I diaspora’s willingness ‘to contribute to the development of Rwanda’⁷⁴ through, inter alia, skills and knowledge transfer initiatives, mentorship, innovation, and investment. This author thus argues that it is imperative for Rwanda’s foreign offices to have the capacity and capability to identify all Rwanda ST&I diaspora, and make efforts to understand and respond to the needs, for the country to fully untap these communities potential for domestic ST&I strengthening (Chirvas, 2022).

9.7 Chapter Summary

This chapter uncovered the central role played by international actors and Rwandan ST&I diaspora, and their potential in shaping and influencing Rwanda’s ST&I policy ecosystem development. Guided by a Critical Realistic approach, this chapter provided deeper insights into Rwanda’s national ST&I system characteristics and policy strategy, in respect to by setting and implementing science and innovation diplomacy. Drawing on empirical evidence and literature, the chapter revealed the institutional and organisational incapacity of Rwanda’s foreign policy as a major causal factor underpinning the ineffective exploitation of the ST&I diaspora and international scientists’ and innovators’ potential to strengthen the domestic ST&I system and flagship policy interventions such as KIC. With empirical evidence from an organisational and place-based ecosystem perspective, this study contributed to this author’s understanding of the causal factors enabling or hindering the attainment of science and innovation ecosystem development outcomes in LICs contexts through

⁷⁴ International Organisation for Migration (IOM) – Rwanda Diaspora Engagement Projects : <https://migration4development.org/en/projects/rwandan-diaspora-engagement-projects> [Accessed: 8 March 2024]

science and innovation diplomacy agenda, as has been broadly reported in previous studies. The findings reported in this chapter shed light on the importance of creating, strengthening, and consolidating the capacity – both within the national ST&I system and in foreign offices – to mobilise and generate evidence for policy as pathways to leverage expertise of international actors including ST&I diaspora. This author thus argues that doing so might offer a pathway towards fostering interactions for RIL for KIC progress. Moreover, creating, strengthening, and consolidating the capacity might pave the way for fostering interactions for RIL and achieving broader NIS development outcomes. From a theoretical perspective, in this chapter, this thesis drew on empirical evidence to add to the contemporary discourse around science and innovation diplomacy agenda and how countries are adopting this agenda to strengthen domestic NISs.

Next is the final chapter of this thesis, which provides a synthesis of the final conclusions, implications, and recommendations.

Chapter 10. Final conclusions, implications, study limitations, proposed further research

10.1 Introduction

This chapter offers a summary of key findings and synthesis of the conclusions drawn from each of the five empirical chapters of this thesis, addressing the research questions below. It also elaborates on the academic and policy implications of the study. Given the intended purpose of policy impact, the policy implications are delineated at macro-, meso-, and micro-scales for Rwanda's national innovation system (NIS). The chapter ends with implications for policy and practice, as well as study limitations and suggestions for further research. Prior to embarking on the conclusions of this study, it is worth recalling that the first three chapters form Part I of this thesis, providing the introduction, background, literature review, and research methods. Part II comprises chapters four and five, presenting the pilot study phase empirics, with chapter six introducing the context-specific integrated and conceptual framework development for the post-pilot phase research. The final part of the thesis, Part III, encompasses chapters seven, eight, and nine, presenting the post-pilot empirics, with chapter 10 providing the key findings, final conclusions.

As highlighted in the previous chapters of this thesis, the purpose of this study was twofold: (i) to expand the knowledge and understanding of system's theory-based conceptual frameworks, the conceptualisation of actor interactions in relation to the formation and operation of regional (place-based), knowledge-based, innovation ecosystems; and (ii) to provide policy makers, researchers and other actors with an interest in science, technology, and innovation (ST&I), study fields, with evidence for policy innovation options pertaining to place-based development in urban settings in LIC contexts. Although these two distinctive yet complementally components of this research generated much complexity, they each highlighted its academic and policy implications. Guided by an ontological and epistemological Critical Realism (CR) – as presented in the Methodology chapter of this thesis, and using Rwanda's Kigali Innovation City (KIC) as a case-study, this work aimed to undertake an in-depth investigation of the inner structure of Rwanda's NIS. Moreover, this study aimed to develop an understanding of '**how**' the university system (academia) – as the main

source of knowledge generation – interacted with other actors for research, innovation and learning (RIL) in support of regional or place-based innovation ecosystem development. The study further sought to explore options for fostering these actor interactions. In line with the purpose of this study, and with respect to the case-study investigated, the main research questions explored in this study were threefold: *How do the academic and research organisations located within KIC interact with other science and innovation system actors for research, innovation and learning (RIL)? To what extent do these interactions contribute (or not) to KIC’s development? And, What are the possible pathways towards fostering these interactions?* Table 10.1 below summarises the summary of key findings of this study in relation to the aforementioned main research questions.

Table 10.1. Summary of key findings from this research

#	Main research questions	Key findings
1.	How do academic and research organisations located in KIC and in its proximity interact with other actors for RIL?	• KIC’s Knowledge Space comprised diverse actors classified in four main categories: KIC’s Knowledge Space central academic actors, KIC’s Knowledge Space academic actors in proximity, Hybrid actors, and Government agencies. • KIC’s Knowledge Space actors exhibited diverse types of interactions or conditions for interaction for RIL, including collaborative R&I facilitation, funding for STEM education and research capacity building, innovation development, university-based innovation incubation centres, innovative teaching and learning, joint supervision of Master’s and PhD students, R&I funding, and research conferences and seminars. • KIC’s Knowledge Space actor categories, histories, cultures and/or purposes, influenced the ways in which each of the actors engaged in intra- and/or inter-actor interactions for RIL. • Intra-actor interactions were dominant among KIC’s Knowledge Space academic actors in proximity, and in Science, Technology, Engineering, and Mathematics (STEM) disciplines. • Inter-actor interactions were dominant among KIC’s Knowledge Space academic actors, with KIC’s Knowledge Space central

#	Main research questions	Key findings
		actors being the least involved, whereas government and hybrid actors played leading roles in funding or financing the R&I and capacity development. - Both intra- and inter-actor collaborations were primarily driven by students' research projects, highlighting the critical role of graduate and postgraduate research students as knowledge and innovation brokers within KIC. - COVID-19 pandemic had both negative and positive effects on KIC's Knowledge Space academic actor interactions. On the one hand, it exacerbated university silos and technological capability inefficiencies, while also calling into question the societal relevance of universities, particularly KIC's Knowledge Space actors in proximity. On the other hand, the pandemic imposed an unprecedented government/university trust by way of scientific and policy advice, and the emergence of unparalleled ST&I capabilities and funding opportunities for RIL activities.
2.	To what extent do these interactions contribute (or not) to KIC's development?	- There was an absence of direct or explicit connection between KIC's Knowledge Space academic actor activities and KIC's planning and development due to numerous factors: misalignments of individual actor agendas, incoherent strategies, policy narratives, and KS actor ignorance of KIC. - Disconnectedness of KIC's Knowledge Space actors from KIC's development strategy, imbalance of agency and control, as well as power contestations, drove KIC's Knowledge Space central academic actors towards silos. - Highly centralised governance and coordination of KIC's development agenda, hindered KIC's transition from its current implementation stage to consolidation and adjustment stages of its development.
3.	What are the possible pathways for	University-based innovation incubation centres constituted the potential for KIC's transition from the contemporary KS to Innovation Space (IS), as the knowledge-based innovation ecosystem transitions to consolidation and adjustment phase of its development. However, there was an absence of policy

#	Main research questions	Key findings
	fostering these interactions?	framework for both university-based and state-based innovation incubation centres to contribute to KIC's development. • Science and innovation funding programmes by GoR and hybrid actors offered potential for supporting KIC transition to IS. However, the two major Government funds, NRIF and RIF, were parallel and disjointed, hampering techno-innovation growth. Moreover, while they both funds focused on technology-enabled sectors largely similar to KIC's priority sectors, the funds lacked specific target for KIC KS university-based innovation incubation centres or other KIC KS activities. • Attracting MNCs may be a viable and complementary policy option not only to support KIC's transition from KS to IS, but also to contribute as a catch-up strategy to enhance Rwanda's NIS. • KIC was institutionally connected to central Government but remained detached from urban context, <i>aka</i> the City of Kigali. • In addition to KIC forming part of City of Kigali or Gasabo district's Joint Action Development Forum (JADF), the presence of City of Kigali Council as an active actor amid KIC's consensual place-based development forum may contribute to advancing KIC towards becoming an inclusive, locally embedded, and relevant knowledge-based innovation ecosystem. • GoR public policy narrative emphasised the importance of harnessing ST&I potentials of the Rwandan diaspora, with Ministry of foreign Affairs and international cooperation (MINAFFET) and National Council for Science and Technology (NCST) facilitating interactions between actors in NIS with the scientific diaspora and other relevant science diplomacy actors. However, NCST's lack of ministerial agency hampers the coordination and negotiation for ST&I's agenda advancement locally and internationally, thereby disenfranchising strategic ST&I policy interventions such as KIC.

The remainder of this chapter elaborates on the key findings presented in Table 10.1 in relation to specific research questions, and synthesises conclusions from the

empirical chapters. It also presents the academic and policy implications of this study, concluding remarks, study limitations, and suggestions for further research.

10.2 Syntheses of conclusions from empirical chapters

As presented in the Introduction chapter, the overarching research questions were investigated in two phases – pilot and post-pilot studies, each focusing on examining four and three specific questions, respectively.

Pilot study research questions:

- 1) *Who are the KIC Knowledge Space actors?*
- 2) *How do the KIC Knowledge Space actors interact for RIL, and do these interactions influence the RIL among these Knowledge Space actors?*
- 3) *Are these interactions related to KIC's regional (place-based) planning and development activities, and if so, how?*
- 4) *How has the COVID-19 pandemic influenced actor interactions in respect of RIL?*

Post pilot study Research questions:

- 5) *How do the KIC Knowledge Space academic actors interact with industry for RIL?*
- 6) *What is the role of government agencies, including foreign offices, in supporting the development of KIC into a knowledge-based innovation ecosystem?*
- 7) *What specific characteristics define KIC as an urban smart city initiative, and to what extent do the KIC Knowledge Space actors interact with adjacent communities in KIC's geographical setting?*

Furthermore, the Introduction chapter of this thesis presented KIC as an evolving national flagship policy intervention, positioned at the interface of the public policy and public administration spectrums of Rwanda's ST&I policy cycle (see Fig.1.2 in chapter one for details). Moreover, from a geographical perspective, the Introduction chapter of this thesis presented KIC as in a peri-urban setting, physically located at the interface of the city centre and the rural area of City of Kigali, and adjacent to an industrial development area, *aka*, Kigali Special Economic Zone (KSEZ) (see Fig.1.3

in chapter one for details). This dual, complex, and multifaceted nature of KIC made it a complex yet interesting case study. While the pilot phase of this research viewed KIC as an ST&I policy intervention, the post-pilot phase drew on the empirical and conceptual findings of the pilot phase to expand the scope by incorporating both ST&I policy and urban innovation perspectives. The synthesis of conclusions below draws on findings from both pilot and post-pilot phases of this study, in relation to specific research questions mentioned earlier.

10.2.1 Identification of KIC's Knowledge Space actors, and their interactions for RIL

In chapter four, this thesis set out to understand KIC's Knowledge Space actors and their interactions for RIL, exploring three research questions: 1) *Who are the KIC Knowledge Space actors?*; 2) *How do these KIC Knowledge Space actors interact for RIL, and do these interactions influence the learning and R&I among these Knowledge Space actors?*; and 3) *Are these interactions related to KIC's regional (place-based) planning and development activities, and if so, how?* The analysis of empirical and at times secondary findings was undertaken through the lens of Triple Helix Systems (THS) categories of KS, Innovation Space (IS), and Consensus Space (CS), with the focus being put on KS' academic actors. The analysis was also guided by the theory of knowledge-based regional development (M. Ranga and Etzkowitz, 2013) (See Literature Review, and Methodology, chapters two and three, for details about these theoretical concepts).

10.2.1.1 Dominance of STEM discipline-focused intra-actor interactions among KIC's Knowledge Space actors

Considering KIC as a social network, and in response to RQ1, this study found that KIC's Knowledge Space comprised a range of actors classified in four main categories: (i) KIC's Knowledge Space central academic actors; (ii) KIC's Knowledge Space academic actors in proximity; (iii) Hybrid actors; and (iv) Government agencies (see Fig. 4.5 in chapter four). In response to RQ2, the study found that KIC's Knowledge Space academic actors possessed various interactive capabilities underpinning their interactions for the creation, dissemination, and use of R&I and learning. These interactions may have stemmed from or been influenced by a range of innovative organisational structures and processes including, *inter alia*,

collaborative R&I facilitation, funding for STEM education and research capacity building, innovation development, university-based innovation incubation centres, innovative teaching and learning, joint supervision of Master's and PhD students, R&I funding, and research conferences and seminars. Related to this, another significant finding was that interactions for RIL may well have stemmed from individual researcher-driven initiatives within the organisations, demonstrating the vital role of these innovative researchers in supporting KIC's transition to the next step of its development, consolidation, and adjustment towards becoming a knowledge-based innovation ecosystem. This study also found that intra-actor interactions were predominant among KIC's Knowledge Space academic actors in proximity, and in Science, Technology, Engineering, and Mathematics (STEM) disciplines, suggesting closer organisational proximity in relation to interactions for RIL among these actors (see Fig. 4.1 and Fig. 4.3 in chapter four). This thesis has thus attempted to propose an inter-disciplinary approach to intra-actor interactions while bridging the STEM – Non-STEM gaps (see Fig. 4.9 in chapter four).

10.2.1.2 Inter-actor interactions: limited involvement of KIC's Knowledge Space central academic actors, but pivotal by students, government, and hybrid actors

Moreover, in response to RQ1 and RQ2, this study found that inter-actor interactions were dominant among KIC's Knowledge Space academic actors, with KIC's Knowledge Space central actors being the least involved, whereas government and hybrid actors played leading roles in funding or financing the R&I and capacity development. KIC's Knowledge Space central actors focused on collaborations for RIL with international actors from outside Rwanda (see Fig. 4.6 in chapter four). One of the significant implications of the identified interaction types was that both intra- and inter-actor collaboration amongst their respective personnel was primarily driven by students' research projects. This finding stressed the critical role of graduate and postgraduate research students as key '*Knowledge and Innovation Brokers*' within KIC.

10.2.1.3 KIC' KS academic actors need agency and power to engage in and influence KIC planning and development

In response to RQ3, this research found no direct or explicit connection between KIC's Knowledge Space academic activities and KIC's planning and development. The study found that this systemic disconnectedness might be caused by a range of factors including, *inter-alia*, strategic misalignments of individual actors' agendas, incoherent strategies, and policy narratives, as well as scanty or non-existent awareness of KIC's development agenda across the KS actors. Moreover, this work found that the disconnectedness between KIC's Knowledge Space actors from KIC's development strategy, and the imbalance of agency, power dynamics for actors' engagement in KIC's development planning drove KIC's Knowledge Space central academic actors towards silos. This author thus argued that this systemic phenomenon could be attributed to the governance and coordination of KIC's development agenda being highly centralised. This phenomenon in part reflects Rwanda's mainstream state-led and top-down approach to ST&I policy and governance at national as well as at place-based regional levels, which in turn may hinder KIC's transition from its current implementation stage to consolidation and adjustment stages of its development.

10.2.2 A nuanced effect of the COVID-19 pandemic

Chapter five of this thesis aimed to understand the impact of COVID-19 on KIC's Knowledge Space academic actor interactions in relation to RIL. In this chapter, the findings were presented in response to RQ4 - *How has the COVID-19 pandemic influenced KIC's Knowledge Space actor interactions in respect of R&I and learning?* The empirical data were analysed through the lens of THS and Innovation Ecosystems (IE) frameworks (See Literature Review, chapter two, for details about these theoretical concepts). This study identified both negative and positive effects of COVID-19 on KIC's Knowledge Space academic actor interactions for RIL. Regarding adverse effects, this study found that the COVID-19 pandemic caused disruptions to R&I and learning activities. Additionally, the pandemic unveiled and, in some instances, exacerbated university silos and technological capability inefficiencies, while also calling into question the societal relevance of universities. Regarding the positive effects, this research found that the COVID-19 pandemic exposed the lack of adaptive capabilities and information communication and technology (ICT)

infrastructural capabilities, amongst KIC's KIS academic actors. It also unveiled the disparities between KIC's Knowledge Space academic actors and the rest of the university system's actors in the country. In addition, the pandemic imposed an unprecedented government/university trust by way of scientific and policy advice, and the emergence of unparalleled ST&I capabilities and funding opportunities for RIL activities. In contrast to expectation, another major finding was the limited technical capacity of the academic actors in the use of online platforms and tools for learning, and research, as well as their limited access to high-speed internet. Another significant finding was that the lasting uncertainty around daily living and academic pursuits not only deterred KIC's Knowledge Space academic actors from interacting for RIL, but also caused financial, social, mental, and psychological stress to the majority of academics and students.

10.2.3 Why developing a robust, context-specific, multi-staged integrated analytical framework mattered for the post-pilot research

Chapter six of this thesis constitutes the main theoretical contribution of this work to the field of ST&I studies. Based on the overarching aim of this research and drawing on the empirical and conceptual gaps identified from analyses of the pilot study findings, this thesis developed a context-specific, multi-staged, integrated analytical framework for studying actor interactions in an innovation ecosystem setting (see Fig. 6.2 in chapter six). As presented in chapter five of this thesis, and from a knowledge-based regional development (Kb-RD) theoretical perspective, the pilot research found that KIC was transitioning from the implementation to the consolidation and adjustment stages of development. However, while KIC's Knowledge Space academic actors exhibited a range of innovative and collaborative capabilities for interacting with other actors, such as industry, intermediary actors, and government agencies, an *in-situ* analysis of these interactions from the perspectives of these other actors required navigating the IS, CS, and FS dimensions of the THS framework. This was beyond the scope of the pilot study. Additionally, while THS remained the fundamental theoretical framework underpinning this research, the systemic, complex, and wicked socio-economic and developmental issues and realities underpinning the geographical location of KIC made the THS framework unsatisfactory for the completeness of this research. These issues were further compounded by KIC's dual

characteristics of being at the same time an ST&I policy flagship intervention in Rwanda's innovation policy landscape, and an urban innovation initiative at the interface of the City of Kigali urban and peri-urban settings. Moreover, this study viewed KIC as a complex, socially constructed phenomenon involving a wide range of actors such as central and local government (including City of Kigali), academia, industry, civil society, and community. These actors differ in their levels of agency, power, interest, capacity, and capabilities to influence the creation, use, and dissemination of knowledge and innovation for KIC's development. This thesis therefore argues that complementing the THS with a robust, context-specific theoretical framework was essential to shape and guide the remaining research questions as the study was transitioning to its post-pilot phase.

Guided by the Critical Realism (CR)'s epistemological foundations and ontological assumptions underpinning this research, and as presented in chapter six of this thesis, the development of the new *multi-staged and context-specific, integrated analytical framework for actor interactions for research and innovation* in Fig. 6.2 involved three main processes: 1) Mapping of theoretical frameworks from an actor interactions for RIL perspective; (ii) Demarcating the centrality of actor interactions for RIL in the architecture of innovation ecosystems at micro-, meso-, and macro-scales, (iii) Investigating contextual radices of individual theoretical concepts to indicate geographical context where the concept was originally developed or deployed for empirical research, and methodological application (see Table 6.1 in chapter six). The newly developed framework was employed to guide and shape the post-pilot research design in response to RQ5, RQ6, and RQ7 as presented in chapters seven, eight, and nine of this thesis.

10.2.4 Conditions for KIC's transition to Innovation Space: beyond reliance on University-based innovation incubation centres

In chapter four, this thesis argued that university-based innovation incubation centres constituted the potential for KIC's transition from the contemporary KS to IS, as the knowledge-based innovation ecosystem transitions to consolidation and adjustment phase of its development (see Fig. 4.10 in chapter four). Drawing on this significant finding, Chapter seven of this thesis, takes the KIC KS university-based innovation incubation centres perspective to explore RQ5 - *How do KIC's Knowledge Space*

academic actors interact with industry and other actors for RIL? and part of RQ6 - *What is the role of government agencies and other actors in supporting the development of KIC into a knowledge-based innovation ecosystem?* In response to these questions, the study sought to understand KIC KS academic actors' university-based innovation incubation centres at functional, organisational, and institutional levels, and how through these capabilities, KIC's Knowledge Space academic actors interact with industry and other actors for RIL. Additionally, the study aimed to explore the role of Government and other actors in supporting these KIC KS university-based innovation centres. Moreover, in chapter six, through a comparative analysis approach, the thesis interrogated the university-based innovation incubation centres' policy innovation pathway, while exploring other policy options for KIC's transition from KS to IS.

Through the lenses of the context-specific, multi-staged, integrated, analytical, and conceptual framework developed and presented in chapter six of this thesis, and in response of RQ6, the research found that variations in university-based innovation incubation centres' structures, governance, and funding were largely contingent upon the mainstream structural architectures of the host universities, *aka* KIC's Knowledge Space academic actors where the innovation incubation centres are embedded. The second major finding was that innovation exhibitions and other networking events organised by KIC's Knowledge Space academic actors in proximity or government, were the major avenues where university-based innovation incubation centres, and to some extent state-based innovation centres, interacted with KIC's Knowledge Space central academic actors or KIC's management team. One possible explanation for this observation was that there was the limited policy framework for these innovation incubation centres to contribute to KIC's development.

10.2.5 Parallel and disjointed science and innovation funding architecture in Rwanda and implications for KIC

One of the more significant findings that emerged from this study in response to RQ6 was the parallel and disjointed nature of innovation funding architecture in Rwanda, and the implications of this phenomenon for KIC. On the one hand, the DUI-model of innovations undertaken by incubates at university-based and state-based innovation incubation centres were largely funded by NGOs, notably the United Nations

Development Programme (UNDP). On the other hand, the R&D-based or ST&I-based models of innovation activities were largely funded by government and were institutionalised, with the National Research and Innovation Fund (NRIF) being managed by Rwanda's National Council for Science and Technology (NCST) while the Rwanda Innovation Fund (RIF) was overseen by the Rwanda Development Board (RDB). However, this study found that there was an institutional disconnect in the ways these funds operated, and a framework to reconcile those two ST&I-based model innovation funding instruments – NRIF and RIF – was proposed through Technology Readiness Levels (TRL) and R&D-based innovation theory lenses (see Table 7.4 in chapter seven). Despite both NRIF and RIF focusing on technology-enabled sectors largely similar to KIC's priority sectors, this study found no direct or specific aspect of these funds targeting KIC KS university-based innovation incubation centres or other KIC's Knowledge Space or IS actors. These findings raised an important question about the nature of Rwanda's innovation funding model and how it was contributing to Rwanda's innovation policy outcomes with respect to national innovation flagship programmes such as KIC. Another significant finding presented in chapter seven of this thesis was the vital role played by international actors in shaping the direction of Rwanda's innovation ecosystem. In addition to playing a central role in innovation funding, this study found that an international private organisation was managing RIF on behalf of GoR through a Public Private Partnership (PPP) model of policy innovation. Moreover, this study found that, attracting international technology companies may be a viable and complementary policy option in supporting KIC's transition from KS to IS as it evolves into becoming a knowledge-based innovation ecosystem. In chapter Seven, this thesis developed a framework that may help in understanding the implications of these policy options for KIC's transition from KS to IS, and for the Rwandan innovation ecosystem at large (see Table 7.5 in chapter seven).

10.2.6 Unpacking KIC's local relevance and embeddedness from an urban innovation perspective

Unlike the previous empirical chapters where KIC's Knowledge Space actor interactions for RIL were explored from an ST&I policy standpoint, this study also investigated KIC from an urban innovation perspective. chapter eight of this thesis thus

investigated the importance of KIC's *spatial* dimension i.e. as a physical space providing proximity, enabling social interactions and/or access to key amenities or technologies. The analysis of empirical and secondary data was guided by the context-specific, multi-staged, integrated, analytical, and conceptual framework, in response to RQ7 - *What specific characteristics define Kigali Innovation City as an urban smart city initiative, and to what extent do Kigali's Innovation City Knowledge Space actors interact with adjacent communities in their geographical setting?* Additionally, in chapter eight, this thesis explored the typology of KIC as a smart city initiative, and how KIC's Knowledge Space actors, also known as KIC citizens, and their smartness influenced, or were influenced by, other actors in the City of Kigali, including, *inter alia*, local authorities and nearby communities. The thesis also discussed the implications of these interactions for the inclusive urban, knowledge-based innovation that KIC aspires to achieve. Based on empirical findings, this study identified the 'smartness of KIC citizens' as a new interpretation of the term 'smart,' which transcends the assumptions of previous studies that have often linked smartness solely to (digital) technologies underpinning smart city initiatives in an urban context. Additionally, drawing on empirical and secondary evidence, this research found that KIC constituted a new typology of smart city initiative which comprised three interweaved dimensions, *aka*, being at the same time strategic, experimental, and educational. This thesis drew on empirical and secondary data to propose a new type of smart city initiative as was found at KIC – the interweaved typology of KIC being at the same time strategic, experimental, and educational, offering new knowledge in urban innovation studies (see Fig. 8.8 in chapter eight). A critical realism approach was deployed to explain this typology in the wider context of Rwanda's state-led and top-down approach to ST&I policy and governance, and in a low-income-country (LIC) context. Despite a contextual dichotomy between KIC and the case studies researched previously, this work expanded on and partly reflected earlier studies, suggesting three distinctive types of urban smart city initiatives (strategic, civic, organic) (Bulkeley et al., 2019). Moreover, using a political economy analysis (PEA) lens as part of the context-specific, multi-staged, integrated, analytical, and conceptual framework, the examination of policy narratives revealed that KIC was institutionally connected to the central Government but remained detached from the urban context, *aka* the City of Kigali (see Fig. 8.7 in chapter eight for details). Another significant finding that

emerged from this study was that KIC's Knowledge Space actors, the KIC management entity, and City of Kigali authorities — particularly the local authorities in Gasabo district where KIC was located — were key players with the potential to influence, drive, or facilitate interactions arising from the social proximity of KIC citizens. To fulfil this collective mandate, beyond aligning government and urban policies, this author argued that it was crucial for all main actors to acquire entrepreneurial, developmental, social networking, and collaboration skills. Applying these capabilities might enhance governance, R&I, and learning within and around KIC. By doing so, this author suggests that these actors would leverage the intertwined characteristics of KIC as a strategic, experimental, and educational urban smart city initiative, thereby advancing KIC towards becoming an inclusive, locally embedded, and relevant knowledge-based innovation ecosystem.

10.2.7 Fostering KIC's Knowledge Space actor interactions for RIL through science and innovation diplomacy: a new ST&I policy innovation pathway

In the preceding empirical chapters four, five, and seven, this study viewed KIC from an ST&I policy perspective while investigating RQ1, RQ2, RQ3, RQ4, RQ5, and part of RQ6. In chapter eight, the research took a spatial dimension of KIC from an urban innovation perspective in response to RQ7. As presented in these preceding chapters, the role of international actors in influencing KIC's actor interactions emerged as one of the significant findings from this study. In chapter nine of this thesis, the research took both ST&I policy and urban innovation approaches to explore the way in which international actors including the Rwandan science and innovation diaspora (might) influence the national and place-based ST&I policy intervention, focusing on KIC as a case-study. The study thus used the science and innovation diplomacy lens, complemented with PEA as part of the context-specific, multi-staged, integrated, conceptual framework, to guide the analysis of empirical and secondary findings in response to part of RQ6 - *What is the role of government agencies and other actors in supporting the development of KIC into a knowledge-based innovation ecosystem?* From a potential organisational perspective, this study identified a trichotomy on how Rwanda's national science and innovation ecosystem actors interacted with international actors. Firstly, the study showed that Government agencies and KIC's Knowledge Space actors engaged in direct interactions with international actors

mainly for RIL, capacity development, and funding. Secondly, and surprisingly in contrast to the first category of actors, this research found that international actors operating in R&I areas in Rwanda, leveraging their parent organisations' capabilities to interact with local actors, thereby influencing and shaping the local NIS dynamics. Thirdly, the study found that government agencies and KIC's Knowledge Space actor interactions with Rwanda's scientific and innovative diaspora were solely channelled through and facilitated by the Ministry of Foreign Affairs and International Cooperations (MINAFFET). Another significant finding was that, irrespective of the approach, the interactions were initiated based on mutual interests of the actors involved. The variations in the ways in which these interactions were formed were contingent upon a range of factors including individual actors' missions, institutional and organisational architectures, and capabilities. From an institutional policy perspective, the study found that MINAFFET played a vital role in facilitating interactions between actors in NIS with the scientific diaspora and other relevant science diplomacy actors. Moreover, in accordance with empirical evidence from participant interviews, the mapping of the Rwanda ST&I and Foreign Policy nexus using the PEA dimension of narrative analysis revealed that the importance of harnessing the scientific, technological, and innovation potentials of the Rwandan diaspora was substantially emphasised in the narratives of contemporary Rwandan government public policy and the country's development agenda (see Table 9.1 and Fig. 9.3 in chapter nine).

10.2.8 Challenges hindering KIC's Knowledge Space actor interactions with international actors

In chapter nine, this thesis also highlighted a set of challenges that may hinder or deter the potential for international actors to contribute to fostering actor interactions for RIL in local and national ST&I in general, and in KIC in particular. For instance, despite the institutionalised facilitation of interactions between local and ST&I diaspora through MINAFFET and Rwanda' Science Granting Council (SGC), *aka*, NCST, the absence of a Ministry for Science and Technology may hamper the coordination and negotiation for ST&I's agenda advancement locally and internationally, thereby disenfranchising strategic ST&I policy interventions such as KIC. Another significant, and perhaps disturbing, finding that emerged from secondary data feeding into this study, was the

divided nature of the Rwandan scientific and innovation diaspora in the UK. This division was mainly caused by diverse migration patterns and history, as well as distinct political views and beliefs regarding the GoR. This author argued that deliberate efforts should be invested to strengthen Rwanda's science and innovation diplomacy in strategic countries such as the UK, to address this form of undesirable phenomenon. The alternative would hinder the attainment of science and innovation diplomacy potential for attracting Rwandan experts, scientists, and innovators, as well as international scientists and innovators. This study also showed that despite varied views, the Rwandan ST&I diaspora in the UK does possess the willingness to contribute to their home country. Drawing on the experience of the UK, this author thus argued that it was imperative for Rwanda foreign offices to have the capacity and capabilities to identify all Rwandan ST&I diaspora and make the effort to understand and respond to the country's needs, in order for it to fully untap these communities' potential for domestic ST&I strengthening.

The findings presented in chapter nine of this thesis therefore shed the light on the importance of creating, strengthening and consolidating the institutional capacity - both within NIS and in foreign offices – to leverage expertise of international actors including from the ST&I diaspora. In doing so, this author therefore argued that this may offer a pathway towards fostering interactions for RIL for KIC's development in particular, and for that of Rwanda's broader NIS in general.

10.3 Research academic and policy implications

The introduction, chapter one, of this thesis stated that NIS were important for societal development and described how this nexus played out as a function, not only of who the actors in the system were, but also how they interacted at multiple levels. Several studies pointed to the lack of or weakness of actor interactions among key actors to enable and stimulate the flow of knowledge and innovation being one of the main causes for perpetual underperformance, stagnation, and or dysfunction of NIS in low- and middle-income countries (LIMCs) (Arocena et al., 2017), particularly in Sub-Saharan Africa (SSA) (Kruss and Visser, 2017), and specifically in Rwanda (Twiringiyimana et al., 2021; Yongabo, 2021b). However, the dynamics of scientific and innovation ecosystems development within the broad national ST&I system largely remained unresearched in developing countries in general and in Rwanda in

particular. Drawing on this knowledge gap, this research focused its attention on the inner structures of Rwanda's NSI and on developing an understanding of '**how**' the university system, *aka*, academia – as the main source of formal knowledge generation – interacted with other actors for RIL in a place-based innovation ecosystem setting. In so doing, this research took the case of Rwanda's KIC to explore and interrogate the deployment of the ecosystem's approach in a low-income country (LIC) setting. Noting the complexity of actor interactions in the ecosystem environment, and given the complex nature of KIC as a 'an evolving ST&I policy intervention' at the interface of public administration and public policy dimensions of Rwanda's ST&I policy cycle (see details in Chapter one of this thesis), the main research problem – actor interactions for research, innovation, and learning – was considered in this research as a 'wicked policy problem' (Head, 2008; Head, 2022). The empirical findings of this study, as summarised in the preceding section, offer the following academic and policy implications pertaining to this research problem.

10.3.1 Academic implications

Given the complexity of this research problem and the deliberate design of this study aimed at achieving a scientific impact, the research led to a range of academic implications for the field of ST&I studies. These implications are outlined below from methodological, conceptual, and empirical perspectives.

10.3.1.1 Methodological implications

The present study has confirmed the findings from previous studies which claimed that a case-study approach was the most relevant method of empirical enquiry for knowledge creation in the context of both conceptual and contextual scarcity (Höglund and Linton, 2018; Davidson, 2017; Mugwagwa et al., 2021; Daniels et al., 2022). Moreover, as explained in the Methodology, chapter three of this thesis, this research adopted the CR as a philosophical foundation for knowledge creation. Fletcher (2017) had claimed that CR was a comprehensive scientific philosophy based on the premises that it fell at the interface of constructivism and positivism as it deployed the features of both frameworks while depicting their ontological and epistemological positions. This research added localism as a third philosophical position to reflect the fact that research had been conducted virtually in an online context amidst the COVID-

19 pandemic travel restrictions, with both interviewee and interviewer creating the reality of the interview situation. Moreover, drawing on the experience of conducting virtual interviews via an online platform, with both interviewee and interviewer being physically located in different contexts and environments, this thesis contrasted with Qu and Dumay (2011), who claimed that in localism, the reality of the interview is only created by the interviewer.

This study adopted a two-phased (pilot- and post-pilot) case-research method, with the aim of testing existing conceptual frameworks while developing new and context-specific conceptual frameworks. This expanded on Ketokivi and Choi's (2014) work suggesting that case-study work involving a single stage of empirical context might lead to the elaboration of existing theory or conceptual framework. Given the wickedness of the research problem investigated in the study using an interdisciplinary approach, this work also concurred with Brown et al. (2023) who stated that interdisciplinarity in research was paramount in that it helped deploy a range of perspectives to understand and shape complex problems.

As mentioned in chapter three of this thesis, given the state of KIC as a flagship policy intervention in Rwanda's science and innovation landscape, this study was methodologically undertaken whilst keeping the two questions below as the contextual foundations: *How can this research be conducted in such a way that it changes practice within and without the academia? How can this research enable policymakers to incorporate research evidence into policy making?* A reflective practitioner and critical transdisciplinary approaches were thus deployed for greater involvement of and knowledge co-creation with research participants, including researchers, senior academic administrators, policymakers, industry, and NGO managers throughout the research design process.

10.3.1.1.1 Advancing knowledge co-creation, and lessening push-pull phenomenon

Research participants were not employed as tools providing empirical data through interviews as is often the case in mainstream research approaches. They rather contributed as active agents in shaping research design through effective participation in the pilot phase, work-in-progress seminar, and post-pilot phase of this research. Moreover, during this research, participants were not confined to static categories or positions within the ecosystem. For instance, some who were in academia during the

pilot study interviews may have previously worked in government, industry, or the NGO sector, and vice versa. Additionally, some individuals who were in academia during the 2021 pilot study interviews had moved to government positions by 2022 and participated in post-pilot interviews from a government perspective. Understanding these dynamics and overlaps among research participants was highly informative and influential in interpreting the findings. Also, recognising how they drew from their diverse experiences helped to better interpret their responses. While most studies on actor interactions within innovation systems and ecosystems tend to take a static or siloed view of participants, this study explored the overlaps and movements across space and time, and how these dynamics influenced the responses and agency of different actors within the ecosystem.

The persuasive interview process was another important approach used to enhance participants' engagement in knowledge co-creation. Some interviewees were, in fact, surprised by the request to review the transcripts as a means of ensuring their insights and perspectives were fully and accurately captured. This author argued that the participants' sense of surprise may have stemmed from this being an unexpected approach, contrasting with the more conventional, unidirectional, and top-down interview process, where participants' involvement is typically limited to answering research questions during the interview period. Particularly for research participants from the government, this study challenged Boaden (2020) in their work on health policy and organisational psychology, which discusses the push-pull phenomenon where mainstream academia disproportionately pushes for their research to be used by policymakers for evidence-based or evidence-informed policymaking, with less pull from the policymakers. Given that this research problem was a real-world policy intervention, the present study alleviated this push-pull tension by pragmatically adopting a co-creation of knowledge approach, involving participants more extensively. It is anticipated that this increased involvement will encourage policymakers to adopt and use the evidence from this research in their policymaking processes.

Overall, this deliberate interpretivist empirical research method of co-creation with research participants ensured the relevance, rigour, and transparency of the qualitative research.

10.3.1.2 Theoretical or conceptual implications

This study makes a significant contribution by framing actor interactions as a structured research problem, thereby enhancing the consensus of research participants on values and certainty on knowledge (see Fig. 1.1 in chapter one). This study drew on an empirically rich case study to develop a range of conceptual frameworks guiding the study of actor interactions at micro- (actor), meso- (ecosystem of actors), and macro- (national system) scales.

From a micro-level perspective, as discussed in chapter four of this thesis, this research found that intra-actor interactions were predominant among KIC's Knowledge Space academic actors in proximity, and in STEM disciplines. With this important finding reflecting the contemporary discipline-siloed structure of universities in Rwanda, this thesis developed a framework for fostering inter-disciplinarity while bridging the interaction gaps between STEM and Non-STEM disciplines in a typically discipline-siloed university setting (see Fig. 4.9 in chapter four for details). This framework could be valuable for policy researchers and practitioners interested in the role of universities in society as it explores the conditions necessary to bring STEM disciplines closer to non-STEM ones such as social sciences, arts, and humanities within a discipline-siloed university setting. By integrating these fields, the framework aimed to enhance R&I in new and emerging technologies. The goal for those technologies and innovations was to meaningfully and contextually address the complex and multifaceted problems embedded in societal needs as highlighted in earlier studies (Marr, 2020; UKaid, 2020; Acemoglu and Johnson, 2023). Additionally, the framework might inform university managers and policymakers seeking to enhance the societal relevance of the university.

From a meso- or an ecosystem perspective, this thesis drew on the contextual gap identified in the mainstream THS framework, to add FS as the fourth functional dimension of THS actor interactions for RIL in a place-based ecosystem. While funding as a means was implicitly assumed to be available to either government, academia, and/or industrial actors, or else all actors in in HIC contexts, as indicated by Ranga and Etzkowitz's (2013), this study revealed that this means was mainly held by hybrid actors in LIC contexts. This funding capability therefore gave the hybrid actors the agency to influence and shape how and when an innovation ecosystem was developed. The contextualised THS conceptual framework presented in Fig. 4.10 in

chapter four offers an option for investigating the formation and development of a knowledge-based innovation ecosystem in an LIC setting. The systemic, complex, and wicked socio-economic and developmental issues and realities underpinning the geographical location of KIC at the interface of urban and rural settings made the contextualised THS unsatisfactory for this study, hence a new multi-stage, integrated, conceptual framework for actor interactions for RIL in a place-based ecosystem was developed. The proposed framework in Fig. 6.2 in chapter six of this thesis offered a new approach to investigating actor interactions by integrating different analytical lenses based on a given specific factor such as research stage and purpose, RQ, area of analysis, and research methods. This integrated framework extended the scope of mainstream conceptual frameworks that tended to recommend viewing actor interactions through a single lens (Daniels et al., 2017b; Kruss and Gastrow, 2017; Schot and Steinmueller, 2018; Daniels et al., 2021). Moreover, from a meso- and urban perspective, this thesis drew on empirical and secondary data to propose a new typology of smart city initiative as was found at KIC – the interwoven typology of KIC being at the same time strategic, experimental, and educational, offering new knowledge in urban innovation studies. A critical realism approach was deployed to explain this typology in the wider context of Rwanda's state-led and top-down approach to ST&I policy and governance, and in an LIC context. Despite the contextual dichotomy between KIC and the case studies researched previously, this work expanded on and partly reflected an earlier study suggesting three distinctive types of urban smart city initiatives (strategic, civic, organic) (Bulkeley et al., 2019).

10.3.1.3 Empirical implications

The findings from this work make several contributions to the current literature. Firstly, this work offers fresh insights into the current academic debate about how and why the lack or limited actor interactions for knowledge and innovation creation, dissemination, and use, constitutes a fundamental factor underpinning the perpetual under-performance or dysfunction of science and innovation systems in developing countries at national levels (Kruss and Visser, 2017 ; Twiringiyimana et al., 2021; Yongabo, 2021b; Daniels et al., 2022). Drawing on the empirically rich case study and guided by a critical realistic approach, this study is the first comprehensive investigation of a knowledge-based innovation ecosystem as an inner-structure or

sub-system to understand the underlying factors hampering or facilitating actor interactions at national science and innovation system level. In doing so, this study sheds light on the importance of intra-actors' and inter-actor interactions in shaping (or not) the co-evolution of an ecosystem, suggesting that the institutional and functional disconnectedness often exhibited by national sciences and innovation systems were deeply rooted in the ecosystems that constituted these systems.

Secondly, the empirical findings of this study expand our understanding of varied pathways towards fostering actor interactions by taking a nuanced approach involving multiple perspectives of an innovation ecosystem, such as ST&I policy, place-based or urban innovation, and foreign policy through science and innovation diplomacy. The present thesis thus confirmed the findings of Almaainah (2021) who showed that the multiple perspective approach was a suitable lens through which to explore the 'meta-governance and complexity of knowledge-based innovation ecosystems' in a given context.

Thirdly, the findings of this research have significant implications for the understanding of how universities – denoted in this research as KIC's Knowledge Space academic actors – play vital and multiple roles in shaping the knowledge-based innovation ecosystems. This study also provides deep insights into the main shortcomings associated with these roles in a LIC and state-led ST&I context. Previous studies suggested that entrepreneurial universities' roles in the knowledge-based innovation ecosystems included: human capital development, advancing knowledge and technology, and participating as an economic development partner with industry, government and other actors. These roles were exhibited through boundary spanning (Heaton et al., 2019); knowledge intermediary and gatekeeping (Appio et al., 2019); and knowledge exchange through co-creation – rather than a unidirectional knowledge transfer, trust-building through social interactions, and institutional entrepreneurship where the 'organisational or individual actors do not only initiate diverse changes in the institutional environment, but also actively participate in the implementation of such change' (Cai et al., 2020, p. 5). The findings of this study indicate that, aside from possessing adequate entrepreneurial and dynamic capabilities, KIC's Knowledge Space academic actors lacked the agency to influence change in the planning and development activities of the ecosystem to which they belonged.

Lastly, this study raised a critical question concerning the applicability of conceptual frameworks originating in the global North for the Rwandan context, despite their central role in framing the national ST&I policy. This thesis highlighted the central role of hybrid actors – including local and international NGOs, multi-governmental and multi-partner programs, bilateral-driven initiatives, as well as financial organisations for development – in influencing the development of KIC through funding. As indicated in the sub-section above, based on this fresh insight in this research domain, a contextualised THS was proposed in chapter five of this thesis, adding the new and fourth FS to highlight the implications of this space for the creation and development of knowledge-based innovation ecosystems in a resource-scarce context.

10.3.2 Policy implications

As indicated earlier in this chapter, this research was designed and carried out with the two questions as guiding considerations: *How can this research be conducted in such a way that it changes practice within and without academia? How can this research enable policymakers to incorporate research evidence into policymaking?* Given the complexity of the case study with KIC as an evolving ST&I policy intervention at the interface of public policy and public administration dimensions of Rwanda's ST&I policy cycle and considering the dual conceptualisation of KIC through both ST&I policy and place-based urban innovation perspectives, the findings of this research led to systemic policy implications. Nonetheless, given the pragmatic interest of this thesis in creating policy impact, the implications were defined based on key actors' concerns or entry points within the system with the greatest prospect of embracing the implications to make change. The implications were thus outlined at micro- or organisation or KIC actor level, meso- or ecosystem level, and maso- or national scale, in relation to this study's research questions.

10.3.2.1 Micro-level implications for individual KIC's Knowledge Space actor interactions with respect to RQ1, RQ2, and RQ4

RQ1 and RQ2 sought to understand how and to what extent the KIC's Knowledge Space academic actors interacted, and the influence of these interactions on R&I and learning activities among the KS actors. Drawing on the findings in response to these questions, a policy framework to promote an interdisciplinary approach among actors

within a discipline-siloed university system was developed (see Fig. 4.9 in chapter four for details). The purpose of this framework was to introduce a new paradigm of adopting a ‘transformative interdisciplinary’ environment that would bring RIL in STEM disciplines on one hand, and social and human sciences – that is, non-STEM disciplines – on the other, closer together through collaboration, knowledge exchange, and communication (Marres and de Rijcke, 2020). The framework recommendations included university- and college- or departmental-level policy mixes and instruments to stimulate intra-actor interactions, together with policy alignment and coherence at intra-university levels, in relation to relevant regional (place-based) and national development strategies. This study thus proposed a paradigm shift regarding the over-emphasis on STEM versus non-STEM programmes, to prevent any STEM path dependency phenomenon as was being practiced HIC countries at the time. This author furthermore argued that an unequivocal commitment on the part of university leaders and researchers as well as students, to promoting and implementing capacity enhancement might be critical for embracing and bringing about this new paradigm to best effect. Additionally, the findings on the limited involvement of KIC’s Knowledge Space central academic actors in inter-actor interactions suggested a lack of interest from these actors. An alternative approach was aimed at enabling epistemic inclusivity of local KIC’s Knowledge Space actors in proximity, enhancing their scientific and technological capacity and capabilities, and increasing the influence and impact of the expertise and experiences of KIC’s Knowledge Space central actors on the former, without jeopardising the latter’s global aspirations and agendas.

The findings of this research with respect to RQ4 on the COVID-19 pandemic indicated that several researchers and teaching staff from KIC’s Knowledge Space academic actors in proximity experienced inadequate ICT skills required to effectively utilise modern digital tools and platforms for research and online learning and working. Capacity strengthening in this area may contribute to enhancing interactions for RIL experiences in a post-pandemic context.

10.3.2.2 Meso-level implications for KIC’s ecosystem with respect to RQ3

RQ3 of this research aimed to understand whether KIC’s Knowledge Space academic actor interactions were (or not) related to KIC’s regional planning and development activities. The findings for this RQ3 revealed a paradoxical phenomenon with the

identified interactions not being linked with KIC's planning and development. On the one hand, KIC's Knowledge Space academic actors in proximity showed negligible awareness of KIC and its aims, and KIC was missing in the narratives of their institutional frameworks such as policies and strategies. On the other hand, KIC's Knowledge Space central academic actors indicated a lack of power and agency to participate in KIC's planning and development activities. Deliberate efforts to align KIC KS actors' policies and strategies with the national ST&I agenda for KIC, and collective and inclusive governance of KIC, could significantly enhance and facilitate collaborations aimed at a collective place-based development agenda.

10.3.2.3 Macro-level implications for Rwanda's ST&I system policymakers and public service entities with respect to RQ6 and RQ 7

The first part of RQ6 aimed to examine the role of Government agencies in supporting the development of KIC into a knowledge-based innovation ecosystem. The findings of this research in response to this part of the question indicated that R&D-based or ST&I-based innovation activities were predominantly funded by government through NRIF and RIF, managed by NCST and RDB, respectively. Despite both funds focusing on technology-enabled sectors mainly related to KIC priority sectors, this research found that neither direct nor specific aspects of either of the two targeting KIC's Knowledge Space university-based innovation incubation centres or other R&I activities were being undertaken by KIC's Knowledge Space actors. Moreover, this study found that the two funding instruments were institutionally and operationally disconnected. This thesis thus developed a framework proposing how these two instruments, alongside other funding instruments, could be reconciled for greater policy outcomes. The framework was designed based on TRL and R&D-based innovation theory lenses (see Table 7.4 in chapter seven for details).

The second part of RQ 6 sought to explore how science and innovation diplomacy could contribute to fostering KIC's Knowledge Space actor interactions and KIC's development. The findings from this study shed light on the role of Rwanda's MINAFFET in facilitating interactions between actors in national science and innovation systems, including KIC, with the scientific diaspora and other relevant science and innovation diplomacy actors in strengthening the national ST&I ecosystem. Additionally, the mapping of the Rwanda ST&I and Foreign Policy nexus,

in Fig. 9.1 in chapter nine, revealed that harnessing the potentials of the Rwandan science and innovation diaspora was significantly highlighted in the Rwanda ST&I policy and strategy. Strengthening the institutional capacity of MINAFFET and foreign offices to strategically harness the science and innovation diaspora may not only foster KIC's Knowledge Space actor interactions for RIL, but may also strengthen the national science and innovation ecosystem. Lessons could be learnt from several countries such as Brazil (Anunciato and Santos, 2020b), India (Balakrishnan, 2019), and France and Switzerland (Flink and Schreiterer, 2010), which had successfully explored this policy option in different ways.

RQ7 partly sought to understand KIC from a policy and practice perspective, with the analysis focusing on local embeddedness, co-location, inclusivity, and sustainability. The mapping of national and place-based (or urban) policy narratives in relation to KIC revealed that KIC was institutionally linked with central government while being detached from the local authorities *aka*, City of Kigali (see Fig. 8.7 in chapter eight for details). Moreover, this study found that City of Kigali authorities – including local authorities in Gasabo district where KIC is geographically located, and the local community in KIC proximity constituted key actors with the potential to influence, shape, and drive KIC's contribution to the development of the region. One possible implication of these findings is twofold: 1) The local authorities, *aka*, City of Kigali and Gasabo district should draw on national development agendas and policies such as Vision 2050, ST&I Policy, NST-1, Smart Rwanda Master Plan, and Rwanda ICT Hub Strategy, to incorporate KIC into the City's and district policies, and implementation strategies; and 2) KIC actors should make deliberate efforts for greater engagement with the local authorities and adjacent communities, thereby shaping KIC into an inclusive, locally embedded, and relevant knowledge-based innovation ecosystem. A further finding of interest from this study was that the intermittent noise from manufacturing factories in KSEZ constituted the sole form of interaction with KIC's Knowledge Space central academic actors. Deliberate policy actions to address this undesirable type of interaction would be paramount for KIC to become an innovation ecosystem where academic and industrial actors can harmoniously co-locate, collaborate, co-evolve, and thrive together.

10.4 Closing remarks

This research took the case of Rwanda's KIC to explore and interrogate how actor interactions influence the formation and development of a knowledge-based and place-based innovation ecosystem in a low-income country setting. Underpinned by a Critical Realist philosophical approach, this research drew on empirical data from desk reviews and interviews to identify the actors and explore the nature of actor interactions for RIL. It further went on to investigate the factors that might facilitate (or hinder) these interactions, and pathways towards fostering actor interactions for an emerging place-based innovation ecosystem development. Guided by knowledge-based regional development theory (Etzkowitz and Klofsten, 2005) and the THS framework, this study found that, as a place-based innovation ecosystem, KIC was transitioning from the implementation to the consolidation and adjustment stage of its growth, with universities within KIC's geographical area and those in its proximity within the City of Kigali constituting KIC's Knowledge Space. Additionally, guided by the newly developed context-specific and multi-stage integrated analytical framework, this research found that KIC KS university-based innovation incubation centres constituted a potential for KIC's transition to IS.

Drawing on the analysis of KIC from the perspective of its KS interactions with actors for RIL, as discussed in the empirical chapters of this thesis and as summarised above, this author argues that a knowledge-based innovation ecosystem does not emerge merely from bringing academic actors into one geographical area. The emergence of an innovation ecosystem and its embeddedness in its place-based setting are largely contingent upon how these KS actors interact for RIL with other actors, including central and local government – City of Kigali in this study, and communities, non-governmental actors, and industry in its geographical or/and cognitive proximity, as well as with international actors, including the science and innovation diaspora. These interactions in turn stem from a broad range of factors such as deliberate policy options, alignment (or misalignment) of individual actors' agenda and intended outcomes, actors' power and agency dynamics, actors' interests, as well as technical and financial capacity. These conditions for KIC's local embeddedness were revealed through the newly developed integrated conceptual framework, as they could not be uncovered by the THS and other related conceptual frameworks originating from the

global North. This thesis therefore contributes to existing scholarship by highlighting a critical concern regarding the practical relevance of these concepts in developing country contexts, notwithstanding their role in framing national ST&I policies.

Based on the lessons learned from KIC with respect to Rwanda's broad ST&I system, this author argues that the institutional and functional disconnectedness often exhibited by an NIS, are deeply rooted in actor agency, collaboration, coevolution, and contestation. Addressing the factors hampering actor interactions at micro- (actor) and meso- (ecosystem of actors) scales, would ultimately lead to strengthening the performance of the broader NIS.

10.5 Study limitations

10.5.1 Design and methodological limitations

This study was designed based on a case-study approach and a primarily qualitative method through expert semi-structured interviews. The findings of this study were thus mainly drawn from participants' perspectives and insights. Whilst immensely valuable in providing empirically grounded and context-specific narratives at micro- and meso-scales, the author was aware that any interview-based data collection methodology was *de facto* limited on many grounds such as statistical significance and subjective bias (Qu and Dumay, 2011). It was assumed that the responses gained were largely dependent on participants' willingness to reply and/or interest in responding, which raised the possibility that non-respondents may have held very different views (Borowska-Beszta, 2017). Additionally, whilst the interviewees were carefully identified and selected for the purpose of this study, their respective professional positions may have influenced their various responses. It is also relevant to note that only 26.5% of participants were female (see Fig. 3.8. in chapter three for details). Whilst this limited number of female participants may partly reflect the contemporary gender divide in Rwanda's university system with women constituting 25.6% of the total academic staff working in Rwanda's higher education sector (GoR, 2019a), a potential gender bias may possibly have influenced participants' responses as Borowska-Beszta (2017) posits. Moreover, this study was limited by the fact that all interviews were conducted virtually via online tools, preventing the interviewer from creating the reality of the interview situation as would have been the case had the interviews been held in person. Notwithstanding these limitations, this work drew on

the empirically rich case-study, qualitative research method to add to our understanding of the complexity of actor interactions for RIL, and our learning from the innovation ecosystem perspectives, as well as in the context of research scarcity (Höglund and Linton, 2018; Davidson, 2017; Mugwagwa et al., 2021; Daniels et al., 2022).

10.5.2 Conceptual limitations

The research was fundamentally conceptualised through THS and Knowledge-based regional [or place-based] development theory – both HIC-centric concepts (Ranga and Etzkowitz, 2013), making it conceptually intensive. Despite this contextual limitation, this work drew on the empirically rich data not only to test the validity of the THS framework, but also to challenge it in relation to the contextual situatedness of the case research. Guided by Ketokivi and Choi (2014)'s transparency and duality criteria of situationally grounded and generality, required for the case-study investigation, this thesis drew on the contextual gap identified in the mainstream THS framework to add FS as the fourth functional dimension of THS actor interactions for RIL in a place-based ecosystem. This change made the framework relevant for researchers interested in actor interactions for the creation, use, and dissemination of the knowledge and innovation relevant to economic development in a LIC context (See details in chapter four of this thesis). Additionally, the systemic, complex, and wicked socio-economic, socio-technical, and developmental issues and realities underpinning the geographical location of KIC at the interface of urban and rural settings made the contextualised THS unsatisfactory for this search, leading to the development of a new Context-specific Multi-stage Integrated Conceptual Framework. While the new framework was deployed to guide the analysis of this research in its post-pilot phase, the same framework is conceptually broad enough to serve as a lens to guide further investigations of similar complex and context-specific research problems in other LICs, as well as in LMIC and HIC contexts (see details of the new conceptual framework development process in chapter six of this thesis).

10.6 Proposed further research

In the author's view, this research has served as a point of departure for future research in multiple directions: Firstly, towards KIC innovation ecosystem, further

studies could draw on the conceptualised THS framework and the Context-specific and Multi-stage Integrated Conceptual Framework developed in this thesis to delve deeper into exploring actor interactions for RIL from the perspectives of KIC's Knowledge Space and FS actors. Understanding the complexity of interactions and varied actors involved in these spaces with multiple interests that at times may create tensions, might offer great opportunities to shape multiple policy options and pathways towards fostering these interactions and shape KIC's place-based development outcomes. Moreover, further research could employ the Context-specific and Multi-stage Integrated Conceptual Framework developed in this thesis alongside the UK Research and Innovation (UKRI) Anticipation, Reflection, Engage, Act (AREA) framework, and in tandem with the United Nations' Sustainable Development Goals (SDGs), particularly the SDG 11 on sustainable cities and communities, to investigate how the communities in KIC geographical proximity participate in the experimentation of technologies and innovations developed by KIC's Knowledge Space actors. A major recent study on directing research and innovation for global goals (STRINGS) suggested that decisions regarding ST&I pathways aimed at tackling specific SDG challenges should involve the actors impacted by those decisions (Ciarli et al., 2022). The emphasis of this further research would thus be placed on people's social and economic benefits and risks, safety, privacy, and agency, as well as on the extent to which all communities participate in co-designing and co-creating these technological innovations.

Secondly, towards Rwanda's broad NIS and beyond: further research that would draw on the learnings from this thesis from urban innovation perspectives to study how KIC's model could be deployed in Rwanda's secondary cities. Such a study would involve systems mapping to explore how deliberate policies could be deployed to assess universities' capacities and capabilities to shape and influence the establishment of knowledge-based innovation ecosystems in those secondary Rwandan cities. Viewing KIC as a proof-of-concept entity through an urban policy innovation perspective, this study recommended exploratory research aimed at scaling out KIC concept in other cities within Rwanda. This would arguably add value to Rwanda's secondary cities' development strategy, as emphasized by Rwanda's NST-2 (GoR,2024). A similar empirically rich case study approach could be deployed to form and develop innovation ecosystems in other developing country cities.

Finally, the issue of the effects of the COVID-19 pandemic on KIC's Knowledge Space actor interactions for RIL is an intriguing one that could usefully be explored in future research. For instance, further empirical studies could, on the one hand, explore how the R&I landscape has changed in the post-pandemic university environment, while on the other hand, further investigations could focus on the depth and breadth of the nature of the financial, social, and psychological insecurities amongst KIC's Knowledge Space academic staff, arisen from the pandemic, and whether (or not) these uncertainties have been fading in the post-pandemic context.

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⁷⁵ Elsevier – Harvard (with titles) referencing style was used in this thesis

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Appendices

Appendix_3.1: Pilot study interview research checklist

Background and context

According to the UCL Doctoral Training Programme Handbook of the academic year 2019-20, doctoral candidates are required to conduct a pilot project in their academic area of interest. A report of this pilot project will be assessed in a Progression Viva prior to upgrade from MPhil to PhD qualification. The pilot project titled: '*A study of Rwanda's university system and emergence of Kigali Innovation City: Understanding interactive capabilities in the triple helix knowledge space*', is to be conducted in the six-month period from December 2020 to June, 2021. This study aims to offer a knowledge contribution to the understanding of interactive capacities in Rwanda's higher education sector with respect to the emerging Kigali Innovation City (KIC). Located in the special economic zone in the suburb of Kigali, the capital city of Rwanda, KIC is an important component of Rwanda's development ambition to become an Information and Communication Technology (ICT) Hub for Africa. The study focuses on the University of Rwanda (UR) - created in 2013 as a merger of seven public universities: the Carnegie Mellon University in Africa (CMUA) - strategically located within the KIC locale; and those in KIC close proximity including the African Institute of Mathematical Sciences (AIMS) and African Leadership University (ALU). UR is represented by the College of Science and Technology (UR-CST) and five research centres hosted by UR-CST, namely: African Centres of Excellence (ACE) in Internet of Things, Data Science, Energy for Sustainable Development, Centre of Excellence in Biomedical Engineering (CEBE), and East African Institute of Fundamental Research (EAI FR). Part of this study is also to understand the extent to which the COVID-19 pandemic has affected the current and future interactions of the aforementioned actors.

Given its aforementioned institutional and geographical setting, KIC is considered as a Triple Helix System (THS) for the purposes of this study. Grounded in systems theory, THS is characterised by (i) its components (or actors): academia, industry, and government, (ii) relationships (or actor interactions), and (iii) their functions. The main functions of THS actors include knowledge and innovation creation, dissemination, and use. These functions are realised through the knowledge, innovation and consensus spaces. Understanding how the aforementioned actors – the main sources of knowledge production within the THS knowledge space – interact and the extent to which these interactions are related to KIC's development, and the implications of these interactions for teaching, research, and innovation, is the ultimate goal of this pilot study. The study aims additionally to understand the extent to which the COVID-19 pandemic has influenced actor interactions. It is anticipated that this work will expand the knowledge base on the THS framework, and in particular, the formation and operation of regional (place-based) innovation policies, for the development of cities in the context of Sub-Saharan Africa (SSA).

The pilot project research design fundamentally focuses I on generating understanding based on the four following broad research questions:

- i. *How and to what extent do triple helix knowledge space actors interact in research and innovation (R&I)?*
- ii. *How do these interactions influence these knowledge space actors' learning and R&I?*
- iii. *Is the interaction related to KIC's regional development activities and planning, and if so, how?*
- iv. *How has the COVID-19 pandemic influenced actor interactions for RIL?*

As a key stakeholder, it is in this context that you are being contacted to make a contribution to this study. I am seeking your contribution to this endeavour through completion of the questions below, either by email or by means of a conversation. All responses will be anonymised in the analysis and evaluation reports. You do not have to answer any question that you feel is not relevant to you or that you would prefer not to answer. You will be included in the distribution lists for the knowledge outputs from this study.

Respondent details

- Your name (optional):
- Your country:

- Your organisation (University/Institute, School, Dept, Research Centre):
- Position in own organisation:

Research Questions

1. General background on the organisation

- When was your organisation (University/Institute, School, Dpt, Research Centre) established?
- What is the size of your organisation? (number of students and staff: academic and administration)
- Who is the main funder of your organisation?
- How long have you been working with the organisation?

2. How are interactions within your University/College/School/Department/Research Centre?

- Does your University/College/School/Research Centre promote and support the culture of entrepreneurship and innovation (disruptive and changing the status-quo mind-set) amongst faculty and students? If the answer to the initial question is yes, how does it do this?
- Do academic staff and researchers from your University/College/School/Research Centre interact with colleagues about research and innovation, and (or) with colleagues in other Colleges/Schools/Research Centres within your organisation? If the answer to the initial question is yes, how do they do this?
- How do these interactions influence teaching, research, and innovation?
- What adjustments or initiatives have been introduced at your University/College/School/Research Centre to foster more effective intra-University/College/School/Research Centre interactions?
- In your view, which ones have been most effective, and why?

3. How is your University/College/School/Department/Research Centre considering interdisciplinarity and multidisciplinary in Research and Innovation (R&I) in the new and emerging technologies?

- Recent studies suggest the need to bring computer sciences closer to social sciences, arts and humanities for RIL in new and emerging technologies such as Artificial Intelligence and Machine Learning (ML), if these technologies are to respond to societal needs responsively and contextually. Does your University/College/School/department/Research Centre involve social and humanities scientists in R&I projects in these areas? If yes, at what stages do they engage? If not, what are the constraints and what would be the appropriate approaches towards bringing them onboard?

4. How are interactions done with other University/College/School/Department/Research Centre in light (or not) of the Kigali Innovation City (KIC) development?

- Do you know (or value knowing) what types of research or innovation activities are currently being done (or) planned at other Universities/Colleges/Schools/Departments/Research Centres offering similar/related programmes to yours? If you do have this knowledge, could you tell us why it is or isn't valuable to you?
- Does your University/College/School/Department/Research Centre share collaborative activities with other universities/institutes? If yes, what are these and how are they initiated and implemented?
- What are the underlying factors that facilitate (or hinder) the interactions with other universities at individual and organisational level?
- What are the mechanisms for evaluating and governing these interactions?
- Your organisation is part of the knowledge platform (to produce skilled graduates and R&I) for the KIC. Are you aware of this?
- If (e) is yes, can you please describe any activities (projects/programmes) being undertaken in your organisation to contribute to the development of KIC?
- Who (or which organisations) are your collaborators in these activities?
- If (e) is no, can you suggest how these activities could be initiated?

5. How does your University/College/School/Department/Research Centre interact with industry?

- a. Do you know of any industry (firms) conducting business in the same domain as that which your University/College/School/Department/Research Centre is teaching/researching?
- b. If yes, which are those firms?
- c. Are these (or some of these) firms located within the KIC area?
- d. Does your University/College/School/Department/Research Centre share collaborative activities with any of the aforementioned firms?
- e. If yes, what are those activities and how are they initiated and implemented?
- f. Does your University/College/School/Department/Research Centre have a program to support (or facilitate) researchers and students wanting to turn their R&I ideas (knowledge outputs) into business?
- g. If yes, how is this done?
- h. If not, what could be the reasons?
- i. What are underlying factors that facilitate (or hinder) the interactions with the industry at individual (academic staff) and organisational level?
- j. What are the mechanisms for evaluating and governing these interactions?

6. How has COVID-19 pandemic influenced interactions for RIL?

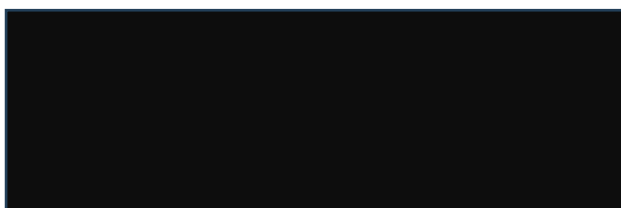
- a. How has the COVID-19 pandemic affected your research so far? (positively (and/or) negatively)
- b. Please elaborate on your response
- c. What do you suggest should be done by your University/College/School/Department/Research Centre or government to support you in a) engaging with R&I, and b) interacting better with other researchers in your University/College/School/Department/Research Centre or elsewhere, under the current COVID-19 pandemic and/or in post-COVID-19 pandemic era?

Appendix_3.2: UCL REC Letter of Approval for pilot research - 19295.001⁷⁶

UCL RESEARCH ETHICS COMMITTEE
OFFICE FOR THE VICE PROVOST RESEARCH



22/02/2021



Notification of Ethics Approval

Project ID/Title: 19295/001 A study of Rwanda's university system and emergence of Kigali Innovation City: Understanding interactive capabilities in the triple helix knowledge space

Further to your satisfactory responses to the reviewer's comments, I am pleased to confirm that your study has been ethically approved until **22/02/2022**.

Ethical approval is subject to the following conditions:

Notification of Amendments to the Research

You must seek Chair's approval for proposed amendments (to include extensions to the duration of the project) to the research for which this approval has been given. Each research project is reviewed separately and if there are significant changes to the research protocol you should seek confirmation of continued ethical approval by completing an 'Amendment Approval Request Form'
<http://ethics.grad.ucl.ac.uk/responsibilities.php>

Adverse Event Reporting – Serious and Non-Serious

It is your responsibility to report to the Committee any unanticipated problems or adverse events involving risks to participants or others. The Ethics Committee should be notified of all serious adverse events via the Ethics Committee Administrator (ethics@ucl.ac.uk) immediately the incident occurs. Where the adverse incident is unexpected and serious, the Joint Chairs will decide whether the study should be terminated pending the opinion of an independent expert. For non-serious adverse events the Joint Chairs of the Ethics Committee should again be notified via the Ethics Committee Administrator within ten days of the incident occurring and provide a full written report that should include any amendments to the participant information sheet and study protocol. The Joint Chairs will confirm that the incident is non-serious and report to the Committee at the next meeting. The final view of the Committee will be communicated to you.

Final Report

At the end of the data collection element of your research we ask that you submit a very brief report (1-2 paragraphs will suffice) which includes in particular issues relating to the ethical implications of the research

Office of the Vice Provost Research, 2 Taverton Street
University College London
Tel: +44 (0)20 7679 8717
Email: ethics@ucl.ac.uk
<http://ethics.grad.ucl.ac.uk/>

⁷⁶ Personal data (names, job titles, signatures, email address, and phone numbers) has been redacted on pages 371, 372, 373, 374, 378, 379, 380, 381, 382, 383, 400, 402, and 404, in compliance with UCL data protection policy.

Appendix_3.3: Changing research from a face-to-face to an online process due to the COVID-19 pandemic

From: VPRO.Ethics <ethics@ucl.ac.uk>

Sent: 15 February 2021 12:40 PM

Subject: FEEDBACK: Ethics Application 19295/001

Dear Remy,

Project ID: 19295/001

Project Title: A study of Rwanda's university system and emergence of Kigali Innovation City: Understanding interactive capabilities in the triple helix knowledge space

Further to the review of your ethics application, I would be grateful if you could respond to the following comments if possible on or before **22nd February**. Please provide as appropriate:

1. An itemised response to reviewer comments
2. A revised application form (highlighted changes)
3. A revised consent form and participant information sheet (highlighted changes)

Please ensure these are in a combined PDF.

Comments

1. 16a: Note that at present research can only be conducted online unless you receive approval from your Dean <https://www.ucl.ac.uk/research/integrity/framework-starting-or-resuming-fieldwork-non-ucl-settings>
2. 20/21: As above, no travel is allowed at present.
3. 45: Please clarify how the interviews will be audio recorded. Tick 'audio/visual recordings' in section 15 if recording. Please detail who will be transcribing the recording and when these will be deleted.
4. 45/48: Please clarify why it is necessary to store hardcopies if the research is online.
5. 47: *"Hardcopies of transcripts and notes will be physically brought back in the EEA (UK) by the Researcher."* Please clarify why this is necessary – these should be uploaded to UCL servers rather than physically transported. As before, travel not possible at present.
6. Please note that someone other than the PI should sign off the form, for example an ethics lead.
7. Recruitment email: please be clear that the research has received approval from UCL REC
8. Consent form:
 - a. Ensure 3 and 6 are consistent.
 - b. 7: You haven't detailed support in the PIL so please remove reference to this
 - c. 2 and 13 can be combined. In 13, please remove 'video' if only audio recording and vice versa.
 - d. 17: state that data will be sent to the UK, not the EEA.
 - e. Is it necessary to store contact details for future research? If not, remove.
9. Consent for face-to-face interviews: Re- number: currently 18 to 34.

Best wishes,

Office of the Vice-Provost (Research)
University College London
2 Taverton Street, London, WC1H 0BT

Website: <https://ethics.grad.ucl.ac.uk/>

Ethics email: ethics@ucl.ac.uk

Appendix_3.4: UR affiliation confirmation for pilot study



UNIVERSITY of
RWANDA

COLLEGE OF SCIENCE
AND TECHNOLOGY

OFFICE OF PRINCIPAL

Ref No: ~~553~~/2020
Date: 26th October 2020

Re: Research affiliation for Mr. Remy TWIRINGIYIMANA

I have a pleasure to confirm that **Mr. Twiringiyimana Remy**, a PhD student in Science, Technology, Engineering and Public Policy (STeAPP) at the *University College London* (UCL), will be affiliated to the University of Rwanda, College of Science and Technology (UR-CST) as a doctoral researcher from 28th December 2020 to 28th June 2021.

During the abovementioned period, he will be conducting empirical research for his doctoral pilot project titled: *"A study of Rwanda's university system and an emergence of Kigali Innovation City: Understanding interactive capabilities in the triple helix knowledge space"*, under supervision of Joanna Chataway, Professor of Science and Technology Policy and Head of STeAPP Department at UCL.

I would like to hereby confirm that I will serve as Remy's Local Supervisor for this doctoral pilot research project.

Any service rendered to Remy Twiringiyimana will be highly appreciated.

Yours sincerely,



College of Science and Technology
University of Rwanda

 P.O Box 3900 Kigali, Rwanda |  principal.cst@ur.ac.rw |  www.ur.ac.rw

Appendix_3.5: Rwanda NCST research permit for pilot study

REPUBLIC OF RWANDA

Kigali, on 07th December 2020

N° NCST/482/ 211 /2020



NATIONAL COUNCIL FOR
SCIENCE AND TECHNOLOGY

Mr. Remy TWIRINGIYIMANA

Dear Mr.TWIRINGIYIMANA

RE: Approval to Conduct Research in Rwanda

I am pleased to inform you that your request to conduct research in Rwanda entitled: *“A study of Rwanda’s University System and an Emergence of Kigali Innovation City: Understanding Interactive Capabilities in the triple helix knowledge space”* as a requirement for the award of Doctor of Philosophy Degree in Science, Technology, Engineering and Public Policy has been approved under research permit No: NCST/482/211 /2020.

This permission covers research activities related to the provided research project title, and project proposal submitted to the National Council for Science and Technology (NCST), for the period from 07th December, 2020 to 06th December 2021.

The research is expected to be carried out under the affiliation of **University of Rwanda, College of Science and Technology (UR-CST)**, under the supervision of [REDACTED], and will take place in **City of Kigali**.

You are requested to submit the final report after completion of your research project to the NCST, Ministry of Education, Rwanda Development Board, City of Kigali and University of Rwanda.

I wish you success in your research.

Appendix_3.6: post-pilot study interview research checklist

Background and context

In accordance with the UCL Doctoral Training Programme Handbook for the academic year 2019-20, the present doctoral study is a follow-up and upgrade of the pilot project titled: '*A study of Rwanda's university system and emergence of Kigali Innovation City: Understanding interactive capabilities in the triple helix knowledge space*', which was conducted in the twelve-month period from February 2021 to February 2022. Located in the special economic zone in the suburb of Kigali, the capital city of Rwanda, KIC is being developed as a 'knowledge, technology and innovation ecosystem', aimed at bringing together world-class universities and R&D organisations, technology firms, incubation centres, and innovative start-ups, as well as creating conditions for innovation and societal development. The pilot study focused on understanding actor interactions within the KIC Knowledge Space from a triple helix system (THS) perspective. It provided preliminary insights pertaining to actor interactions in relation to research, innovation and learning (RIL) within the KIC Knowledge Space. The present doctoral study draws on the pilot study's empirical and conceptual insights, to conceptualise KIC through two distinctive yet complementary lenses, namely: (i) KIC as an STI policy flagship intervention – a science and innovation system perspective, and (ii) KIC as urban smart city initiative – an urban innovation perspective. In both perspectives, the research is geared towards deepening the understanding of actor interactions, as well as exploring different pathways towards creating new or fostering existing interactions for the development of an inclusive place-based knowledge and innovation ecosystem in a regional setting, in a low-income country (LIC) context.

Based on the empirical and conceptual gaps identified by the pilot study, and guided by the proposed dual conceptual underpinnings of KIC, the proposed post-pilot doctoral research fundamentally focuses on responding to the following further three Research Questions⁷⁷:

- v. *How do KIC Knowledge Space academic actors interact with industry for RIL and learning?*
- vi. *What is the role of government agencies in supporting the development of KIC into a knowledge and innovation ecosystem?*
- vii. *What specific characteristics define Kigali Innovation City as an urban smart city initiative, and to what extent do Kigali Innovation City Knowledge Space actors interact with adjacent communities in their geographical setting?*

As a key stakeholder, it is in this context that you are being contacted, to make a contribution to this study. I am seeking your contribution to this endeavour through completion of the questions below, either by email or by means of a conversation. All responses will be anonymised in the analysis and evaluation reports. You do not have to answer any question that you feel is not relevant to you or that you would prefer not to answer. You will be included in the distribution lists for the knowledge outputs from this study.

Respondent details

- Your name (optional):
- Your country:
- Your organisation:
- Position in own organisation:

Research Questions

0. General background on the organisation

- e. When was your organisation established?

⁷⁷ These three post-pilot RQs are numbered v, vi, and vii, following the four RQs explored during pilot-study. For simplicity, the post-pilot questions in this interview check list are numbered 1,2, and 3.

- f. What is the size of your organisation? (number of staff)
- g. Who is the main funder of your organisation?
- h. How long have you been working with the organisation?

Academic actor interactions in KIC's Knowledge and Innovation space:

1. How do KIC Knowledge Space academic actors interact with industry for RIL and teaching? *[THS lens]*
 - i. How are university-based innovation (or incubator) centres or laboratories governed, what are their mandates and how are they funded? *[IE lens]*
 - j. How do these innovation centres interact with firms and other organisations, and what are those firms and other organisations? *[IE lens]* In your experience, what are the three conditions that would make the firms want to engage with these university-owned innovation centres or laboratories? *[IE and PEA lenses]*
 - k. Are their programs related to KIC's regional development activities and planning, and if so, how? If not, how can their programs be better aligned with KIC's development priority domains/areas? *[S3 lens]*
 - l. In your experience, could you describe any three specific areas of support needed for university-based innovation centres (incubators) to better deliver their mandate relative to KIC priority areas? Who should provide that support? *[PEA and S3 lenses]*

RQ1 above is a follow-up question to KIC's Knowledge Space Actors. Targeted participants for RQ1: same interviewees as those who participated in the pilot study.

Pathways towards facilitating KIC's transition to a knowledge and innovation ecosystem:

2. What is the role of government agencies in supporting the development of KIC into a knowledge and innovation Ecosystem? *[KSI lens]*
 - a. Are you aware of KIC? If yes, how would you describe it in three words? *[IE]*
 - b. How would you describe the relationship between your organisation and KIC as a national ST&I flagship programme? Is it (relationship) changing? *[PEA lens]*
 - c. Does your organisation collaborate with any other government agencies on matters related to KIC development? If yes, would you state those agencies and describe three main activities that you collaborate on? If not, could you please think of any three key challenges that may prevent such collaborations? *[IE, S3, and PEA lenses]*
 - d. Are you aware of any R&I funding and/or STEM capacity building projects or programs, from your organisation or elsewhere, targeting the KIC development? If yes, how are those projects initiated and which KIC actors are being targeting? If not, how do you suggest these can be initiated? *[S3, PEA lenses]*
 - e. Does your organisation interact with international or foreign actors such as universities, funding agencies, research centres, banks, private sector, NGOs, philanthropists, entrepreneurs etc., for RIL funding and STEM capacity building relative to KIC's development? If yes, how are these interactions initiated? *[SD, S3, PEA lenses]*
 - f. In your experience, is the Rwandan Ministry of foreign affairs and International Cooperation involved as a (or part of) channel of communication with the international organisations, international scientists and innovators, diaspora, on matters of STEM capacity and/or R&I funding? If so, how do these channels influence the national university system and flagship programs such as KIC? *[SD, S3, PEA lenses]*
 - g. In your experience, does the Ministry of Foreign Affairs and International Cooperation have dedicated staff members of offices for STEM capacity building and R&I funding? If yes, are you aware of any projects that have stemmed from such offices? Do any of those projects relate to KIC development? If not, how would you suggest the role of the Ministry of Foreign Affairs could better support national ST&I flagship programs such as KIC? *[SD, S3, PEA lenses]*

Targeted respondents for Q2: Middle- to senior-level officers from relevant government ministries and agencies - selected on the basis of KIC's priority sectors

- Ministry of ICT and innovation (MINICT)
- Ministry of Education (MINEDUC)
- Ministry of Trade and Industry (MINICOM)
- Ministry of Agriculture (MINAGRI)
- Ministry of Health (MoH)
- Ministry of Infrastructure (MININFRA)
- Ministry of Foreign Affairs and Cooperation (MOFA)
- Rwanda Development Board (RDB)
- National Council for Science and Technology (NCST)
- National Industrial Research and Development Agency (NIRDA)
- Rwanda Information Society Authority (RISA)
- Rwanda Agricultural Board (RAB)
- Rwanda Biomedical Centre (RBC)

KIC as an Urban Smart City initiative – Urban innovation (UI) perspective:

- 3. What specific characteristics define Kigali Innovation City as an urban smart city initiative, and to what extent do Kigali Innovation City Knowledge Space actors interact with adjacent communities in their geographical setting? [UI lens]**
- a. *In your experience, how would you describe KIC as a Smart City initiative? [IE, UI lens]*
 - b. *In three words, how would you define the word 'Smart' in the context of urban development? [UI lens]*
 - c. *In your experience, could you describe the technological or non-technological experimentation projects or programs currently being implemented or planned to be implemented as part of KIC's development? [UI lens]*
 - d. *How are these projects designed and configured? [UI lens]*
 - e. *Why and how are these projects implemented? [UI lens]*
 - f. *Who are the organisations involved in the design and configuration of each of these projects, and how are funded? [UI lens]*
 - g. *What is the scope of these projects (a particular project may be of international, national, regional or community scale)? [MLS and STS lenses]*
 - h. *How could the Smart City technologies or platforms be utilised at 'ground level' by academics and those who use (or are expected to use) KIC for innovation activities? [UI and MLS and STS lens]*
 - i. *In your experience, are there any projects run by KIC universities and (or) research organisations that target the social, economic, and environmental issues facing the City of Kigali and/or local communities living in KIC's vicinity? If so, what are those projects, and how are they coordinated and funded? [TIP, KSI, PEA, S3 lenses]*
 - j. *Can you describe any three areas (ways) in which the City of Kigali and/or grassroots communities located in the KIC vicinity benefit or have benefited from living in KIC's neighbourhood? If not, please propose three areas in which the community could benefit from being in the vicinity of KIC? How best could the community contribute to the formulation of innovation activities aimed at KIC's development? [KSI, PEA lenses]*

Targeted respondents for Q3:

- MINICT (Department responsible for KIC project)
- RDB (Department responsible for KIC project)
- City of Kigali authorities
- Gasabo district authorities
- KIC Knowledge Space central actors (CMU-Africa, AIMS-Rwanda, ALU-Rwanda, KCRC, UR CEBE)
- Rwanda Civil Society Platform (RCSP)

Appendix_3.7: UCL REC Letter of Approval for pilot research- 19295.002

STeAPP Local Research Ethics Committee
UCL STeAPP
Shropshire House (4th Floor)
11-20 Capper Street, London WC1E 6JA

Date: 19.07.2022

RE: SLREC Approval Number – 0018 – Remy Twiringiyimana

Dear Remy Twiringiyimana

Project ID: 19295/002

Title of project: 'Fostering the knowledge space actors' interactions in an emerging place-based innovation ecosystem: The case of Kigali Innovation City'

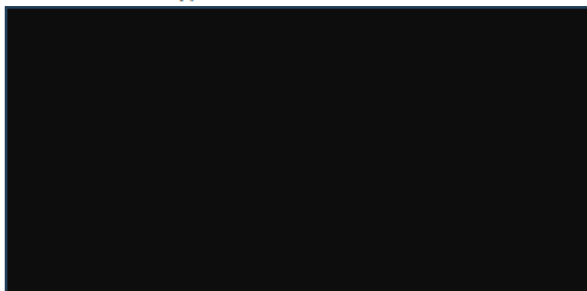
Thank you for submitting your project application to the SLREC. I can confirm that your application has been approved from the date of this letter. This approval is valid until **December 2022**. If you need an extension or if you need to change anything material in the approved application during the course of your project, please let me know in case you need to submit a formal Amendment Form which can be found on the STeAPP Hub [here \(for PhD students\)](#).

Please use the following approval number '**0018**' in all correspondence.

At the end of the project, we would be grateful if you could submit a short summary of your results and confirm that you have taken any and all the required steps to delete any personal data collected as part of the project.

Wishing you very best wishes with your work.

Yours sincerely,

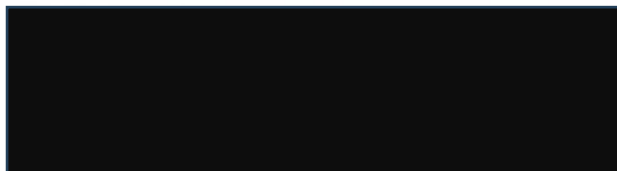


Appendix_3.8: RP affiliation confirmation for post-pilot study

Office of the Vice Chancellor

Kigali, date: 02/06/2022

Ref. No: RP/VC/437/2022



Re: Research affiliation for Mr. Remy TWIRINGIYIMANA

I have the pleasure to confirm that **Mr. Twiringiyimana Remy** is a PhD student in Science, Technology, Engineering, and Public Policy (STeAPP) at the University College London (UCL), under the supervision of [REDACTED]

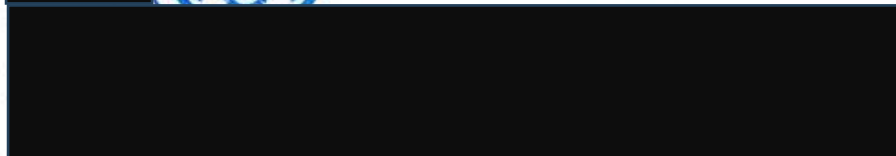
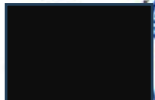
[REDACTED] UCL. Remy will be affiliated with Rwanda Polytechnic (RP) as a doctoral researcher from 30th June to 30th November 2022, under the main local supervision of Dr. [REDACTED]

During his period, he will be conducting empirical research for his doctoral project titled: *"Fostering the knowledge space actors' interactions in an emerging place-based innovation ecosystem: The case of Kigali Innovation City"*.

This empirical research is a follow-up and upgrade of the pilot research study that was successfully conducted in Rwanda from February to December 2021, under the NCST Research Permit N°: NCST/482/211/2020, and UCL Research Ethics Committee (REC) approval N°: 19295/001.

Any service rendered to Remy Twiringiyimana will be highly appreciated.

Yours sincerely,



Appendix_3.9: Rwanda NCST research permit for post-pilot study

REPUBLIC OF RWANDA



NATIONAL COUNCIL FOR
SCIENCE AND TECHNOLOGY

Kigali, on 14th July 2022
N°: NCST/482/341/2022

Remy TWIRINGIYIMANA
[REDACTED]

Dear Remy,

RE: Approval to Conduct Research in Rwanda

I am pleased to inform you that your request to conduct research in Rwanda entitled: **“Fostering the knowledge space actors’ interactions in an emerging place-based innovation ecosystem: The case of Kigali Innovation City”**, has been approved under research permit No: **NCST/482/341/2022**.

This permission covers research activities specifically related to the provided research project title, and project proposal submitted to the National Council for Science and Technology (NCST) for the period from **14th July 2022 to 13th July 2023**.

The research will be carried out under the affiliation of **Rwanda Polytechnic**, under the supervision of [REDACTED] at RP, and will take place in Kigali City.

As a requirement, you are requested to prepare a power point presentation of your results, and present at **NCST Stakeholders Scientific Conference** and submit both the progress and final reports after completion of your research activities to the NCST, RP and the Mayor of Kigali City.

I wish you success in your research.

Sincerely, [REDACTED]



Appendix_3.10: Research participant information sheet for [leader/manager of academic/government/industry/civil society entity]

UCL Research Ethics Committee Approval ID Number: 19295/002

YOU WILL BE GIVEN A COPY OF THIS INFORMATION SHEET

Title of Study: Fostering the knowledge space actor interactions in an emerging place-based innovation ecosystem: The case of Kigali Innovation City

Department: Science, Technology, Engineering and Public Policy

Name and Contact Details of the Researcher (PhD Student): Remy Twiringiyimana

Name and Contact Details of the Principal Researcher (Supervisor):

1. Invitation Paragraph

You are being invited to take part in a research project. The project is part of doctoral training programme. This is a six (6) month study (July to December 2022), leading to PhD qualification in Science, Technology, Engineering, and Public Policy (STeAPP). The present project is an expansion in scope and scale of the pilot study that was conducted in Rwanda from December 2020 to February 2022. Before you decide it is important for you to understand why the research is being done and what participation will involve. The study is being carried out by a researcher (Doctoral Candidate) in the Department of Science, Technology, Engineering and Public Policy (STeAPP) at UCL. Participation is voluntary. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information. Thank you for reading this.

2. What is the project's purpose?

Drawing on the pilot study findings, the aim of this study is to offer a knowledge contribution to, and deeper and detailed understanding of, actor interactions in relation to research, innovation and learning (RIL) with respect to the emerging Kigali Innovation City (KIC). The project aims also to explore the different pathways to creating new and/or fostering existing interactions for the development of KIC as an inclusive place-based knowledge and innovation ecosystem. Located in the special economic zone in the suburb of Kigali, the capital city of Rwanda, KIC is a flagship programme and an important component for Rwanda's ambition to become a knowledge and innovation Hub for the [African] continent. This study focuses on five (5) academic entities which constitute the 'knowledge space', and thirteen (10) central government ministries, agencies and foreign offices, two (2) local government entities in the City of Kigali as well as one (1) non-governmental organisation, altogether constituting the consensus, innovation, and funding spaces of KIC.

Why have I been chosen?

You have been chosen due to your role in academic, research and innovation development, or STI policy and/or strategy development in your organization. Approximately 18 interview participants will be invited to take part in this research project.

3. Do I have to take part?

Your participation is entirely voluntary. If you decide to take part you will be given this information sheet to keep and be asked to sign a consent form. A refusal to participate will not disadvantage you in any way or affect your relationship with UCL. You may also decide to withdraw your participation up to three weeks following the interview date without giving a reason. If you decide to withdraw from this research, you will be asked what you wish to happen to the data you have provided up to that point.

4. What will happen to me if I take part?

You will be invited to take part in a single interview, taking no longer than 1 hour. You will be asked to comment on your knowledge of KIC, how you would describe the relationship between your organisation and KIC as a national ST&I flagship programme and/or a smart city initiative. You will also be asked to comment on how you would suggest the role of your organisation for better support the development of KIC.

5. Will I be recorded and how will the recorded media be used?

The audio recordings of the interview will be used only for data analysis. No other use will be made of them without your written permission, and no one outside the project (Mr Remy Twigiriyimana- Researcher [REDACTED] – Local Supervisor) will be allowed access to the original recordings. You can decide not to be recorded, in which case notes of the interview will be taken in real-time.

6. What are the possible disadvantages and risks of taking part?

There are no immediate risks for those people participating in this research. All participants will have the opportunity review their contributions, which should reduce the risk of re-identification of participants who have chosen to remain anonymous.

7. What are the possible benefits of taking part?

Whilst there are no immediate benefits for those people participating in the project, it is hoped that this work will expand their knowledge base on the systems theory-based conceptual frameworks into context, and the formation and functioning of regional (place-based) knowledge and innovation ecosystems. This will also provide the policy makers, researchers and other actors with interest in this domain, with evidence for innovation and industrial policy for place-based development, including cities, in the low-income country (LIC) context, particularly in Sub-Saharan Africa (SSA).

8. What if something goes wrong?

Please direct any concerns or complaints to the Supervisor, [REDACTED]
[REDACTED] Should you feel the complaint has not been handled to their satisfaction you can contact the Chair of the UCL Research Ethics Committee (ethics@ucl.ac.uk)

9. Will my taking part in this project be kept confidential?

All the information that we collect about you during the course of the research will be kept strictly confidential. Unless you explicitly choose to be, you will not be able to be identified in any ensuing reports including the doctoral thesis or any publications emanating from anonymised data from this study.

10. Limits to confidentiality

Confidentiality will be respected unless there are compelling and legitimate reasons for this to be breached. If this was the case we would inform you of any decisions that might limit your confidentiality.

11. What will happen to the results of the research project?

A doctoral thesis will be developed, presented and assessed in the Doctoral Viva. This thesis and any publications such as policy brief will be circulated to all participants on request. At the end of the Researcher's doctoral study, the data will be deleted.

12. Local Data Protection Privacy Notice

Notice:

The controller for this project will be University College London (UCL). The UCL Data Protection Officer provides oversight of UCL activities involving the processing of personal data, and can be contacted at data-protection@ucl.ac.uk

This 'local' privacy notice sets out the information that applies to this particular study. Further information on how UCL uses participant information can be found in our 'general' privacy notice [here](#). The information that is required to be provided to participants under data protection legislation (GDPR and DPA 2018) is provided across both the 'local' and 'general' privacy notices.

The categories of personal data used will be as follows:

- Name
- Email Address
- Job Title

The lawful basis that would be used to process your *personal data* will be 'performance of a task in the public interest'.

Your personal data will be processed for the purposes outlined in this notice. If we are able to anonymise the personal data you provide we will undertake this, as you have indicated in the Consent Form (Point 3), and will endeavour to minimise the processing of personal data wherever possible.

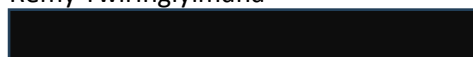
If you are concerned about how your personal data is being processed, or if you would like to contact us about your rights, please contact UCL in the first instance at data-protection@ucl.ac.uk.

13. Who is organising and funding the research?

The doctoral project will be funded by STEaPP, UCL.

16. Contact for further information

Remy Twiringiyimana



Thank you for reading this information sheet and for considering taking part in this research study.

Appendix_3.11: Pilot study participant demographic data

#	Participant ID	Participant location during interview time	Organisation name	Participant's affiliation per organisation	Organisation category	Organisation type	Functional area	Years of experience (in position or organisation)	Gender
1	Participant_PS01	Rwanda	UR	1	Public research university	Academia in KIC Proximity	High level academic administrator in the area of R&I	6	Male
2	Participant_PS02	Rwanda	ACE ESD	2	WB & Public research centre (ACE)	Academia in KIC Proximity	High level administrator in centre	11	Male
3	Participant_PS03	Rwanda	UR	1	Private teaching university	Academia in KIC Proximity	Researcher and academic staff		
4	Participant_PS04	Rwanda	AUCA	1	WB & Public research centre (ACE)	Academia in KIC Proximity	High level administrator in university	10	Male
			ACE IoT	2		Academia in KIC Proximity	High level administrator in centre	4	Female
			UR			Academia in KIC Proximity	Researcher and academic staff		
5	Participant_PS05	Rwanda	ACE IoT	2	WB & Public research centre (ACE)	Academia in KIC Proximity	High level administrator in centre	4	Male
			UR			Academia in KIC Proximity	Researcher and academic staff in		
6	Participant_PS06	Rwanda	IPRC-Kigali, RP	1	Public polytechnic	Academia in KIC Proximity	High level administrator in college	10	Male
7	Participant_PS07	Rwanda	ACE ESD	2	WB & Public research centre (ACE)	Academia in KIC Proximity	High level administrator in centre	2	Male
			UR			Academia in KIC Proximity	Researcher and academic staff		
8	Participant_PS08	Rwanda	UTB	1	Private university	Academia in KIC Proximity	High level university administrator in university	6	Female
9	Participant_PS09	Rwanda	ALU-Rwanda	1	Private university	Academia in KIC Central	University administrator		Female
10	Participant_PS10	Rwanda	MINEDUC	5	Public Policy	Academia in KIC Proximity	High level analyst in government	17	
			ICTP-EAIFR		ICTP & Public research centre (Regional CoE)	Academia in KIC Proximity	High level official in centre leadership		Male
			PASET		WB & Multi-national Programme	Academia in KIC Proximity	High level official in programme leadership		
			ACE		WB Programme	Academia in KIC Proximity	High level official programme leadership		
			KCRC		Rwandan based NGO (research centre)	Academia in KIC Proximity	High level official in centre leadership		
11	Participant_PS11	South Africa	UR	3	Public research university	Academia in KIC Proximity	Former high level university administrator	7	Male
			ACE in Energy for Sustainable		WB & Public research centre (ACE)	Academia in KIC Proximity			
			KCRC		Private research centre	Academia in KIC Central	High level official in centre leadership		
12	Participant_PS12	Sweden	UR	2	Public research university	Academia in KIC Proximity	Researcher and academic staff	7	Male
13	Participant_PS13	Rwanda	ULK	1	Private polytechnic	Academia in KIC Proximity	Academic administrator in area of R&I		
14	Participant_PS14	Rwanda	Polytechnic	1	Public research university	Academia in KIC Proximity	High level administrator in university	6	Male
15	Participant_PS15	Rwanda	UR	1	Public research university	Academia in KIC Proximity	High level academic administrator in university	19	Male
			CMU-Africa	2	PPP university (ADB Regional CoE)	Academia in KIC Proximity	High level administrator in university	7	Male
16	Participant_PS16	Rwanda	KCRC	2	Rwandan based NGO (research centre)	Academia in KIC Central	Research and academic staff	11	Male
						Academia in KIC Central	High level administrator in centre		
	Average experience							8	
	Total participants' affiliation per organisation			28					
	Average participants' affiliation per			1.75					

Appendix_3.12: Post-pilot study participant demographic data

#	Participant ID	Participant location during interview time	Organisation Name	Organisation Category	Participant's affiliation per organisation	Organisation Type	Functional area	Years of Experience (in position or organisation)	Gender
1	P_PPS01	Rwanda	RP	Academia	1	Academia in KIC Proximity	High level administrator in university	2	Male
2	P_PPS02	Rwanda	UR	Academia	1	Academia in KIC Proximity	Researcher and academic staff	23	Female
3	P_PPS03	Rwanda	ACE ESD, UR	Academia	2	Academia in KIC Proximity	High level administrator in university	12	Male
4	P_PPS04	Rwanda	UR	Academia		Academia in KIC Proximity	Researcher and academic staff		
4	P_PPS04	Rwanda	NCST	Government	1	Central Government	High level administrator in government	1	Female
5	P_PPS05	Rwanda	Mutware Educate Ltd.	Industry	1	Industry Outside KIC	High level administrator in firm	3	Male
6	P_PPS06	USA	CIU-Africa	Academia	1	Academia in KIC Central	Researcher and academic staff	20	Male
7	P_PPS07	Switzerland	Sajin Partners Ltd	Industry	1	Industry Outside KIC	High level administrator in firm	14	Male
8	P_PPS08	Rwanda	NCST	Government	1	Central Government	High level administrator in government	2	Male
9	P_PPS09	Rwanda	RAWISE	Civil Society	2	Local NGO	High level administrator in LINGO	7	Female
			NCST	Government		Central Government	High level administrator in government		
10	P_PPS10	Rwanda	Coventry University Africa Hub	Industry	1	Academia in KIC Proximity	High level administrator in university	1	Male
11	P_PPS11	Rwanda	NIRDA	Government	1	Central Government	High level administrator in government	3	Male
12	P_PPS12	Rwanda	ICTP-EAIFR	Academia	1	Academia in KIC Proximity	High level administrator in centre	4	Male
13	P_PPS13	Rwanda	Technoserve	Civil Society	1	International NGO	High level administrator in NGO	2	Male
14	P_PPS14	Rwanda	MINICT	Government	1	Central Government	High level administrator in government	3	Male
	Average experience							7	
	Total participants' affiliation per organisation				16				
	Average participants' affiliation per organisation				1.14				

Appendix_3.13: Detailed calculation of average interview time

Pilot phase				Post-pilot phase			
Participant ID	Original time	Convert sec and hou	Time in minutes	Participant ID	Original time	Convert sec to mins	Time in minutes
Participant_PS01	48min04sec	0.07	40.07	Participant_PPS01	46min27sec	4.50	50.50
Participant_PS02	56min12sec	0.20	56.20	Participant_PPS02	58min09sec	0.15	58.15
Participant_PS03	57min44sec	0.73	57.73	Participant_PPS03	54min19sec	0.32	54.32
Participant_PS04	44min37sec	0.62	44.62	Participant_PPS04	37min20sec	0.33	37.33
Participant_PS05	49min6sec	0.10	49.10	Participant_PPS05	59min41sec	0.68	59.68
Participant_PS06	48min15sec	0.25	48.25	Participant_PPS06	42min20sec	0.33	42.33
Participant_PS07	37min1sec	0.02	37.02	Participant_PPS07	49min53sec	0.88	49.88
Participant_PS08	43min39sec	0.65	43.65	Participant_PPS08	36min07sec	0.12	36.12
Participant_PS09	53min09sec	0.15	53.15	Participant_PPS09	36min29sec	0.48	36.48
Participant_PS10	42min08sec	0.13	42.13	Participant_PPS10	41min38sec	0.63	41.63
Participant_PS11	1hr10min49sec	60.82	70.82	Participant_PPS11	29min09sec	0.15	29.15
Participant_PS12	48min04sec	0.07	48.07	Participant_PPS12	51min04sec	0.07	58
Participant_PS13	42min09sec	0.15	42.15	Participant_PPS13	51min59sec	0.98	149
Participant_PS14	51min05sec	0.08	51.08	Participant_PPS14	27min06sec	0.10	27.10
Participant_PS15	55min25sec	0.42	55.42	Total time in mins			729.68
Participant_PS16	49min13sec	0.22	49.22	Total average time in mins			52.12
Total time in mins			788.67	Convert decimal min in sec			7.2
Total average time in mins			49.29	Total average time in mins and sec		52min7sec	
Convert decimal min in sec			17.40				
Total average time in mins and sec		49min17sec					
Overall average interview length for Pilot and Post-Pilot Phases combined							
	Pilot phase	Post-Pilot phase					
Time in min and sec	49min17sec	52min7sec					
Convert sec in min	0.28	0.12					
Average time in min	49.28	52.00					
Overall average intr 50.64							
Conver min in sec 38.40							
Overall average	50min38sec						

Thematic analysis - Integration of theoretical frameworks into qualitative research

Adopted Transformation technique: Transforming the codes/themes into components/concepts related to the framework (Abu, 2019).

Step 1: Preparing data.

- Prepare the data (organisation)
- Import data (both transcripts and demographic data into NVivo)
- Check and confirm whether the system has made connection between transcripts and corresponding demographic data (see maps in folder).

Step 2: Create containers for each RQ: Assign labels to (or create anchor code for) each of the Research questions.

Step 3: Determine coding strategy.

- Description-focused coding
- Interpretation-focused coding

Data analysis process

- What did I do on/with data before importing them into NVivo
- What did I do within NVivo
- What I did do after NVivo

Step 4: Sorting

I decided to do code sorting outside NVivo – as recommended by Adu (2019), to allow me space to means to move codes under identified/created themes as smoothly as possible in Excel Spreadsheet, before sending the themes and associated codes back into NVivo, for further analysis

What did sorting process involve?

- Grouping codes based on shared relationships- forming clusters.
- Labelling the clusters -forming categories or themes

Table 1. Post-pilot data coding and themes development process

Note: adopted transformation technique of integrating theoretical frameworks into qualitative research i.e naming pre-determined categories from research questions with names reflecting corresponding theoretical framework.

⁷⁸ While thematic analysis in pilot study phase was done using Automatic Coding and RQs in NVivo, the analysis in Post-Pilot phase was guided by grounded theory. In the latter, NVivo was instrumental in organising Code, with open coding – breaking down the data into categories was done outside Nvivo.

Main RQ Label	Pre-determined themes	Pre-determined themes' Related Theoretical framework	Dropped pre-determined themes	Emerging themes	Proposed theme organisation in chapters
(RQ1) Nature of KIC university-industry interactions	(RQ1.a) Describing University-based innovation or (incubation) centres structural and funding models. Chap 7 (1) ⁷⁹	THS		Assessing openness and impact of university-based innovation incubation centres. Chap 7 (2)	
	(RQ1.b) Identifying university-based innovation centre types of interactions. Chap 7 (3)	THS		Supporting university-based innovation incubation centres- challenges and opportunities. Chap 7 (6)	
	(RQ1.b) Describing actors interacting with KIC university-based innovation centres. (Chap 7 (4))	THS			
	(RQ1.b) Describing conditions for KIC university-based innovation to attract other actors. Chap 7 (5)	THS			
	(RQ1.c) Assessing innovation centre programmes relationship with KIC development priority areas. Chap 7 (7)	S3, RDT			
	(RQ1.d) Describing support mechanisms for innovation centre's better alignment with KIC development priorities. Chap 7 (8)	PEA, RDT			
(RQ2) Government and other actors' role in supporting KIC development	(RQ2.a) Describing KIC [as a knowledge-based innovation ecosystem]. Chap 7/8 (1) ⁸⁰	KSI		Exploring lessons learned from COVID-19 pandemic response. (move to Chap 5)	

⁷⁹ Chap 7 (1): **Chap 7** means **chapter 7**, and **(1)** stands for first theme/time of section under Chap 7. Themes under chapters are proposedly arranged in a chronological order in Tabel2 below - Logical arrangement of themes into chapters.

⁸⁰ Previous chapter 9 merged with 7 and 8, mainly due to overlap in emerging themes in response to RQ2 and RQ3

Main RQ Label	Pre-determined themes	Pre-determined themes' Related Theoretical framework	Dropped pre-determined themes	Emerging themes	Proposed theme organisation in chapters
	(RQ2.b) Describing and assessing actors' relationships with KIC. Chap 7/8 (3)	PEA		Exploring policy options for KIC transition to Innovation Space. Chap 7(9)	
	(RQ2.c) Identifying and describing other actors interacting for KIC development. Chap 7/8 (4)	S3, PEA			
	(RQ2.c) Describing challenges hampering interactions for KIC development. Chap 8 (5)	S3, PEA		Proposing steps to interact with KIC. Chap7/ 8 (7)	
	(RQ2.d) Identifying and describing R&I funding or STEM capacity building programs targeting KIC. Chap 7/8 (6)	S3, PEA		Understanding challenges and opportunity for KIC to transition into an inclusive knowledge-based innovation ecosystem. Chap 7/8 (8)	
	(RQ2.e) Describing interactions with international or foreign actors. Chap 9 (1)	SD		Understanding factors hampering actor interactions with KIC. Chap 7/8 (5)	
	(RQ2.f) Describing role of ministry of foreign affairs in facilitating interactions with international or foreign actors and scientific diaspora. Chap 9 (2)	SD, S3, PEA		Understanding [policy implications of] KIC development strategy beyond Rwanda. Chap 7/8 (2)	
	(RQ2.f) Describing influence of international or foreign actors, and diaspora to KIC. Chap 9 (3)	SD, S3, PEA			
	(RQ2.g) Assessing STEM situation in ministry of foreign affairs and international cooperations structure. Chap 9 (4)	SD, S3, PEA			
(RQ3) KIC characterization [as a spatial urban innovation intervention]	(RQ3.a) Defining the term "Smart". Chap 8 (1)	UI		Critiquing KIC smartness from a rural perspective. Chap 8 (4)	
	(RQ3.b) Describing KIC [as a Smart City Initiative]. Chap 8 (3)	UI		Describing smartness as a digital public	

Main RQ Label	Pre-determined themes	Pre-determined themes' Related Theoretical framework	Dropped pre-determined themes	Emerging themes	Proposed theme organisation in chapters
				good. Chap 8 (2)	
	(RQ3.c) Describing experimentation projects for KIC development. Chap 8 (6)	UI		Exploring role of KIC smartness to urban [the rest of City of Kigali]. Chap 8 (7)	
	~~(RQ3.d) Describing experimentation project design process.~~	UI	Dropped		No significant info addressing RQ or no data at all
	~~(RQ3.e) Stating reasons and means for project implementation~~	UI	Dropped		No significant info addressing RQ or no data at all
	~~(RQ3.f) Identifying actors involved in project design and funding~~	UI	Dropped		No significant info addressing RQ or no data at all
	~~(RQ3.g) Describing project scope~~	UI	Dropped		No significant info addressing RQ or no data at all
	(RQ3.h) Describing role smart city tech or platforms for KIC actors. Chap 8 (5)	UI			
	(RQ3.i) Identifying and describing KIC actors projects targeting City of Kigali and/or local community. Chap 8 (8)	UI, TIP, KSI, PEA, S3			
	(RQ3.j) Describing or proposing areas of City of Kigali and/or local community benefit from KIC. Chap 8 (9)	UI, KSI, PEA			
	(RQ3.j) Proposing City of Kigali and/or local community contribution to KIC development. Chap 8 (10)	UI, KSI, PEA			
Total	26		4	11	

Note: Some questions were labelled with more than one container or anchor code (theme) i.e. RQ1.b (three themes), RQ2.c (two themes), RQ2.f (two themes), and RQ3.j (two themes). See details in Table 1 above.

Lesson learned for further research: In follow-up email to participants, it would be useful to ask them to provide some information as to why they did not answer some of the questions. For instance, for RQ4, sub-questions d, e, f, and g were not answered.

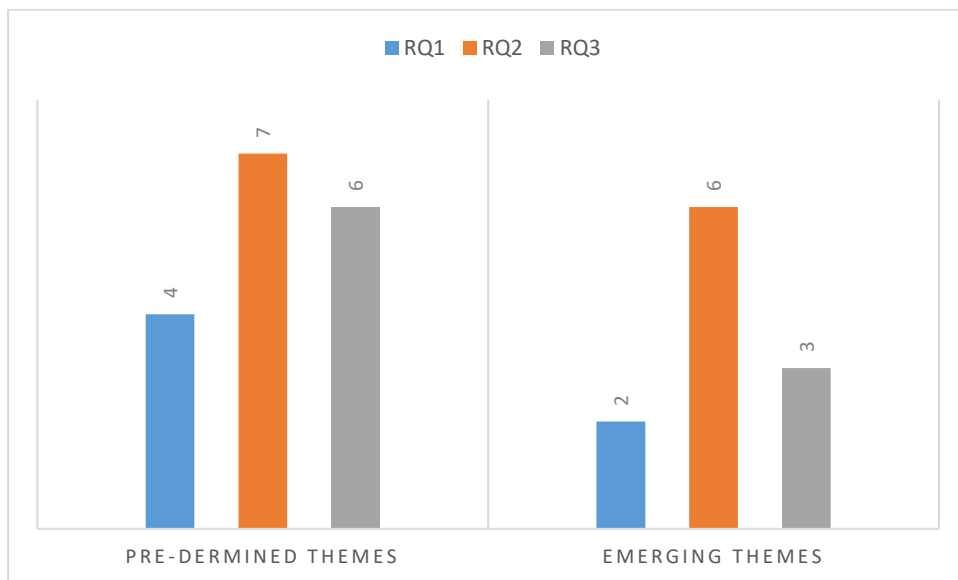


Figure 1: RQ and related themes identified from post-pilot data analysis

Table 2. Logical arrangement of themes into Thesis Chapters

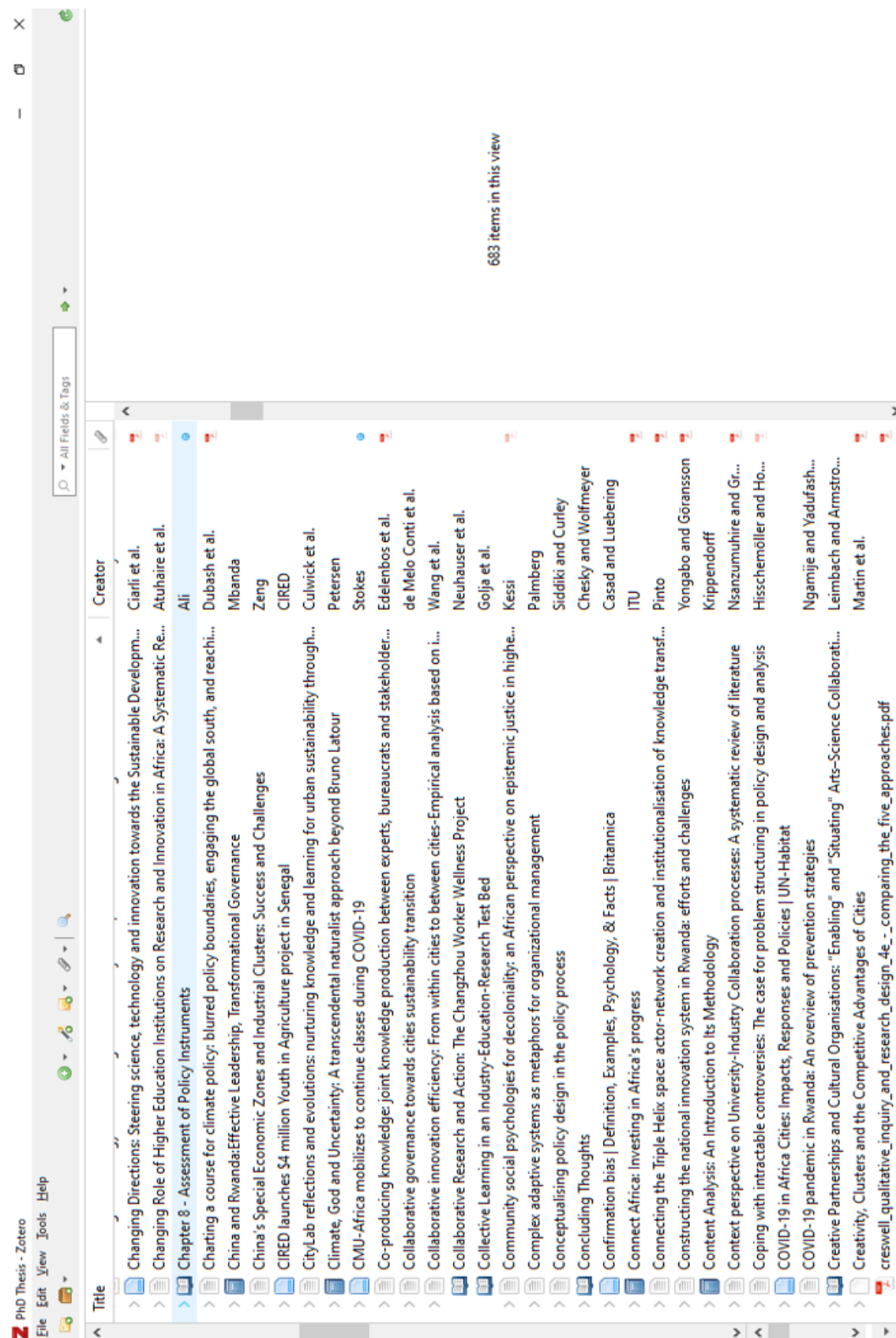
#	Theme name	Theme type	Related theoretical framework	RQ # in Post-pilot data analysis	Actual RQ # in thesis narrative
Chapter 8 (now chapter 7)					
1.	Describing University-based innovation or (incubation) centres structural and funding models	Pre-determined	THS	1	5
2.	Identifying university-based innovation centres types of interactions	Pre-determined	THS	1	5
3.	Supporting university-based innovation incubation centres-challenges and opportunities	Emerging		1	5
4.	Assessing innovation centre programmes relationship with KIC development	Pre-determined	S3, RDT	1	5
5.	Exploring policy options for KIC transition to Innovation Space	Emerging		2	6
Chapter 9 (deleted, and content merged with chapters 7 and 8)					
1.	Describing KIC [as a knowledge-based innovation ecosystem]	Pre-determined	KSI	2	6
2.	Understanding [policy implications of] KIC development strategy beyond Rwanda	Emerging		2	6
3.	Describing and assessing actors' relationships with KIC	Pre-determined	PEA	2	6
4.	Identifying and describing other actors interacting for KIC development	Pre-determined	S3, PEA	2	6
5.	Describe challenges hampering interactions for KIC development	Pre-determined	S3, PEA	2	6
	Understanding factors hampering actor interactions with KIC	Emerging		2	6
6.	Identifying and describing R&I funding or STEM capacity building programs targeting KIC	Pre-determined	S3, PEA	2	6

#	Theme name	Theme type	Related theoretical framework	RQ # in Post-pilot data analysis	Actual RQ # in thesis narrative
7.	Proposing steps to interact with KIC	Emerging		2	6
8.	Understanding challenges and opportunity for KIC to transition into an inclusive knowledge-based innovation ecosystem	Emerging		2	6
Chapter 10 (now chapter 8)					
1.	Defining the term “Smart”	Pre-determined	UI	3	7
2.	Describing smartness as a digital public good	Emerging	UI	3	7
3.	Describing KIC [as a Smart City Initiative]	Pre-determined	UI	3	7
4.	Critiquing KIC smartness from a rural perspective	Emerging	UI	3	7
5.	Describing role smart city tech or platforms for KIC actors	Pre-determined	UI	3	7
6.	Describing experimentation projects for KIC development	Pre-determined	UI	3	7
7.	Exploring role of KIC smartness to urban [the rest of City of Kigali]	Emerging	UI	3	7
8.	Identifying and describing KIC actors projects targeting City of Kigali and/or local community	Pre-determined	UI, TIP, KSI, PEA, S3	3	7
9.	Describing or proposing areas of City of Kigali and/or local community benefit from KIC	UI, KSI, PEA	UI, KSI, PEA	3	7
10.	Proposing City of Kigali and/or local community contribution to KIC development	UI, KSI, PEA	UI, KSI, PEA	3	7
Chapter 11 (now chapter 9)					
1.	Describing interactions with international or foreign actors	Pre-determined	SD	2	6

#	Theme name	Theme type	Related theoretical framework	RQ # in Post-pilot data analysis	Actual RQ # in thesis narrative
2.	Describing influence of international or foreign actors, and diaspora to KIC	Pre-determined	SD, S3, PEA	2	6
3.	Describing role of ministry of foreign affairs in facilitating interactions with international or foreign actors and scientific diaspora	Pre-determined	SD, S3, PEA	2	6
4.	Assessing STEM situation in ministry of foreign affairs and international cooperations structure	Pre-determined	SD, S3, PEA	2	6

Note: Emerging theme on “**exploring lessons learned from COVID-19 pandemic response**” does not fit within any of chapters above for post-pilot phase. It is relevant though to address pilot study RQ4 in **chapter five** specific on COVID-19 pandemic.

Appendix_3.15: Overview of thesis secondary data sources in Zotero library



Source: Author's Zotero personal database.

Appendix_3.16: Key events where this research was presented and discussed

Type of event	Presentation topic	Date/Period	Venue	Type of audience	Type of input sourced
STeAPP Doctoral Training Programme skills workshop on interdisciplinary research Practice	Systemic analysis of university patterns of interaction with other Actors in Inclusive National Innovation System	6 th November 2019	UCL, UK	STeAPP staff and doctoral students	- Conceptual - Methodological - Presentation
Master of Public Administration module session	Public sector innovation: Community-based health insurance in Rwanda (A social innovation)	4 th December 2019	UCL, UK	STeAPP MPA students	- Contextual - Conceptual - Presentation
PMA Science Funding and Governance module session	Triple Helix, what is it and how did it evolve?	28 th February 2020	UCL, UK	STeAPP MPA students	- Contextual - Conceptual - Presentation
MPA Development, Technology, and Innovation Policy (DTIP) module session	Role of Higher Education and its contribution to innovation and Development- The case of Rwanda	19 th November 2020	UCL, UK	STeAPP MPA students	- Contextual - Conceptual - Presentation -
MPA Knowledge and Governance module session	How to deal with limited science capacity - Reflections with respect to the situation of Rwanda	11 th February 2021	UCL, UK (online)	STeAPP MPA students	- Contextual - Literature - Presentation
MPA Science Funding and Governance module session	Rwanda Higher Education System and its link to Research System	25 th February 2021	UCL, UK	STeAPP MPA students	- Literature - Contextual - Conceptual - Presentation
MPA Urban Innovation and Policy module session	A study of Rwanda's university system and emergence of Kigali Innovation City: Understanding interactive capabilities in triple helix knowledge space	15 th March 2021	UCL, UK (online)	STeAPP MPA students	- Literature - Contextual - Conceptual - Methodological - Presentation
Seminar upgrade	A study of Rwanda's university system and emergence of Kigali Innovation City: Understanding of interactive capabilities in the triple helix knowledge space	4 th February 2022	UCL, UK (online)	Examiners UCL STeAPP researchers and academic staff, and PhD students UR researchers	- Literature - Contextual - Conceptual - Methodological - Presentation

Type of event	Presentation topic	Date/Period	Venue	Type of audience	Type of input sourced
Winter Writing Retreat	Actor interactions as a capability (or infrastructure) in fostering a place-based innovation ecosystem- theoretical dimensions	21 st -25 th February 2022	University of Edinburg, UK	Participating Ph.D students, and academic staff	- Literature - Conceptual -
MPA Development, Technology, and Innovation Policy (DTIP) module session	A study of Rwanda's emerging Kigali Innovation City: Fostering actor interactions in a place-based setting	8 th March 2022	UCL, UK	STeAPPP MPA students	- Literature - Contextual - Conceptual - Methodological - Presentation
DSA Conference 2022	Kigali Innovation City: decentring knowledge production for inclusivity and publicness	6 th -8 th July 2022	UCL (online)	Academia, Government, Industry, Civil Society	- Contextual - Conceptual - Methodological - Presentation -
Globelics Academic (GA2022): 15 th Ph.D School on Innovation and Development	Exploring contextual imperatives and policy narratives in the emergence of a knowledge-based innovation ecosystem: the case of Kigali Innovation City	15 th -26 th August 2022	Tampere University, Finland	Participating Ph.D students, and academic staff	- Literature - Contextual - Conceptual - Methodological - Presentation -
Doctoral research work-in-progress seminar	Fostering the knowledge space actor interactions in an emerging place-based innovation ecosystem: the case of Kigali Innovation City	29 th September 2022	UCL, UK (online)	Research participants- Rwanda policy and science systems stakeholders UCL STeAPPP researchers and PhD students UR researchers	- Literature - Contextual - Conceptual - Methodological - Presentation
Meeting with Rwanda High Commissioner to the UK	Presentation of Science Diplomacy component of research	14 th October 2022	Rwanda High Commission, London UK	High Commissioner Embassy Staff	- Contextual - Empirical
MPA Development, Technology, and Innovation Policy (DTIP) module session	Role of Higher Education and its contribution to innovation and development-The experience of Rwanda	16 th November 2022	UCL, UK	STeAPPP MPA students	- Literature - Contextual - Conceptual - Presentation
MPA Development,	Drivers and barriers in mobilising, producing,	6 th February 2023	UCL, UK	STeAPPP MPA students	- Literature - Contextual

Type of event	Presentation topic	Date/Period	Venue	Type of audience	Type of input sourced
Technology, and Innovation Policy (DTIP) module session	and integrating knowledge – The experience of Rwanda				- Conceptual - Presentation
MPA Development, Technology, and Innovation Policy (DTIP) module session	Exploring policy narratives and contextual imperatives in the emergence of a knowledge-based innovation ecosystem: the case of Kigali Innovation City	10 th February 2023	UCL, UK	STeAPP MPA students	- Literature - Contextual - Conceptual - Methodological - Presentation
UCL CLIE Viva Preparation Course	Preparing for your Viva for non-native speakers	17 th -21 st February 2023	UCL, UK	PhD students	- Conceptual - Methodological - Presentation
Triple Helix Conference (THC2023)	Exploring contextual imperatives and policy narratives in the emergence of a knowledge-based innovation ecosystem: the case of Kigali Innovation City	26 th – 29 th August 2023	La Salle-Ramon Llull University, Spain	Participating PhD students, and academic staff	- Literature - Contextual - Conceptual - Methodological - Presentation

Source: Author's compilation

Appendix_3.17: UCL research paper declaration forms

UCL Research Paper Declaration Form referencing the doctoral candidate's own published work(s)

Please use this form to declare if parts of your thesis are already available in another format, e.g. if data, text, or figures:

- *have been uploaded to a preprint server*
- *are in submission to a peer-reviewed publication*
- *have been published in a peer-reviewed publication, e.g. journal, textbook.*

This form should be completed as many times as necessary. For instance, if you have seven thesis chapters, two of which containing material that has already been published, you would complete this form twice.

1. For a research manuscript that has already been published (if not yet published, please skip to section 2)

a) What is the title of the manuscript?

Kigali Innovation City: decentring knowledge production for inclusive national development.
COVID-19 and Beyond: why science-as-usual will not work

b) Please include a link to or doi for the work

<https://nomadit.co.uk/conference/95#11266>

c) Where was the work published?

Development Studies Association (DSA) Conference Website

d) Who published the work? (e.g. OUP)

DSA

e) When was the work published?

July 2022

f) List the manuscript's authors in the order they appear on the publication

Twiringiyimana, R. (sole author)

g) Was the work peer reviewed?

No

h) Have you retained the copyright?

Yes

i) Was an earlier form of the manuscript uploaded to a preprint server? (e.g. medRxiv). If 'Yes', please give a link or doi)

n/a

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c) Where is the work intended to be published? (e.g. journal names)

Click or tap here to enter text.

d) List the manuscript's authors in the intended authorship order

Click or tap here to enter text.

e) Stage of publication (e.g. in submission)

Click or tap here to enter text.

- 3. For multi-authored work, please give a statement of contribution covering all authors** (if single-author, please skip to section 4)

Click or tap here to enter text.

- 4. In which chapter(s) of your thesis can this material be found?**

Chapters 5, 8, and 10

- 5. e-Signatures confirming that the information above is accurate** (this form should be co-signed by the supervisor/ senior author unless this is not appropriate, e.g. if the paper was a single-author work)

Candidate

Remy Twiringiyimana

Date:

November 2024



Date

November 2024

1. For a research manuscript that has already been published (if not yet published, please skip to section 2)

a) What is the title of the manuscript?

STI Policy and Governance in Sub-Saharan Africa: Fostering actor interactions in research and innovation

b) Please include a link to or doi for the work

<https://doi.org/10.1177/09504222211026218>

c) Where was the work published?

Industry and Higher Education Special Edition

d) Who published the work? (e.g. OUP)

Sage Journals

e) When was the work published?

July 2021

f) List the manuscript's authors in the order they appear on the publication

Twiringiyimana, R., Daniels, C., & Chataway, J.

g) Was the work peer reviewed?

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First author contributed to the design of the study. He also wrote the first draft of the manuscript. The second author played a significant role in the conceptualisation of the study. He also contributed to the writing of the manuscript. The third author provided substantial input in revising the manuscript for intellectual content. All authors read and approved the final manuscript prior to submission.

4. **In which chapter(s) of your thesis can this material be found?**

Chapters 1,2,3,4,5,6,7,9, and 10

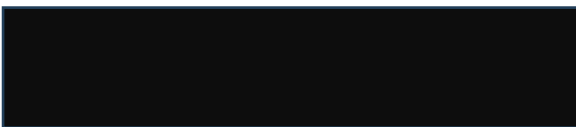
5. **e-Signatures confirming that the information above is accurate** (this form should be co-signed by the supervisor/ senior author unless this is not appropriate, e.g. if the paper was a single-author work)

Candidate

Remy Twiringiyimana

Date:

November 2024



Date

November 2024

1. For a research manuscript that has already been published (if not yet published, please skip to section 2)

a) **What is the title of the manuscript?**

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b) **Please include a link to or doi for the work**

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d) **Who published the work?** (e.g. OUP)

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e) **When was the work published?**

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f) **List the manuscript's authors in the order they appear on the publication**

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a) **What is the current title of the manuscript?**

Exploring contextual imperatives and policy narratives in the emergence of a knowledge-based innovation ecosystem: the case of Kigali Innovation City [updated paper]

b) **Has the manuscript been uploaded to a preprint server?** (e.g. medRxiv; if 'Yes', please give a link or doi)

No

c) **Where is the work intended to be published?** (e.g. journal names)

Sage Journals: Industry and Higher Education Special Edition

d) **List the manuscript's authors in the intended authorship order**

Twiringiyimana, R. (Sole author)

e) **Stage of publication** (e.g. in submission)

In review and editing.

3. **For multi-authored work, please give a statement of contribution covering all authors** (if single-author, please skip to section 4)

[Click or tap here to enter text.](#)

4. **In which chapter(s) of your thesis can this material be found?**

Chapters 3, and 4.

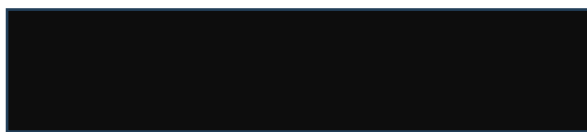
5. **e-Signatures confirming that the information above is accurate** (this form should be co-signed by the supervisor/ senior author unless this is not appropriate, e.g. if the paper was a single-author work)

Candidate

Remy Twiringiyimana

Date:

November 2024



Date

November 2024

Appendix_4.1: KIC Knowledge Space actors' interactive capabilities

S.N	Type of Interactions	Nature of Interactions	Actors Involved	Leading actor/ R&I organisers	Type of KIC leading
1	Collaborative R&I facilitation	Inter-actor interactions	KCRC/CMU-Africa/Affiliated researchers	KCRC	Hybrid
2	Funding for STEM E&R capacity building	Inter-actor interactions	PASET/UR/ACE	PASET	Hybrid
3	Funding for STEM E&R capacity building	Inter-actor interactions	WB/GoR/UR/ACE	WB	Hybrid
4	Funding for STEM E&R capacity building	Inter-actor interactions	UR/Sida (Sweden)	Sida	Hybrid
5	Funding for STEM E&R capacity building	Inter-actor interactions	UR/MCF Scholarship Programme	MCF	Hybrid
6	Funding for STEM E&R capacity building	Inter-actor interactions	CMU-Africa/MCF Scholarship Programme	MCF	Hybrid
7	Innovation (product) development	Intra-actor interactions	ACE IoT	ACE IoT	Academia (in proximity)
8	Innovation (product) development	Inter-actor interactions	RP/UR	RP	Academia (in proximity)
9	Innovation (product) development	Inter-actor interactions	RP/UR	Individual researchers	Academia (in proximity)
10	Innovation Hub/Incubation Centres	Intra-actor interactions	UR/ACE ESD	ACE ESD	Academia (in proximity)
11	Innovation Hub/Incubation Centres	Intra-actor interactions	RP	RP	Academia (in proximity)
12	Innovation Hub/Incubation Centres	Intra-actor interactions	ACE ESD/UR/UR	ACE ESD	Academia (in proximity)
13	Innovation Hub/Incubation Centres	Intra-actor interactions	RP	RP	Academia (in proximity)
14	Innovation Hub/Incubation Centres	Intra-actor interactions	UTB	UTB	Academia (in proximity)
15	Innovation Hub/Incubation Centres	Intra-actor interactions	ULK-Polytechnic	ULK-Polytechnic	Academia (in proximity)
16	Innovative teaching	Inter-actor interactions	AIMS-Rwanda/UR/ACE ITMS	AIMS-Rwanda	Academia (central)
17	Join-supervision of Masters and PhD students	Inter-actor interactions	ACE IoT/Other Research Centres/Universities	ACE IoT	Academia (in proximity)
18	Join-supervision of Masters and PhD students	Inter-actor interactions	UR/Other Universities/Research Centres	UR	Academia (in proximity)
19	R&I Funding	Inter-actor interactions	NCST/UR/UR	NCST	Government
20	R&I Funding	Inter-actor interactions	NCST/ACE IoT	NCST	Government
21	R&I Funding	Inter-actor interactions	NCST/ACE ESD	NCST	Government
22	R&I Funding	Inter-actor interactions	NCST/ACE IoT/UR/Industry	NCST	Government
23	R&I Funding	Inter-actor interactions	UR/ACE IoT	UR Centre for Innovation	Academia (in proximity)
24	R&I Funding	Inter-actor interactions	NCST/ACE IoT	NCST	Government
25	Research Conferences	Inter-actor interactions	KCRC/CMU-Africa/Other actors	KCRC	Academia (central)
26	Research Seminars	Inter-actor interactions	UR/Other actors	UR	Academia (in proximity)
27	Standardisation	Inter-actor interactions	Rwanda FDA/UR	Rwanda FDA	Government
28	Leadership skills dvpt for engineers	Inter-actor interactions	RP/ALU-Rwanda	ALU-Rwanda	Academia (central)
29	Teaching and supervision of postgrad students	Intra-actor interactions	UR/Research Centres	UR	Academia (in proximity)
30	Teaching and supervision of postgrad students	Inter-actor interactions	ACE IoT/UR/AIMS-Rwanda/CMU-Africa	ACE IoT	Academia (in proximity)
31	Teaching and supervision of postgrad students	Inter-actor interactions	ACE ESD/UR/Other Research Centres	ACE ESD	Academia (in proximity)
32	Teaching and supervision of postgrad students	Inter-actor interactions	CMU-Africa/Other Universities/Research	CMU-Africa	Academia (central)
33	Technology Transfer Offices (TTOs)	Inter-actor interactions	UR/Other Universities/Community	UR	Academia (in proximity)
34	Writing articles and/or books	Intra-actor interactions	UR	UR	Academia (in proximity)
35	Writing articles and/or books	Intra-actor interactions	UR	Individual researchers	Academia (in proximity)
36	Writing articles and/or books	Intra-actor interactions	AUCA	AUCA	Academia (in proximity)
37	Writing articles and/or books	Intra-actor interactions	AUCA	Individual researchers	Academia (in proximity)
38	Writing grant proposals/Contracted research	Inter-actor interactions	UR/ACE IoT/Other Research Centres	ACE IoT	Academia (in proximity)
39	Writing grant proposals/Contracted research	Inter-actor interactions	UR/ACE IoT/Other Research Centres	ACE IoT	Academia (in proximity)

Appendix_4.2: KIC Knowledge Space actor network analysis: degree of centrality

Rank	Label	Value
#1	UR	20
#2	ACE IoT	10
#3	RP	6
#4	WB	5
#5	ACE DS	5
#6	NCST	5
#7	CMU-Africa	5
#8	Other research centres	4
#9	ACE ESD	4
#10	PASET	3
#11	Other universities	3
#12	Individual researchers	3
#13	ACE ITMS	3
#14	AIMS-Rwanda	3
#15	UR Centre for Innovation	2
#16	Mastercard Foundation	2
#17	KCRC	2
#18	ALU-Rwanda	1

#19	Industry	1
#20	CEBE	1
#21	Community	1
#22	ICTP-EAIFR	1
#23	AUCA	1
#24	Rwanda FDA	1
#25	Sida	1
#26	Other affiliated researchers	1
#27	UTB	0
#28	ULK-Polytechnic	0

Appendix_4.3: KIC Knowledge Space Actors' network analysis: centrality of betweenness

Rank	Label	Value
#1	UR	0.558
#2	RP	0.143
#3	CMU-Africa	0.136
#4	ACE IoT	0.131
#5	NCST	0.081
#6	Individual researchers	0.068
#7	KCRC	0.068
#8	Other research centres	0.031
#9	Other universities	0.018
#10	The Mastercard Foundation	0.018
#11	ACE DS	0.013
#12	WB	0.007
#13	ACE ESD	0.005
#14	AIMS-Rwanda	0.002
#15	PASET	0.002
#16	ACE ITMS	0.001
#17	ALU-Rwanda	0
#18	UTB	0

#19	Industry	0
#20	CEBE	0
#21	UR Centre for Innovation	0
#22	Community	0
#23	ULK-Polytechnic	0
#24	ICTP-EAIFR	0
#25	AUCA	0
#26	Rwanda FDA	0
#27	Sida	0
#28	Other affiliated researchers	0