Exploring the Urban Digital Divide in Kigali: Spatial Analysis and Institutional Adaptation

OTIOMA CHUKS

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ABSTRACT

The availability and use of the ICTs, which hold potentials for cities, are often uneven across geographies and demographics; a condition which has been referred to as the digital divide. Given the invisibility of digital access, certain geo-demographic groups could face the risk of digital exclusion. Bridging the digital divide entails understanding at least the baseline ICT asset ownership and use in the focus cases, to ensure that interventions are relevant to problem context and geography. However, most studies explore the digital divide at macro-spatial levels (frequently, national and regional levels), which makes them less relevant for knowledge generation and policies at intra-urban scales, the actual hubs of innovations.

From the foregoing, this study aims at exploring the state of ICT access in Kigali at administrative sector levels and existing digital bridge (ICT gap-closing) policy initiatives. It employs a Quantitative-qualitative (Quant-qual)/mixed method. It analyses official census data on ICT Key Performance Indicators (KPIs) across dimensions and space, 35 administrative sectors. The study establishes the relative digital access performance of the sectors based on the measurement of their ICT Location Quotients (ICTLQs) derived from the KPIs and classifies them into ICT-Basic (concentration) and ICT-Non-Basic (sparsity) sectors. It finds that Internet use by location does not match ICT asset ownerships. This indicates that Kigali City is still at the rudimentary stage of ICT access. The digital KPIs, spatially grouped into four distinctive clusters, show that all ICT-Basic sectors and clusters are centrally-located. The study establishes that the digital divide does exist in Kigali City; spatial distribution of ICT access is significantly clustered, with High-High co-types at the core and Low-Low co-types on the northeastern periphery of Kigali City. This espouses spatiality-digitality relations. Using data reduction method on 19 variables, the study establishes that existing urban inequality reflected in infrastructure access, sector urban agglomerative strength, planning status or settlement formality and household socio-economic status are replicated as correlates of the digital divide in Kigali City. However, youth employment exhibits an inverse relationship with sector ICT access in this case; evidence of higher unemployment levels at the city cores than the peripheries. The underlying socio-economic analysis confirms that there is still significant gendering of digital access.

Premised on the perspective that policy initiatives are critical to closing spatial divergence in digital access, the study examines the existing ICT interventions in Kigali City, based on qualitative data from policy documents and interview of multi-actors in key ICT projects. It finds, based on actors' accounts, that ICT policy initiatives have been conceived to cut across geographies and demographics. The projects are mostly nationally-conceived and each has a thematic focus which falls within community development, skills/education development, private sector development, e-government or cross-cutting. The study concludes that at the root of the positive outcomes of these digital bridge policy initiatives are innovation networks, which are intricate linkages of actors working across geographies, ICT-projects and themes in a policy-supported environment. Using SWOT analysis, it highlights the main constraints of the ICT policy initiatives; poor electricity, paucity of funding, shortage of high profile local skillsets to domesticate technology, service deficiency in local content, the challenge of managing multi-actor interests in partnering agencies and self-exclusion tendencies among some of the target social groups.

It recommends, among other things, that the baseline spatial-statistical analysis should guide spatially targeted ICT policy interventions to bridge ICT access gap and that the dimension of ICT be incorporated in traditional urban planning and service provision to ensure its prioritisation as part of key urban services and utilities.

Key words: Urban digital divide, ICT access, spatiality and digitality, spatial-statistical analysis, ICT cluster, digital bridge policy initiatives, innovation networks, Kigali City

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DEDICATION

Dedicated to that segment of the youth, who seek opportunities to explore their talents and make positive contributions to society.

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LIST OF ACRONYMS

AED	Academy for Educational Development
ANOVA	Analysis of Variance
AU	African Union
CD	Community Development
CoK	City of Kigali
CRMDTA	Cumulative-Recursive Model of Digital Technology Access
CSR	Complete Spatial Randomness
DIDIX	Digital Divide Index
DOI	Digital Opportunities Index
e-gov	e-government
eIIx	e-inclusion Index
FIQ	Field Interview Quote
GIS	Geographic Information Systems
GITR	Global Information Technology Report
GoR	Government of Rwanda
ICT	Information and Communications Technology
IDI	ICT Development Index
INSEAD	Institut Européen d'Administration des Affaires/European Institute for Business Administration
ITU	International Telecommunication Union
KIST	Kigali Institute of Science and Technology
KPI	Key Performance Indicator
KTH	Swedish Royal technical University
LDCs	Less Developed Countries
MDAs	Ministries, Departments and Agencies
MINEDU	Ministry of Education, Rwanda
MININFRA	Ministry of Infrastructure, Rwanda

MYICT	Ministry of Youth and ICT
NGO	Non-Governmental Organisation
NICI	National Information and Communications Infrastructure
NISR	National Institute of Statistics, Rwanda
NRI	Networked Readiness Index
NUR	National University of Rwanda
OECD	Organisation for Economic Cooperation and Development
PPP	Public-Private Partnership
PSD	Private Sector Development
QoS	Quality of Service
RDB	Rwanda Development Board
RICTA	Rwanda Information and Communication Technologies Association
RINEX	Rwanda Internet Exchange
RTN	Rwanda Telecentre Network
RURA	Rwanda Utilities Regulatory Authority
SD	Skill Development
SIBIS	Statistical Indicators Benchmarking the Information Society
SIDA	Swedish International Development Cooperation Agency
SRMP	Smart Rwanda Master Plan
SWOT	Strength Weakness Opportunities and Threats
TIDM	Technology and Innovation Diffusion Model
UAF/P	Universal Access Fund/Provision
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
USP(F)	Universal Service Provision (Fund)
WB	World Bank
WEF	World Economic Forum

1. INTRODUCTION

1.1. Background and Justification

Innovations in Information and Communications Technologies (ICTs) have transformed the economic and social formations of cities, and hold promise of enhanced opportunities for citizens(Graham & Marvin, 2001). However, disparities exist in the potential digital opportunities in terms of availability, use and quality of ICT services among the population. For example, it is estimated that only 34% of households in developing countries have access to the internet(UNDP, 2015). This kind of disparity has been termed "the digital divide", which according to Organisation for Economic Cooperation and Development (OECD)'s (2001) definition (cited in Vicente & López, 2011) refers to "the gap between individuals, households, businesses and geographic areas at different socio-economic levels with regard to both their opportunities to access ICTs and to use the Internet for a wide variety of activities". Hence, emerging ICT services in urban areas present a mix of opportunities and threat of exclusion of certain segments of the city. Such exclusion stands a chance of going unnoticed given the invisibilities of digital infrastructures and the relatively less attention paid to this new topic in urban geography (Graham & Marvin, 2001).

Following the growing relevance of the digital divide as an element of urban inequality, attempts have been made to account for its factors, often treating socio-economic variables(Eynon & Helsper, 2014; Várallyai, Herdon, & Botos, 2015). Socio-economic strata have been found to be related to the digital divide (Eynon & Helsper, 2014): women in Britain have fewer activities online and higher level of education positively correlates with Internet skills and access. However, other studies explore the role of geography, especially distance, centrality and agglomeration, in digital connectivity status and usage(Terlouw & Denkers, 2011; Tranos, Kourtit, & Nijkamp, 2014). In a study conducted in China, Tranos et al. (2014) employed a logistic regression-based method and found an inverse relationship between distance (between pair of locations) and the probability of being mutually connected. Terlouw and Denkers (2011) found core-periphery differentials in web usage and competitiveness in The Netherlands and Northwest Germany. This has relevance for geography, at least for one thing: urban geographers and neighbouring researchers, as observed by Graham & Marvin (2001), fear that digitality could signal the death of space, that is the irrelevance of spatial factors in cyber cities, hence the possible death of their own disciplines. This is rooted in the recency and near invisibility of telecommunication services and tendencies to be viewed as being outside the domain of traditional urban studies. However, other studies in economic geography have lent credence to the continued significance of spatiality in digital information access and enablement(Graham, 2015), innovation, business clustering and the emerging knowledge economies(Arribas-Bel, Kourtit, Nijkamp, & Steenbruggen, 2015; Johansson, Karlsson, & Stough, 2007).

The study of urban digital divide is relevant to African cities for several reasons. In the emergence of cities as an information entity, the cyberspace is fast becoming the new public realm, where those who lack the resources to be connected are excluded from the benefits of information technologies (Loader, 1998). In a spatial context, in the emergent networked cities the most likely new geographies are such that the premium spaces are connected while the inactive spaces are bypassed (Graham & Marvin, 2001). Some corroboration for this proposition is already found in Britain (Riddlesden & Singleton, 2014) and South Africa(Jaglin, 2008). Besides, African countries occupy the lowest rungs in ICT Development Index, IDI (International Telecommunication Union, ITU, 2016). It seems the existing socio-economic inequality

could be replicated in the digital divide. Within the low performing countries in Africa, in terms of IDI, Rwanda appears somewhere midway, 26 out of 39 countries and 154 out of 156 on a global scale in the ITU ranking.

Rwanda has made remarkable progress in public utilities provision and urbanisation policies(Rwanda Utilities Regulatory Authority, RURA, 2016). However, it performs low in terms of digital indicators. Integrating elements of digital access into its ongoing efforts at intensifying urbanisation and e-governance has potential for improving its performance. Although available indicators (ITU, 2016; RURA, 2016) give a country-level view of digital performance, they have less relevance for intra-urban analysis. Therefore, this study proposes a finer spatial scale of analysis of digital access in Kigali in order to determine the pattern of distribution based on selected digital Key Performance Indicators (KPIs) and their relations with spatial-economic variables[1]. The digital or ICT KPIs are used in this study to represent physical access (that is household ownership of ICT assets such as radio, television, mobile phones and computers) and use by location (for example at home, office/school, cyber café). The study also seeks to understand digital bridge interventions in Kigali City [2]. These are used in this context as policy-anchored initiatives that are aimed at providing and/or improving ICT access, especially targeted at the geographic areas and socio-economic groups who are not connected or who have poor connection and use of ICTs. Elaboration on digital bridge policies and their links with ICT access is presented in subsection 2.3.

1.2. Research Problem

Although most studies of the digital divide have contributed to general understanding the phenomenon, certain research gaps are identifiable. Firstly, most of them are only preoccupied with the measurement of digital divide or seek to account for the phenomenon. Secondly, these studies are often conducted at the macro-spatial levels: sometimes at regional scales (Vicente & López, 2011), exploring rural-urban divides (Noce & McKeown, 2008; Whitacre, 2008) and even at country levels, especially those related to Digital Opportunities Index(DOI)/IDI computation (International Telecommunication Union, 2014). Pick, Sarkar and Johnson (2015) posit that apart from the focus on non-spatial multivariate analysis of the digital divide which dominates the literature, those which explore spatial aspects seem to have a paucity of insights into the digital divides at the urban level and are therefore less useful for urban analysis. Additionally, very few studies have considered the state and role of institutional processes in bridging the digital divide in the developing countries(see Madon, Reinhard, Roode, & Walsham, 2009), particularly focusing on Africa; and none is available exclusively for Kigali at present amidst vigorous urbanisation and ICT policy efforts.

A deeper understanding of the phenomenon, the urban digital divide, and contribution to closing the research and policy gap would require a synthetic approach aimed at benchmarking digital divide at finer spatial scales. For example, more detailed studies could improve such spatially-targeted projects as Universal Access Fund, UAF (see RURA, 2016 for projects). Integrating spatial-economic analysis in a single study and assessing institutional adaptation to the emerging challenges of digital divide have potential for deepening problem understanding. Urban broadband infrastructure and access are part of public utilities and should be incorporated into urban studies and policy.

[1] Where 'spatial-economic' is used in this study (as frequently applied throughout this work) it comprises spatial and socio-economic factors; in other words, combined geographic, demographic and economic factors. These have been fused in this manner in order to avoid clumsiness in capturing the factors collectively and frequently.

[2] 'Kigali City' and 'Kigali' have been used interchangeably throughout this report. However, there is a sector (spatial sub-unit) of Kigali/Kigali City which is also named 'Kigali' to which no specific reference was made in the work.

1.3. Research Objectives and Questions

1.3.1. Main Objective

The main objective of this research is to explore the spatial distribution and spatial-economic correlates of digital divide in Kigali in order to contribute to its knowledge for urban digital bridge policies.

1.3.2. Sub-objectives and Questions

1 To assess the digital performance of Kigali in terms of physical digital access and use.

- What is the level of physical digital access and use in Kigali?
- What are the distinctive spatial clusters of Kigali based on digital access indicators?
- What spatial pattern is identifiable in the distribution of digital access?

2 To analyse the relationship between spatial-economic factors and digital access performance [3]

- How are spatial-economic variables related to indicators of digital performance in Kigali?

3 To understand the efforts at improving the current state of digital access performance in Kigali

- What are the key existing ICT access projects and who are the actors involved?
- What are the achievements, strengths, constraints and prospects of these projects?
- Which policy measures should be applied to improve digital performance drawing on the analysis of the spatial-economic and ICT interventions?

1.4. Thesis Structure

This thesis is organised in five chapters. The first chapter contains the introduction and justification, statement of research problem and objectives of the work. Chapter 2 has the conceptual framework and literature review. It contains the proposed conceptual framework: the digital divide (conceptual and measurement issues). The literature review will discuss the spatial-economic determinants of the digital divide, integrating contributions from multivariate and spatial analysis. It will present contributions from the geography of information and innovation in exploring the digital divide, including ongoing discourse on digitality and spatiality. The role of institutions (plans, policies, projects and actors) in ICT access (bridging the digital divide) will be examined, with Kigali-relevant case studies from Africa and the promise of ICT access in inclusive city development. In the third chapter, the methodological framework will be presented and described, with reference made to relevant literature for guidance and method validation. In the fourth chapter the research findings and discussion of results will be presented. Chapter 5 will summarise the lessons learnt and make recommendations for policy and future research.

[3] Digital performance or digital access performance has been used in this context to capture the level of access, especially in a relative sense, as regards variance/variability/distribution across indicators and space. Hence, digital/ICT access and digital/ICT performance have been used in this study interchangeably, albeit the later connotes elements of relative applications.

2. CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW

The conceptual and measurement issues of the digital divide are examined in the first section of this chapter. In the section that follows it explores the relations between digitality and spatiality: connections which have received remarkable attention in earlier studies in geography of infrmation and spatial econometrics. Geography of information often espouses the continued role of spatial factors in ICT utilisation and evolution of technological clusters. Alongside socio-economic and spatial aspects, the role of institutions in bridging the digital divide will be presented: the discourse on the role of digital bridge policies. The final part presents an outlook for ICT in inclusive city development.

2.1. The Digital Divide: Conceptual and Measurement Issues

In the literature, several approaches exist which seek to conceptualise, measure and often explain the digital divide. They often form the conceptual bases for the computation of ICT indices by the various research communities. Some of the most widely used frameworks are discussed in this section, and then the current study is hinged on those considered most relevant to guide the research.

One of the most widely employed frameworks is the Networked Readiness Index (NRI), also called Global Information Technology Report, GITR, which is a joint project by Institut Européen d'Administration des Affaires/European Institute for Business Administration (INSEAD) and World Economic Forum (WEF). An example is World Economic Forum/INSEAD's (2014) NRI . The NRI conceptualises the digital divide using three key dimensions; environment (the ICT market and support services, favorability of regulations and political stability) and stakeholders' readiness to adopt ICT and the actual usage of ICT. It is a comprehensive framework which presents more than 50 indicators, under these dimensions, on which countries are ranked. However, NRI has been criticised for its cumbersomeness, inconsistency; frequently varying indicators(Pick et al., 2015) and arbitrary assignment of weights to dimensions, which may not reflect local perspectives(Barzilai-Nahon, 2006). Nevertheless, NRI remains one of the most-readily available and global ICT performance references.

Another well-known framework is the ITU DOI guide, for example ITU Guide or Framework for Measuring ICT Access 2014 (ITU, 2014). The ITU measures the digital divide using the DOI guide, which comprises three dimensions; opportunities, infrastructure and utilisation. Each of these is divided into specific indicators for profiling access and performance. It covers household access and use by location (home, school, cyber café and work) and socio-economic correlates (for example employment and gender), which makes it multi-dimensional. Access in terms of any of the indicators means physical availability, use and socio-economic conditions, which may motivate use or serve as barrier. Where access to/use of ICTs (also termed digital access) is unequal across demographic and/or spatial groupings, it is generally referred to as the digital divide. Hence, digital access and the digital divide are two sides of the same coin. The ITU guide or framework, updated regularly, is most widely adopted and used by countries as the official digital access performance indexing framework, monitoring and evaluation guide, and often replicated at the country level for Universal Access/Service Provision (UAP/USP). However, it has a long tradition of application at the national level and often silent on performance at subnational levels, even if its indicators could fit well into the regions and cities where they are drawn. This is understandable since the ITU focuses primarily on countries. The application of the framework for further profiling of the ICT

performance of cities and towns within each ITU country falls, primarily, within the domains of the individual countries.

The Technology and Innovation Diffusion Model(TIDM), developed by Rogers (1995), plays key roles in temporal modelling of mobile phone adoption and use. It is suitable where timelines and hierarchy of adopters (also known as users, senders and receivers, or agents) is of essence in longitudinal studies. Since the TIDM seeks to predict adoption trends among agents, including behavioural and human influences, it becomes difficult to model the true situation as the quantification of complex human relations is near impossible. Coupled with this is the assumption of a unidirectional information flow (from innovators through adopters to laggards), which belies reality. Despite the complexities and shortcomings of adoption models (there are variants but they work in the same way), they are handy in behavioural studies of innovation and technology diffusion; for example (Sahin, 2006) presents a review of the TIDM and studies built on it.

van Dijk (2005) proposes the Cumulative-Recursive Model of Digital Technology Access (CRMDTA), which captures the cycle of technology access. The stages are motivation, material access, digital skills, usage and anticipated innovation. This framework is rich in its composition of elements of attitudinal barriers or drivers of digital use (that is motivation), skills and usage. However, it is purely aspatial in its framing. It was conceived in its original form as a socio-digital divide model. Nevertheless, where the model is adapted in a spatially-oriented analysis of the digital divide such an exercise could gain insights from its rich indicators and relations between them.

The Statistical Indicators Benchmarking the Information Society, SIBIS (European Commission, 2003) is also recognised , especially within the European Union . The SIBIS Digital Divide Index (SIBIS DIDIX), also termed e-inclusion index(eIIx), measures material access and use, and considers groups at risk of digital exclusion; women, citizens aged 50 and above, low-income and low-education groups. Similar to NRI, it assigns weights to indicators, which may not reflect the priorities of the users at subnational levels (Barzilai-Nahon, 2006).

The variance in the frameworks discussed so far attests to the difficulty in conceptualising and measuring the digital divide. The divergent theoretical leanings do not make any proposed framework ineffective but reflect the multidisciplinary character of the topic. Hence, efforts have been made to harmonise perspectives by the development of a multidisciplinary framework. Key among these is Dewan and Riggins(2005). Their framework takes into account topical issues (dimensions, indicators and order of access), spatiality (specifically, spatial level of analysis), theoretical leanings of research and method of analysis (see Fig. 2.1). Although the framework is highly adaptive, it failed to capture third-order access, which is the offline outcome of digital access, in its original framing. The absence of the third-order access in their framework is understandable when placed within the context of its time. It was developed during the early years of Internet in the 2000s; hence basic access was covered. Elaborate conceptual and measurement references are available for digital skills(van Deursen, Courtois, & van Dijk, 2014; Van Deursen & Van Dijk, 2010) and third-order access (van Deursen & Helsper, 2015) which could augment the framework. These comprehensive frameworks or system of indicators of digital skills and offline outcomes of digital access can be adapted for research targeted at digital literacy and participation, especially in mature information society or advanced digital economies.

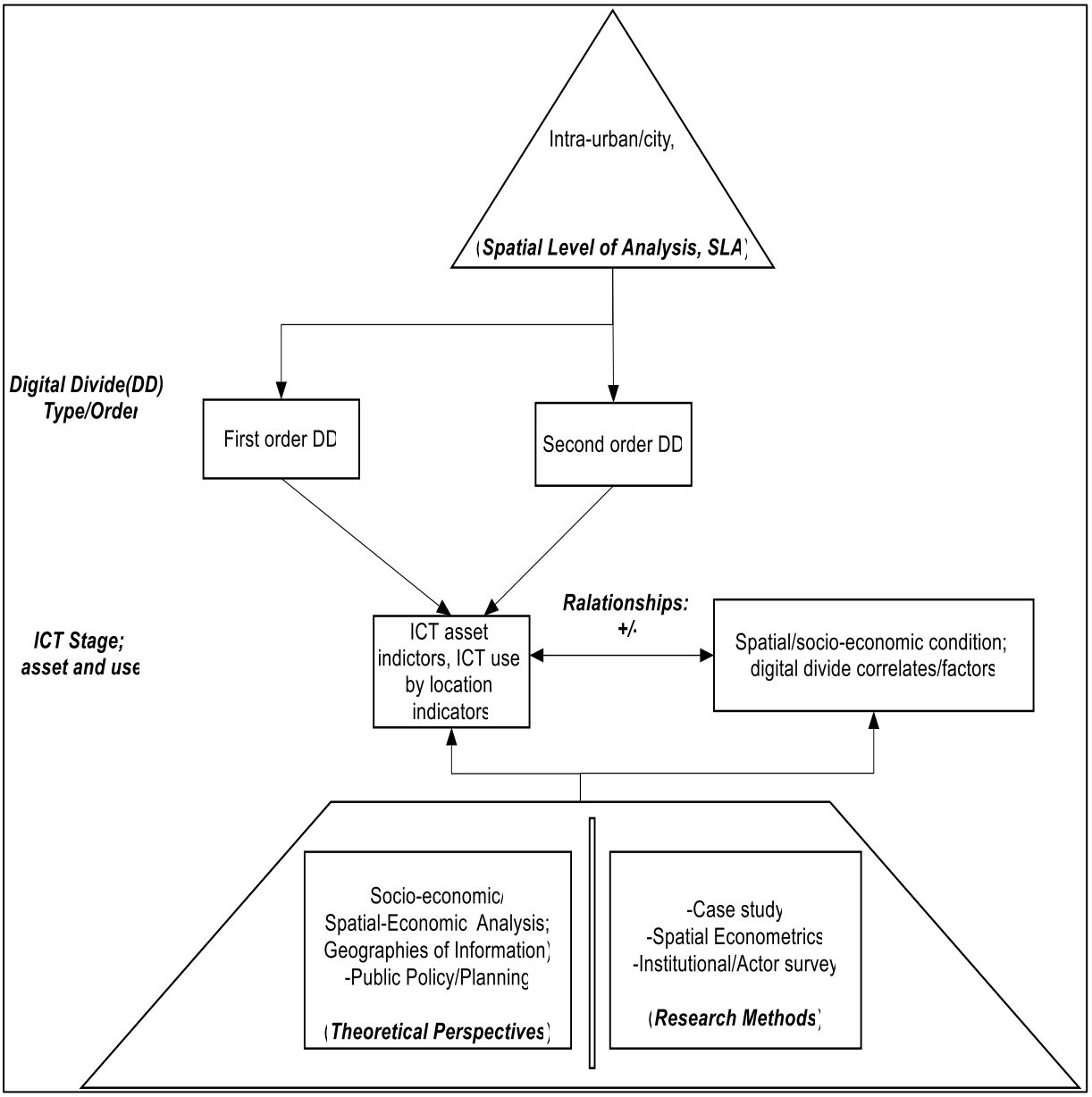

Fig. 2.1 Conceptual Framework

Adapted from Dewan & Riggins (2005)

Within the adapted framework of Dewan & Riggins (2005), the present study takes a bearing. It applies the ITU indicator-type, explores the digital divide at an intra-urban unit (level of analysis) and fuses spatial-econometric with institutional analysis in order to understand the underlying correlates of digital access and policy initiatives/efforts at digital access in Kigali.

The conceptual framing of this study is justifiable. First there are variants of digital access dimensions and indicators, all of which cannot be covered in a single study, except in large scale research at the behest of international development agencies. Additionally, the indicators or aspects considered depend on the theoretical perspective of the research. Hence, Barzilai-Nahon (2006) posits that in the study of the digital divide, dimensions and indicators considered should be situated within the context of the case being considered in terms of purpose and topic of analysis, spatial unit of observation(level of analysis) and approach to indicators, which include the existing socio-economic and policy environment. For example, it may be needless to engage in connectivity of users in the capital city of a developed country, in the true

sense of physical access, since access in such a case would typically be well-developed. It could be justified if it is aimed at relating physical access to such other aspects as attitude (for instance, security perception which may demotivate use), digital skills, immersion and participatory outcomes. Second, the ITU indicators to be applied in this study are highly adaptive, albeit little has been done to apply them at sub-national levels, hence the need for urban research and policy-relevant analysis. The focus on the basic access-order (indicators of first-order and second-order) is aimed at fitting the study into the context of the stage of ICT development of the study area, Kigali City and understand relations with existing spatial and socio-economic factors. Hence, within the known continuum of the geographies of information; the geography of digital access and enablement, the geography of digital participation and the geography of representation(Graham, 2015), the current study proceeds with the exploration of unevenness in basic access and enablement. Third, it adopts a spatial-econometric method; integrates spatial and socio-economic analysis, in line with earlier studies (Ghezelayagh et al., 2014; Holloway, 2005; Nishida, Pick, & Sarkar, 2014; Pick et al., 2015) and aligns with the thinking that institutions matter in the study of the digital divide(Howard, Busch, & Sheets, 2010; Madon et al., 2009; Pick & Sarkar, 2015). The synthesis of spatial thinking and institutional perspectives is rooted in the premise that spatial analysis guides or should guide public policy, in this case digital bridge policies. This argument is given credence by the fact that most of the digital bridge policies are typically spatially-targeted, especially at poorly-performing neigbourhoods or public organisations (see Madon et al., 2009; National Communication Commission-Nigeria, 2016; RURA, 2016).

A specification of the spatial level of analysis (SLA), topical indicators (that is, digital Key Performance Indicators, KPIs), spatial and economic variables, and institutional elements considered in this study are presented in the methodology section.

2.2. Spatiality and Digitality

In this study spatiality is used to capture the inherent or obvious relation between the spatial distribution of socio-economic factors and level of development or performance of technological clusters, as regards household access to ICTs. Digitality, a term derived from Negroponte(1995), in his seminal work "Being Digital", refers to the pervasive use of mobile telephones, wireless access to information and services on the world wide web platform and the intensified technologically-mediated interactions and cyber-culture among people.

Within the domain of internet geography spatiality-digitality relations have been explored (Crang, Crosbie, & Graham, 2006; Graham, 2011, 2015; Graham & Marvin, 2001) and in economic geography/spatial econometrics (Baum, Gellecum, & Yigitcanlar, 2004; Nishida, Pick, & Sarkar, 2014; Pick & Nishida, 2015; Tranos et al., 2014). What cuts across these studies is the position that the spatial-economic status of any given location is a driver of its share of ICT usage. Where interconnectivity of locations within and between cities are explored (for example, Tranos et al., 2014) the distance between any give points determines their probability of being connected.

In a reverse relation digital activities equally influence urban physical- and socio-spatial activities. In a survey of 310 land use and regional planners ,Talvitie (2004) found that Finish planners perceived digitality to reduce the effect of distance on urban activities through such ways as new means of mobile employment and reduced transaction distances. This corroborates Graham and Marvin's (2001) position that that urban geographers and neighbouring scientists and practitioners fear that digitality may signal the death of distance/space, and by extension their own discipline. However, other scholars (for example those earlier mentioned in internet and economic geography, and spatial econometrics) have consistently

and diligently espoused the argument that spatial determinants will remain strong in the evolution of technological clusters, access and use.

The possibility of the urban fringe dwellers to be excluded in the emergent spatial structure of the ICT-enabled society is evidence of the instrumentality of space in digital access. On availability and quality of service, in a space-time analysis of 4.7 million results of Internet speed across the European Union between 2010 and 2013, Riddlesden and Singleton (2014) found that areas of varying spatial densities experienced fluctuating speed and therefore quality of service(QoS) over time. The areas of higher densities which are the urban hubs are associated with higher speed in contrast to the low-speed-associated peripheries. Though the cases were drawn from the developed countries, these have relevance for cities in developing countries, such as Kigali City, where peripheries are comparatively disadvantaged, especially as regards innovation and infrastructure (see City of Kigali, 2013). On this ground, location is seen to play a vital role in not only physical access but QoS. In congruence with this finding, urban peak and off peak hours or alternatively daily mobility behaviour was found to drive the daily trends of mobile usage and digital signature of the city; spatial footprint and trends of peak and off peak mobile phone data usage (Reades, Calabrese, Sevtsuk, & Ratti, 2007; Steenbruggen, Borzacchiello, Nijkamp, & Scholten, 2013; Tranos et al., 2013). This is given credence by (Kelley, 2014) who posits that geo-social information tends to be concentrated in the areas of high population density and commercial intensity, albeit with pockets of relatively intense activities in sub-urban zones.

Using the 2007 census data of the United States of America in a multivariate regression analysis of 2 million farms in 3,070 counties, Basu and Chakraborty (2011) found that the existing geo-demographic differentials, which accounted for unevenness in infrastructure access, were replicated in internet access and speed among farmers selected from metropolitan and regional fringes. Specifically, non-metropolitan service areas (nMSAs) in the southern part of the country were found to be dominated by farms with less than 30% access to high speed internet.

Unequal access, rooted in stronger dividing geographic and demographic factors mean that the peripheries would remain weak, less active in ICTs. Checking the strong forces of geography and demographics entails employing policy intervention and collaborative instruments. This is examined in the next subsection.

2.3. The Role Institutions in Bridging the Digital Divide

In the context of this study institution connotes an aggregation of policies, projects, people (actors) and practices/mechanisms involved in the quest to provide ubiquitous and better quality ICT service/access to citizens in the focus area. Hence it captures the ICT ecosystem which comprises operators, regulators, users and such intervening actors as development partners and NGOs who seek to reduce ICT access gap at household, community and corporate levels.

In this study digital bridge policies refer to officially documented plans which are targeted at providing and/or promoting ICT asset ownership, use and/or content across geographies and socio-economic groups. These policies affect the provision and use of ICT asset directly while taking into cognizance the expansion of infrastructure, enhancement of skills and other socio-economic correlates of digital access. Digital bridge policies are used in this context in a sense similar to technology policies(Chary & Aikins, 2009) , ICTs policies (Graham, Ojanperä, & Friederici, 2017) and digital inclusion policies (Madon et al., 2009), which have the ultimate goal of providing and improving ICT access, especially targeted at the poor. These visions, plans and practices of bringing connectivity to the disconnected frequently involve governments, private sector and NGOs (Andreasson, 2012; Graham et al., 2017). Digital bridge policies

have one commonality; documented visions which are hinged on projects/initiatives aimed at connecting the disconnected. In Kigali City (Rwanda), these policies are translated into action through ICT projects/initiatives which cut across such themes as education, business, governance and community development (Ministry of Youth & ICT Rwanda, 2015a)

Madon et al. (2009) applied the term "digital inclusion" for digital bridge(ICT gap-closing activities of actors through policies and projects) and "institutionalization", which is defined as the process whereby digital inclusion projects can become institutionalised through the establishment of structures of symbolically accepted goals linked to relevant social activities and supported by appropriate material resources"(p. 97). In the present study, since the process of bridging the gap (institutionalisation) is dynamic, the term "institutional adaptation" is employed to capture the changing policy and multi-actor efforts aimed at meeting these emerging ICT services and needs in a budding city, Kigali.

There are basically two-sided policies; demand-side digital access policies or supply-side digital access policies. The demand-side focuses on ICT use. Hence it covers issues related to enhancement of or restriction on uses through such policy instruments as incentives (for example subsidy and broad content) or restrictions (for example censorships) respectively. However, the political environment determines regulatory strictness, terms of information access and digital content. World Bank Group (2016) recognises that in exercising use control the regulator often faces the dilemma of liberal or restrictive access. Where unfiltered content access is allowed, even in cases where use is in mainstream service; e-urban governance, economic and social-political (civic) participation, the government may be a little insecure about the volume of information available to its citizens. Where, on the other hand, content access is heavily restricted, the government risks resistance from the citizens and non-state actors, especially freedom of information and transparency advocacy groups.

The supply-side focuses on the overall ICT provision such as Universal Access Provison(UAP) or physical coverage (as regards served and underserved areas), QoS, competitive pricing (comparative billing), operator market dominance, spectrum allocation, technology deployment, tax and levies, cost issues and interoperability (operators information and infrastructure sharing). On the all-important issue of pricing and affordability the approach is quite indirect; since service provision is unbundled the government cannot fix price. The strategy is often targeted at ensuring wider and mass coverage, favourable tax regimes and reduced transaction cost (for example through access to land and fast tracked permit processing) and investment security. These have long term user-base growth, cost lowering effect and robust competition and consequently reduced consumer price.

On the melting point of use (that is, demand) and provision (supply) especially as regards availability, volume consumption and quality of service, World Bank Group (2016) broaches the question on commodity status of ICT; whether ICT (Internet access, for instance) should be considered a public or private good. This is complicated on grounds that a generic consideration could lead to some conclusions that Internet access, essential in nature, by an individual may not necessarily reduce its availability to another, in which case it could easily pass for a public good. However, use of ICT infrastructure and service such as base stations or digital content by an individual may reduce service availability and quality to another user, for example, through traffic channel congestion and delayed or distorted content. Given the large scale investment in human capital and technology, and complex processes required to maintain an acceptable service level, which often the public sector cannot or does not provide, the ICT service sector is typically unbundled and hence the commodity easily passes for a private good. This presents another dilemma which is explored here in the context of Kigali (Rwanda).

In Rwanda, the National Government strives alongside the districts to ensure wider telecommunication service coverage, quality and affordability through regulatory instruments. In 2003, the Universal Service Provision(USP) was established to pursue this goal, in line with World Forum for Information Society (See RURA, 2016). However, the government does not provide the service directly to citizens. The operators prioritise locational efficiency, network optimisation and revenue maximisation. The cities and villages stand the risk of splintered networks; service concentration on premium locations and systematic exclusion of less economically viable areas as a result of telecommunication sector unbundling(see Graham & Marvin, 2001).

Basically two scenarios could unfold. There could be a completely deregulated, unbundled tele-service provision. An alternative could be an unbundled sector with positive interventions, incentivisation and compliance to reach inactive spaces, even as government seeks to run state service provision. Each of these has spatial-economic and social significance for the players. Whatever the case or choice, private investments must not be jeopardised; investors and development partners must not be demotivated. The poor must not be excluded from the cyberspace. Digital inclusion typically requires convergence of interests, rescaled priorities, objectives setting and collaboration. Other players have critical roles to play as well. Institutional interventions (that is policy initiatives) therefore become critical for ICT service gap closing. This involves collaborative problem-solving and tradeoffs in this multi-actor system.

The essence of policy initiatives is illustrated by Villasenor et al (2015) in a study conducted to assess digital service uptake for commercial transactions in selected developing countries, where they found geography mattered less than policy in digital service performance. This is rooted in the fact that policy, in particular, and overall strength of institutions (including commercial operators, intermediaries and users) played roles in reducing the spatial and socio-economic gaps in ICT access. The report presented by Villasenor et al., (2015) revealed that farmers were very much involved in mobile money adoption and usage, with embedded local content, even if these, as often is the case, are not in the formally highly educated segments of society. Where service provision and regulatory environment are favourable for operators and user-inclusive, geographic and demographic divides are heavily reduced. Hence sound policy choices in an environment which has committed and collaborative actors can always break spatial and demographic barriers.

Evidence of success of digital bridge policies and enablement is available for Rwanda (ITU/UNESCO, 2015; Luca, Sahy, Joshi, & Cortes, 2013). Although Odufuwa, (2012) reported a relatively less impressive performance rating in mobile telephone ownership for Rwanda(24.4%) in an Africa-wide study (12 countries) exploring the demand- and supply-sides of broad band penetration, Rwanda was rated best in perceived policy and regulatory effectiveness. In terms of ownership it came next to the least-performing of the countries surveyed at that time, Ethiopia (18.3%) while South Africa topped the chart at 84.2%. In mobile money service penetration, Rwanda's performance lied mid-way at 3.3% with Kenya topping the chart (60.3%) and Ethiopia at the bottom (0%). With continued policy efforts mobile phone penetration in Rwanda currently stands at 77.8% (Lancaster, 2016; RURA, 2016a). However the figures are lumped for the entire country, thereby obfuscating distinction between such local ICT and innovation clusters as Kigali City and other cities on the one hand, and within the cities on the other. In mobile transaction services, it was reported that policy initiatives in Rwanda raised financial inclusion target to 90% by 2020 to redress the current state where 52% of adults are financially excluded((Villasenor et al., 2015). This could be linked to the SRMP; the recent rigorous pursuit of the Smart Africa Initiative (piloted and driven by Rwanda) designed with the vision to connect, innovate and transform communities in terms of ICT adoption, usage and immersion. SRMP covers areas of broadband access, economic policy, political and technological environments of Rwanda.

These efforts hold promise for movement towards knowledge-based economy, driven by cities which typically serve as the ICT hubs. Some contributions to the literature on the state and outlook for ICT in inclusive, knowledge-based development are presented in the next section. These are expected to deepen understanding of the promise of ICT for the city.

2.4. The Outlook: Information and Communication Technologies in Inclusive City Development

As urban economies become increasingly information technology-driven it is expected to transform the transactional experience of and create a range of unprecedented opportunities for users across geographic and socioeconomic strata. Even where the gains of the emergent digital economy are certain, inclusiveness in digital dividends is not a given. As a corollary of this argument, Butcher (1998) reported that ICTs were gaining traction in development process through community ICT service centres in South Africa. The study examined the use of ICTs in education and training through policy initiatives. He found, based on qualitative analysis, that the socioeconomic character of access depicted a continuing gap between the well-off and the deprived segments. He emphasised the disequilibrium in ICT education and affordability and recommended that gap closing mechanisms should incorporate issues of ICT-embedded education and cost-effectiveness to spread the gains of emerging technologies. Butcher's observation becomes more relevant when viewed against the background of the continuing exclusion of the marginal areas, which often are also the socioeconomically least resourced.

A recent study by Villasenor, West and Robin (2015) corroborates the position. In an assessment of the digital inclusion projects in 21 selected developing countries they used key elements such as country commitment, e-financial transactions and participation criteria and found that access to financial services provided opportunities for individual prosperity and economic enhancement. Besides, it was found that improvement in affordability and coverage of the hitherto underserved areas encouraged marginal groups, especially women, to embrace digital financial services, particularly mobile money.

Beyond the generic mention of the role of ICTs in city fast-tracked urban service access, citizen transactions and participation in development activities, concrete cases of success exist. ITU/UNESCO (2015) in the *State of Broadband Report* presents an account of ICT use in Argentina and Rwanda, the most relevant cases for this discourse. In the case of Argentina it was reported that a joint smart education project with UNICEF enabled school attendance rate monitoring system. With the availability of mobile phones, which were integrated with Education Information System, the school principals were informed about the attendance rates and tendencies of students. This enabled the authority to take prompt disciplinary measures. In the case of Rwanda, as reported in the study, water quality was being monitored with the aid of sensors and information disseminated via mobile short message services. This is one of the features of Smart Africa Project which is being piloted in Rwanda, with ICT-enabled urban service integration, green economy and enhanced citizen information service transactions.

In concrete econometric terms, WEF/INSEAD (2015) in Global Information Technology Report(GITR) built on existing literature to establish that once a critical threshold of 20-24% digital penetration is reached, a Gross Domestic Product(GDP) growth of 3% could be achieved with a 10% increase in investment in telecommunication infrastructure. This is of especial importance to Kigali where ICTs have continued to receive strong policy and investment commitment through consistent multi-year strategies and Smart Rwanda Master Plan(SRMP), with the latest being SRMP 2015-2020 (Ministry of Youth & ICT Rwanda, 2015b).

On the promise ICT for urban resilience, recent mainstream studies recognise its role, particularly in climate change governance and e-resilience in Costa Rica (Ospina & Heeks, 2015) and the proposed

Sustainable Development Goals, SDGs(UN-Habitat, 2015). The Costa Rica case study is based on the Resilience Assessment Benchmarking and Impact Toolkit (RABIT) which measures ICT impact on livelihood and coping capabilities across selected resilience components such as learning, flexibility and diversity. It was found that mobile ICT usage had positive impact on recovery from shocks and stressors. Where ICT plays a key role in the ability to recover, adapt and transform amidst stressors, it is considered e-resilience (Ospina & Heeks, 2010). If this holds, then the rebounding Kigali is a relevant case in point, given its recent experience of civil unrest and fast-paced recovery hinged on ICT-driven urbanisation policies, for instance, SRMP.

Elsewhere, the UN-Habitat officially recognises the role of ICTs in the New Urban Agenda, incorporated in the proposed post-2015 Sustainable Development Goals (SDGs). With special reference to the proposed goal 11: *Making cities and human settlements inclusive, safe, resilient and sustainable*, 'ICTs are increasingly recognised as an integral of the SDG process. Modern technology is widely accepted as a way of enabling and measuring the SDGs and is linked with the Open Working Group's Outcome Document in Goal 17 on enhancing the use of enabling technologies and in the report by the Expert Group on Digital Revolution: *Means of Transformation; Harnessing Broadband for Post-2015 Development Agenda'*(UN-Habitat, 2015, p. 2). This justifies the role of ICTs as urban innovation and inclusive development enablers.

Placing Kigali within the context of urban socio-economic resilience, ICT (especially household-user access) could enhance value chain in terms of income diversity and redundancy (multiple sources and surplus from safety nets), employment generation (also relates to diversity, redundancy and flexibility), information and education, transactional flexibility and rapidity, and multi-actor participation and inclusiveness.

3. RESEARCH METHODOLOGY

In this chapter background information on Kigali City is presented to give insights to the context of the problem being examined, and the analysis and discussion that follow later in the work.

3.1. Case Justification

Kigali, a population of 1, 132, 686, is selected as a case study given its well-articulated urban development plans, in which ICT has been identified as a cross-cutting and major component, in line with ITU Universal Service Provision/Fund (RURA, 2013; 2016). This entails ICT integration with urban planning, health, through tele-medicine, business and education. Besides, it has a forward-looking plan, Kigali 2040 (City of Kigali, CoK, 2013). However, Kigali (Rwanda) is relatively behind in ICT ranking, and internally some of the areas are poor in terms of access and usage, compared to neighbouring countries (ITU, 2016; RURA, 2013). Apart from general descriptive data and public opinion, no scientific spatial analysis of the problem under investigation is available for Kigali, even if ICT is recognised as a major focus of the Universal Access Fund, being the economic and technology hub of the country. This section presents brief background information on the existing socio-economic condition, especially within the context of youth and ICT, and planning/governance of Kigali City.

3.1.1. Socio-economic Condition of Kigali City

Kigali justifies its urban hub status in Rwanda as it generates up to 50% of the country's GDP, through activities spread mainly across agriculture, industry and services, which contribute 5.5%, 32.6% and 61.9% respectively(National Institute of Statistics of Rwanda, NISR, 2012 cited in Rwanda Environmental Management Authority, 2013). The service sector comprises wholesale and retails, transport, ICT, finance, real estate and technology consulting, which are concentrated in the Central Business District. Kigali City has areas with specialised functions: Gasabo District is the administrative hub, Nyarugenge(financial hub) and Kicukiro(knowledge/ICT hub). This is indicative of the service-inclination of the city, which contrasts the rest of the country: composed of manly rural farm-activities.

The pursuit of knowledge-based economy hinged on the education and services sectors underscores the relevance of youth education and enrolment. In Kigali City, youth educational attainment is 33% and 11% for secondary and university education respectively(NISR, 2014). It therefore poses a challenge for driving the services sector, which typically demands intensive knowledge and skills. The situation becomes more challenging when viewed against the background that Kigali City represents a paradox in terms of the relation between education and youth employment. For instance, (NISR, 2014) reported that the youngest (of the youth), 14-19, have the highest Labour Force Participation Rates (LFPRs) if they are uneducated. The young population within age 20-24 maintain up to 80% LFPRs if they have primary school education, as the situation worsens through secondary education to the university graduate cohort, who experience further delays in labour market entry. This worst-hit segment has an employment rate of 17%.

The case of the unemployed cohort becomes even more complicated considering the fact that they live in a city which has been reported to have a fairly lower level of poverty. As at 2012, Kigali City had a poverty rate of 15%, with 92%, 90% and 74% living above the poverty line in Kicukiro, Nyarugenge and Gasabo Districts respectively(NISR, 2012). However, poverty, as used in the report has a local context, being a situation in which an adult cannot afford non-food items because of insufficient money. Being educated

without economic empowerment poses a challenge for individual well-being, creativity and piloting the technology-driven and emerging service economy. This calls for efforts at linking skill development with local economic strategy, especially targeted at self-empowerment, since labour supply by those who have attained the higher cadre of education outstrips demand. The situation has led to social protection programmes targeted primarily at the unemployed youth and women, in which ICTs have been recognised to help improve existing urban economic situation and create new opportunities through innovation-based start-ups and scale-ups (Ministry of Youth & ICT Rwanda, 2015b).

3.1.2. Urban Planning and Administration in Kigali City

Kigali City accounts for 50% of the urban population of Rwanda, a country which is composed of 16.5% urban population. This makes Kigali City a relevant hub of innovation and development in the country; moreso where a city is officially defined, in Rwanda, as a settlement with at lesast 200, 000 inhabitants. Others are municipalities, between 30,000 and 200, 000 and agglomerations, between 10, 0000 and 30, 000 (Ministry of Infrastructure Rwanda, MININFRA, 2015).

Kigali City is divided into three Districts: Gasabo, Kicukiro, and Nyarugenge. These Districts are further divided into 35 sectors and 161 cells, and the cells are sub-divided into 1,061 villages. The 2006 Organic Law No. 10 established the City of Kigali as a local government with administrative, legal and financial autonomy(City of Kigali, 2013a). The city development is guided by its multi-term spatial development plan, City of Kigali Development Plan (CKDP): the current one is CKDP 2013-2018. While the city has autonomy, such is always exercised in congruence with national spatial development culture and plans. This is because Rwanda operates a top-down but well-coordinated planning framework, in which the Law Governing Planning and Building in Rwanda 2012 is the overarching legal reference for urbanisation in the country (MININFRA, 2015). The Law Governing Planning and Building sets procedures of urban development management and technical implementation aimed at supporting coordinated, sustainable and inclusive development. Although many Ministries and Agencies (MDAs) participate in the pursuit of urban development in Kigali City, including Ministry of Local Government, which is the parent ministry of City of Kigali Council, the MINIFRA takes the lead and therefore coordinates the activities related to urban development.

While spatial development strategies conceived at the national level, implemented at the city levels, provide broad guidelines for such planning themes as land use management, urbanisation and infrastructure, they do not capture the condition effectively at the district ands sector levels. This gap is filled by One Stop Centres at the district level, who are the facilitators of urban planning: permits, approvals, certificates and land registration; they work under the supervision of the district governments(City of Kigali, 2013a). The districts in turn use the sectors as the immediate spatial unit of implementation, which makes the latter critical for both spatial and socio-economic development. They serve as a link between the cells and the mainstream city. The significance of the 35 *administrative sectors* of Kigali City is also rooted in the fact that they meet the country's minimum standard for classification as agglomerations (at least 10, 000 people) and form the foundation intra-urban units for strategic spatial-econmic developement. However, these are based on a single-indicator classification, population. These administrative units, applied in this study as the Spatial Level of Analysis(SLA), are frequently used as 'sector(s)' throughout.

Kigali City has a clearly defined structure for its daily urban administrative activities. It is governed by a City Council (City of Kigali Council/Kigali City Council, KCC) which comprises 31 Councilors who are elected for a five-year term. This council formulates its local regulations and laws, drawing on the reference frameworks of the parent ministry, MINALOC. The actual functioning of the City of Kigali

Council is anchored on a Bureau which comprises a Chairperson, Deputy and Secretary. The political head of the council is the Major, who alongside two Deputies form the Executive Committee, to oversee the day-to-day government business of KCC (City of Kigali, 2013a, 2017).

While Kigali City has clear plans and well-established structures for spatial development, its ICT sector (activtity) depends heavily on the national ICT policies, projects and MDAs. The Ministry of Youth and ICT (policy formulation), Rwanda Development Board (project implementation) and RURA (ICT sector regulation) are the key government agents in issues related to ICTs in the country. Although decentralised ICT policy formulation and project implementation could facilitate innovation transfer, domestication and use in local contexts, Kigali City cannot be considered to be one of the most adversely affected by the current centralised system: it doubles as a provincial-city and the seat of national government. It is frequently being positioned as the country's competitive regional hub. This is evidenced by its record of innovation in public sector operations and service delivery. For example, City of Kigali (2013a) reported that the city had installed an internal document tracking system for real time sharing among employees, thereby facilitating decision-making; upgraded corporate websites, connected to fibre-optic-enabled Internet across agencies and had an initiative to provide every employee with a laptop. In addition, Management Information System has been installed for urban planning to facilitate construction licence application. The aspect of laptop for employees and broadband access in the local authorities is of especial significance for ICT access in Kigali City and this study since household access to Internet in offices is one of the indicators adopted for measuring digital access. In addition, fast-tracked planning transactions could also have positive implications (time and money cost reduction) for telecommunication service providers, who are involved in multi-location activities and frequently request permits for physical construction, especially underground cables and base transceiver stations.

3.2. Spatial Level of Analysis

In the study of the digital divide, the spatial level of analysis is important since it determines the degree of aggregation or otherwise of data and influence resolution of results (Pick, Sarkar, & Johnson, 2015; Dewan & Riggins, 2005). In this study the 35 sectors of Kigali City (Fig 3.1) are selected as intra-urban units of observation. Such intra-urban units of observation and analysis have added value since the proposed study has primary relevance for urban research and policy applications, in contrast to national and regional domains, where regional- and city-level of observations and analyses are more relevant(Pick & Sarkar, 2015)

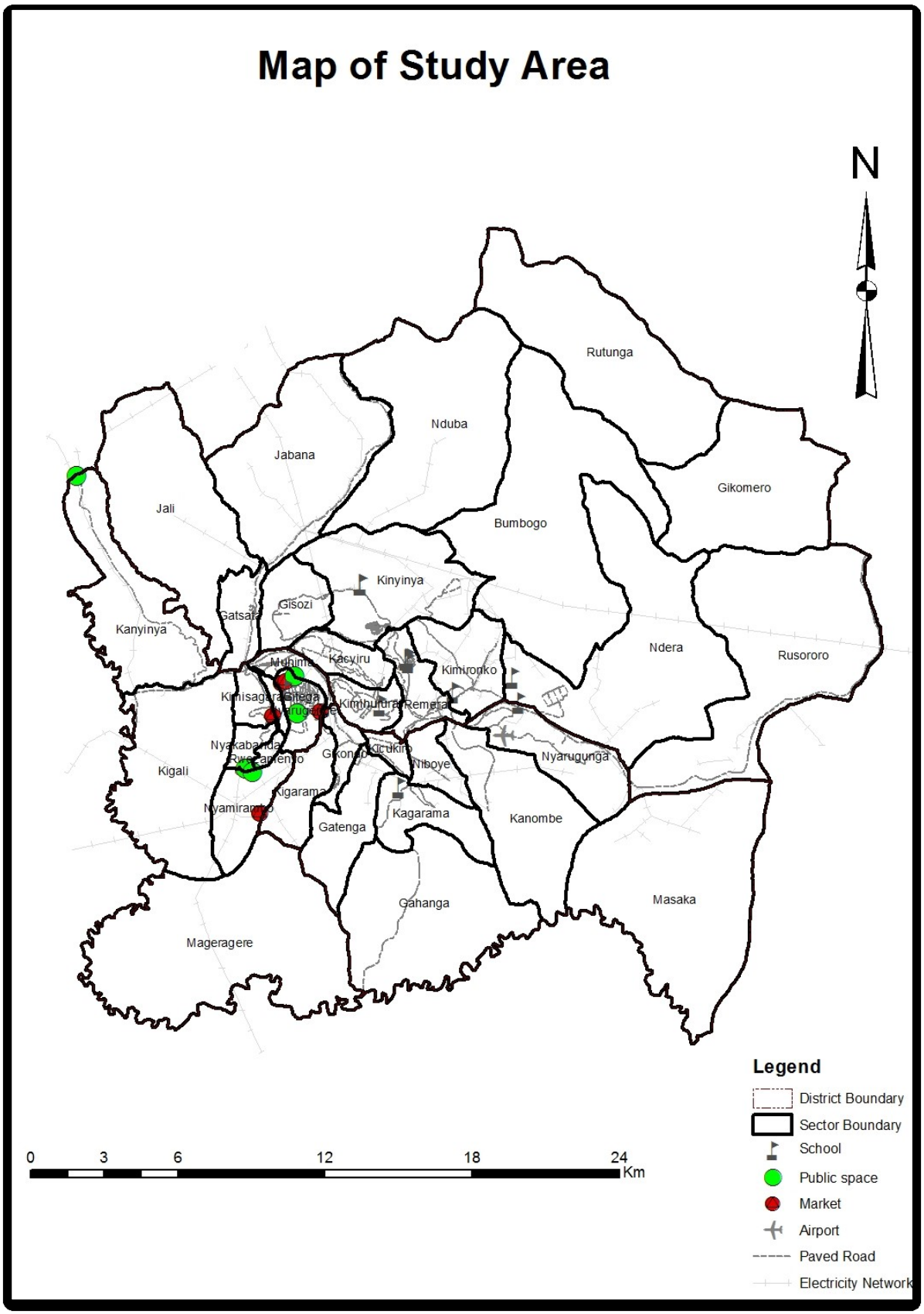

Fig. 3.1 Map of Kigali City Showing Key Urban Features

Input Data from Ministry of Infrastructure Rwanda (2016)

3.3. Information and Communication Technologies within the Economic Development Framework of Kigali City

The pursuit of innovation and technology has been at the core of policy in Kigali City, evidenced by the multi-term ICT policy, Smart Rwanda Master Plan(SRMP), which envisions the country as a regional innovation hub by 2020. This is anchored most importantly on Kigali City. It seeks to jumpstart the country's development status from a low income, poverty rate at 30% from 60% in 2000, to middle income economy in 2020 (Ministry of Youth & ICT Rwanda, 2015b).

The formulation of innovation-targeted and innonvation-driven master plans such as the SRMP is rooted in the understanding that what actually makes for a thriving agglomeration is diverse, beyond population. In the emergent technology-mediated economy, typically driven by cities, this entails, among other things, a strong urban foundation in terms of infrastructure, competitive human capital, ICT-enabled communities, multi-actor participation and shared/inclusive prosperity. This becomes critical when viewed agianst the background that ICT for Development(ICT4D) is enschrined in the SRMP, which specifically identifies cities as one of its seven pillars; others are smart agriculture, health, education, business and industry, finance and government, all of which have significance for the urban population. These are seemlessly-embedded in the SRMP, a component of the official multi-term Economic Development and Poverty Reduction Strategy(EDPRS); see Fig 3.2. The relevant ICT policy initiatives are discussed in Chapter 4 of this study.

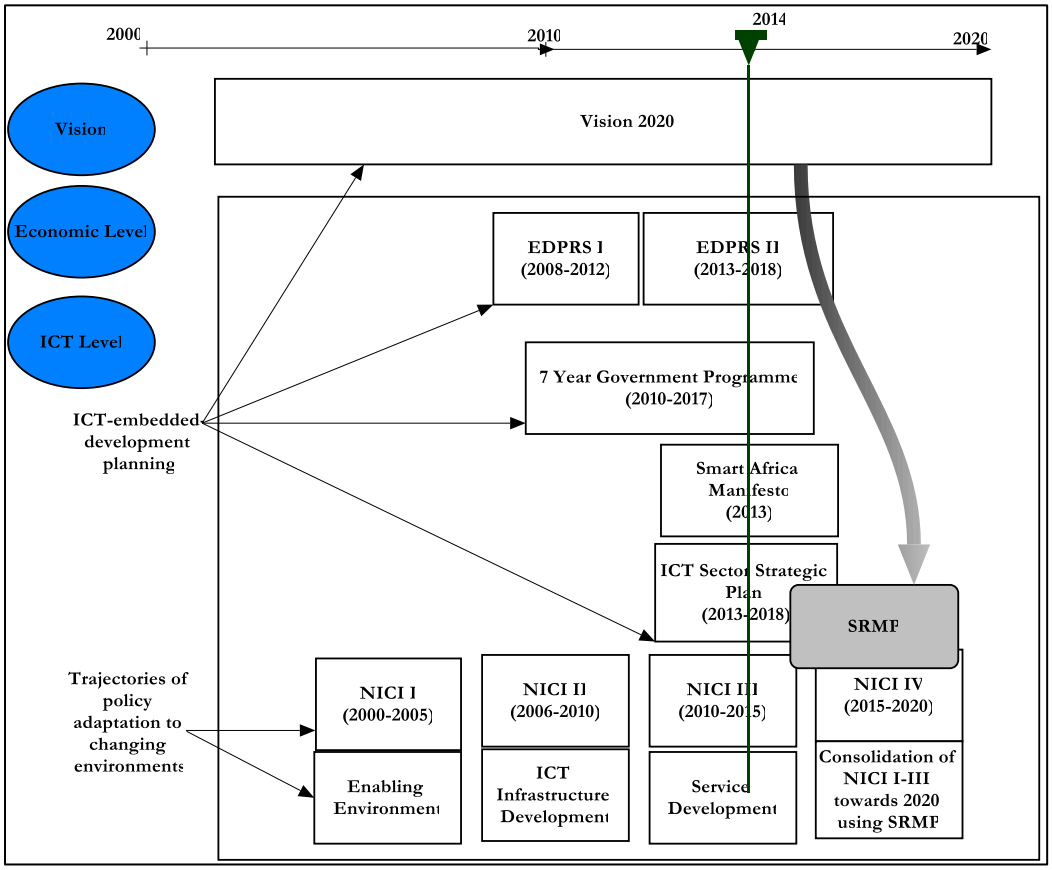

Fig. 3.2 Alignment of ICTs with Economic Development Vision and Strategy in Kigali City [4]
Adapted from Ministry of Youth & ICT Rwanda (2015b)

[4] This is adapted from a country-wide strategy. It is relevant for Kigali City, which is the key driver of innovation and seat of national policies such as National Information and Communications Infrastructure Plans (NICI I-IV).

The strive for innovation in Kigali City has been reported to have set the city on the part to improved ICT use and economic performance. Rwanda, anchored on Kiglia City, has been reported to earn a Networked Readiness Index(NRI) of 83 out 143 (World Economic Forum/INSEAD, 2015). However, the city is not a physical and socio-economic monlith; differentials exist in terms of geographic constraints, lifestyles, education and infrastructure distribution, especailly electricity (City of Kigali, 2013); also see Fig. 3.1. Understanding internal variations in the setting where all critical pillars of development are anchored on ICTs mainly forms the motivation to conduct this study of the digital divide at the intra-urban level. Therefore, it further lends credence to the use of its minimum strategic agglomerative base (sectors as SLAs) to unveil spatial differences in digital asset and use linked to the underlying socio-economic conditions and ICT policy initiatives. Being technologically-ready to reap the gains of e-urban governance and kowledge-based economy would depend on the level of equipment and performance of the city and citizens at micro-spatial levels; only then can there be an inlusive ICT-enabled city.

3.4. Data Collection and Analysis

3.4.1. Primary Data

Qualitative data was collected through semi-structured interviews administered to the telecommunication regulator (RURA), MYICT, one private operator in the telecommunication sector(Airtel), three NGOs; Rwanda Telecentre Network(RTN), One Laptop Per Child(OLPC) and Rwanda Information and Communication Technology Association/Rwanda Internet Exchange (RICTA/RINEX) working on officially-recognised digital bridge projects in Kigali. The selected NGOs were not nominated by any government agency but only verification was sought from official sources and through community projects they had implemented. Interview helped to enrich background knowledge and dynamics of telecommunications service, policies and projects from multi-actors in Kigali City ICT ecosystem. They helped to understand policy papers and other documents which were analysed.

Semi-structured interviews were in form of questionnaires and captured in audio recording to ensure no response was missed. The only exception was one case in which the respondent chose to provide written responses, owing to corporate preference and security concerns. Semi-structured interviews are flexible, and allows for a deep and rich communication(Edwards & Holland, 2013; see also Bryman, 2012). Unlike structured interviews, the outcome of these semi-structured interviews was not intended for quantitative statistical analysis. The audio recording was manually transcribed for textual citation and extraction of the underlying meaning of responses. Textual data played two key roles in the discussion. First, it helped to understand the general ICT policy environment rooted in insider accounts; as ground truthing of policy documents and claims. Second, it helped to place the discussion in context, where strong statements were made or findings were presented; for example in accounting for the constraints of policy initiatives it could otherwise have been generic or bland. Institutional analysis enables the understanding of the nature of projects, stability and dynamics of digital bridge institutions, their linkages to social activities, and material and resources committed to such projects(Madon et al., 2009). Hence the structure of the interviews was such that it reflected three components which relate to the third research sub-objective and its corresponding questions; project setting and governance(relates to nature of institutions), outcomes and challenges and prospects of UAP(relates to achievements, prospects and constraints).

3.4.2. Secondary Data

The digital access data collected for this study is based on ITU ICT access guide (ITU, 2014). Key ICT indicators were used in this case. The indicators on which data were collected (for the sector) are households who own a mobile phone(%), households with fixed land lines(%), households with computer(%), households with Internet at home (%), households with Internet at work/school(%),

Households who use Internet at the cyber café (%) and Household Internet use from other sources, not specified (%). The source of the digital KPIs is the National Institute of Statistics Rwanda (NISR), census released in 2015. Therefore, the indicators for which data was collected is relevant for the case study. The topic, that is access indicators selected and used for digital divide exploration, should fit the stage of ICT development and ICT access-order of the case study being researched(Barzilai-Nahon, 2006; Dewan & Riggins, 2005). Since Kigali City is expected to be at the rudimentary stage of digital access the basic indicators of physical access and Internet use are sufficient to explore the pattern of ownership and usage at this stage.

Socio-economic (SE) data was collected for confirmatory analysis (to ascertain the relation between ICT performance and SE and spatial variables). The SE data that was used includes youth population(%), elderly population(%), employment by status (%), employment by type(%), gender(%), education by level(%), female household headship(%), house ownership (%), improved water source(%) and electricity access (%). Spatial variables are share of total population, urban population, number of innovation centres (schools, at least secondary), natural constraints (% of sector constrained geographically), planning/design status (%). Socio-economic (SE) and establishment data (innovation centres/post primary schools) was sourced from NISR, data on geographic constraint was collected from The City of Kigali Master Plan (City of Kigali, 2013b). Age and education components could give insights into the mutual association between cognitive and social activities (especially education and learning) and ICT access, especially as regards the digital natives (millennials), who are regarded as strong agents of digitality (Prensky, 2001). Gender could help reveal the possible inequality in access to ICTs. Access to physical facilities such as water and electricity could also have some relation with ICT indicators, as equally expected of economic geographic/spatial factors.

3.4.3. Data Analysis

ICT Location Quotient (ICTLQ) was used to determine the performance of the sectors in digital access. It was computed as the share of ICT for each sector relative to city performance (see Annex, A2). This is indicative of ICT-orientation and specialisation of each sector. The overall ICT score for each sector, ICT LQ Aggregate (LQICTagg), helped to determine ICT-basic (concentration) and ICT-non-basic (sparsity) sectors. LQ is widely recognised and used in economic geographic analysis of variables to determine the relative regional performances and concentrations of such variables as employment shares and technological determinants(Burger, van Oort, & van der Knaap, 2010; Martin, 2012; Smit, Abreu, & de Groot, 2013; US Bureau of Labour Statistics, 2011). There are specific applications in Internet geographies in the frame of ICT Location Quotients (Song, 2008) and Internet Consumption Quotients (Zook, 2001), especially using domain names inventory at macro-spatial levels.

Spatial analysis was conducted using digital access based on output of cluster analysis. In relation to sub-objective one (research question 2 and 3) the spatial-statistical methods used were Cluster Analyses(CA); spatial grouping of sectors based on the digital KPIs and test of the significance of Complete Spatial Randomness (CSR) of distribution pattern of digital KPIs; which helped to establish the extent to which the observed spatial pattern is clustered. K-means clustering is widely used in spatial analysis to group observations into similar clusters such that within-group difference is minimised and between-group difference is maximised (Rogerson, 2015). Not only did the CA help in spatially defining the ICT clusters, it also became handy as a tool for determining the influence of the individual indicators the ICT spatial classification using the ANOVA F-statistics and determining cluster centres. The cluster centres give insights into heterogeneity with groups; showing which sectors are typical representatives of each ICT cluster. GIS software was used to visualise spatial distinctive clusters based on the attributes exported from CA output.

Moran's I enables the test of the extent of clustering; confirms or invalidates the assumption that distribution of ICT utilisation is completely spatially random (see Pick et al., 2015). In the case of Kigali City, the LQICTagg was subjected to test in order to determine the extent of clustering and then to establish the existence (or non-existence) of the digital divide in the city. This is based on the assumption that if the digital divide were non-existent in Kigali City the spatial distribution would be random. However, the Global Moran's I assumed Kigali City to be a single unit as it captured the global distribution of ICT access across the city; the exact spatial units or existence of co-types was not reflected at the intra-urban level. Hence, the Anselin Local Indicator of Spatial Association, LISA (Anselin, 1995) was employed to show the significance of clustering of ICT co-types within the city.

Correlation coefficients of digital KPIs and spatial-economic variables were computed to generate matrix of correlates of the digital divide. This helped to confirm the variables which are associated with digital access in the case study and aid the understanding of the underlying socio-economic and spatial contexts in which digital performance could be high or low. This does not however seek to investigate and ascribe cause-effect relationships. Given the multiple socio-economic and spatial indicators explored as correlates of the digital divide, Factor Analysis (FA) was applied to reduce the data in order to determine key factors of the distribution. The eigenvalue was set at 1 as cut-off for Principal Components (PCs) selection; the most representative of the dimensions was determined based on Rotated Component Matrix.

Policies and project analyses were conducted qualitatively based on policy documents and actors' interviews, in order to address objective 3: organised efforts at improving digital access in Kigali City. Policy initiative matrix was developed showing projects profiled using 10, mainly qualitative, attributes; Spatial Level of Conception, Theme/Focus, Geographic Target, Demographic Target, Goal, Project Typology, Primary Actor(s), Secondary Actor(s), Reported Outcomes and Challenges/Constraints. SWOT analysis was conducted covering relevant policies and projects for which data was available at the city level, otherwise national policies and projects were placed in the city context.

3.5. Ethical Issues

Interviews with regulators, operators and NGOs could be considered sensitive as they sought information on aspects of policies and projects, and actors' roles and relations. However, specific questions on cost or budgeting were not treated in this work, which made it less sensitive. In addition, sensitive questions, such as actor relations, were carefully presented and responses were not forced from the respondents. Actors interviewed only obliged to grant such interviews acting in official capacities and directives; as such their accounts were agreed to be treated as those of the group(s) which they represented. Besides, policy documents required for learning about Universal Access Provision (UAP) and plans treated were authorised and used with due acknowledgement and referencing. In both cases of interview and document use, individual anonymity was guaranteed and data considered open to the public was analysed and reported. Since disaggregated income data was considered sensitive, official indicators of well-being such as household access to electricity, tenancy and planning status of the sectors were used as proxies.

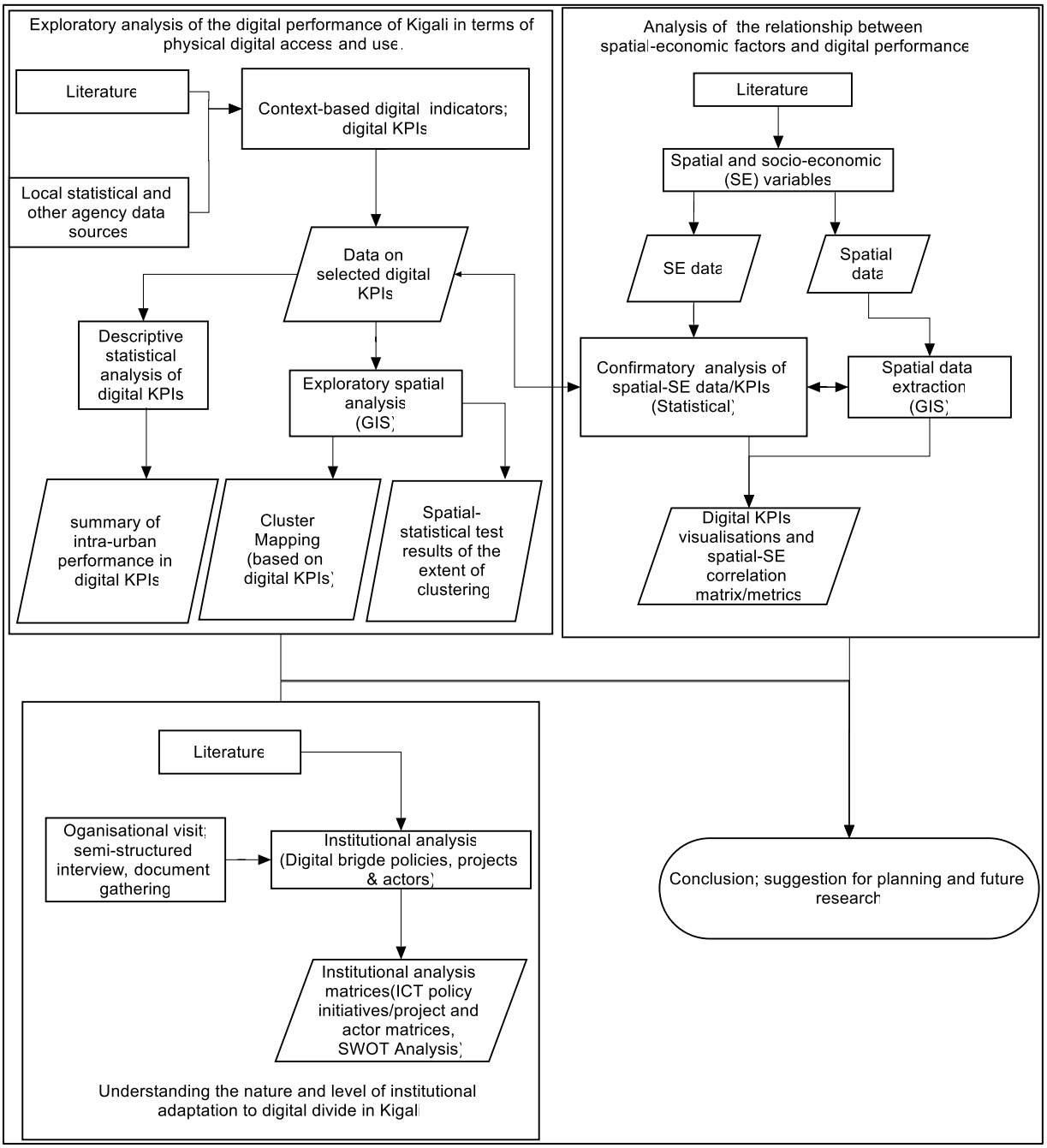

Fig. 3.3 Methodological Framework

Adapted from (Pick et al., 2015)

4. RESULTS AND DISCUSSION

In this chapter the results are presented and discussed to answer the questions on ICT performance, groupings and spatial patterns, correlates of access and policy initiatives (institutional efforts) targeted at improving digital access in Kigali City. These first two objectives of the research are addressed in the first section. The second section addresses the policy initiatives.

4.1. Digital Key Performance Indicators across Sectors in Kigali

The first subsection (4.1.1) unveils the state of ICT access in Kigali at the administrative sector level, based the analysis of selected ICT key performance indicators (KPIs) across dimensions and space. This is followed by analysis of the spatial grouping of the digital KPIs in order to describe the existing ICT clusters in Kigali City. In the later part of the section (subsections 4.1.3) the spatial distribution of ICT access in Kigali City is tested to confirm the existence of the digital divide.

4.1.1. Digital Access and Use: Physical Digital Asset Ownership and Use in Kigali City

In this section the performance of Kigali across ICT KPIs and space is presented and discussed. In its individual indicators the sectors of Kigali City maintained collectively an excellent performance in terms of mobile phone ownership as shown by 84.8% mean access score (Table 4.1). Computer ownership was comparatively low at 13.2%. This pattern of ICT asset ownership seen in the more recent communication devices is a replica of the observation found in the traditional communication assets (radio and TV). While mean percentage access in radio stood at 73.6%, there was a mismatch with TV access score, which stood at relatively low level, 37.7%. Inherently, the issue of cost and socio-economic class could be associated with such a mismatch since these assets of relatively low ownership are, by general market observation, more costly than the others.

Table 4.1 Descriptive Statistics of ICT KPIs of Physical Access/Ownership and Use (%), Kigali 2012

KPI	Mean	Std. Deviation
Radio	73.62	3.52
TV	37.71	21.68
Fixed telephone	1.11	0.68
Mobile phone	84.80	12.11
Computer	13.25	10.23
Internet (home)	45.09	12.21
Internet (office/school)	50.61	9.52
Internet (cyber café)	58.09	8.73
Internet (others)	16.86	4.53

Number of sectors (N) =35 Data on ICT Asset and Use Derived from NISR (2015)

On the indicators of connectivity and use by location, offices/schools and cyber cafés were found to be of greater access opportunities than homes at 50.6%, 58% and 45% respectively. Hence, the largest proportion of the population still relies on cyber café for Internet; indicative of a rudimentary stage of ICT access.

Access and use at the cyber café could have implications for users' convenience, privacy and cyber security. Generally, access at home and office/school should naturally be preferred. If in the collective access statistics such ideal pattern was found it could be indicative of a well-off performance and state of ICT access where convenience, privacy and personal security are guaranteed, to a greater extent. This point is rooted in the rising concerns for cyber insecurity which comes in form of malicious software, hacking/personal data theft and accidental exposure to obnoxious contents (European Commission, 2015). Expectedly, the ownership of fixed telephones maintained the least performance of all indicators. This early modern digital asset was costly and originally owned by the top socio-economic strata of society at the time they represented the latest technologies.

However, the mean digital performance statistics only show collective physical access and use. In order to spot variations within the digital KPIs, ICT performance was distributed using box plot (Fig. 4.1). This enables the summary of performance in terms of distribution around the median scores (50th percentile). The descriptive analysis is applied to spot any possible outliers in performance based on categories of indicators. Sector best performance in terms of any indicator is found in mobile ownership, though most of these lie below the 50th percentile. Although Internet access records a lower general performance than the ownership indicators of TV and mobile phones, they (Internet use indicators) maintain closer distributions around the median scores. This makes Internet use by location more homogenous than ownership of ICT assets. Hence, performance of sectors is unevenly distributed in terms of dimensions (asset ownership and use).

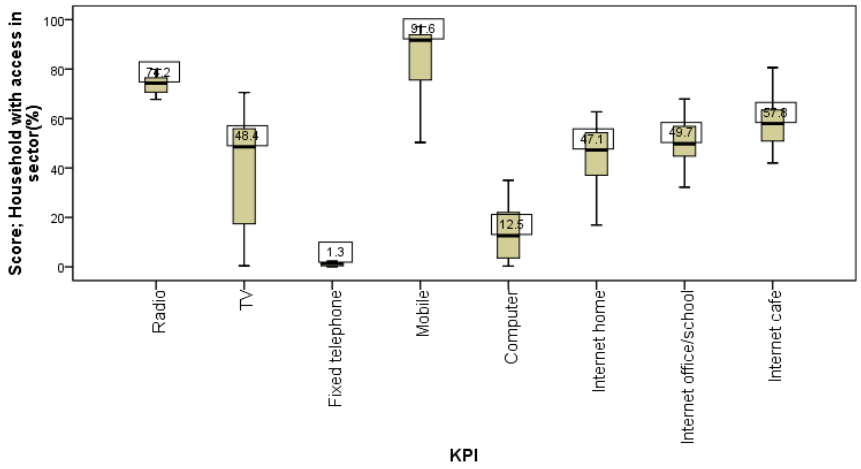

Fig. 4.1 ICT Performance of Kigali across KPIs, 2012.
Data on ICT Asset Ownership and Use Derived from NISR (2015)

The box plot becomes handy for at least two things. First, the distribution is not symmetric. The mean access score is not typical of the performance distribution of ICT indicators. Hence the median ICT KPIs scores are a better descriptive summary of performance in this case. Second, the box plot is a preliminary tool for exploring possible disproportionately performing sectors, which could be outliers (since every observation is a sector score for the focus indicator). Since there is neither a score below the 25th percentile nor above 75th percentile of any KPI this descriptive exploration by box plot detects no outliers. However, certain top performing sectors in modern ICT assets do exist. Some of the distinguished sectors are Niboye, Rwezamenyo, Kicukiro, Gikondo, Kimironko, Kacyiru, Nyabugongo and Nyakabanda (see Annex A1 for all indicators). All falls within the geographic core of Kigali City, with observable physical

accessibility to ancillary city services and opportunities such as roads, schools and shopping centres (see Fig 3.1 for Key Urban Services in Kigali). These high profile sectors maintain the lead across the digital indicators, as the relatively low performing sectors such as Gikomero, Bumbogo(north-eastern, constrained region), Kanyinya (western fringe),Mageragere and Gahanga(southern, less active axis) maintain relatively low status across KPIs.

The overall pattern of distribution across ICT KPIs and space is captured in the ICT Location Quotient (LQICTagg) stastics based on aggregation of sector scores in all KPIs relative to Kigali City aggregate across all KPIs. The top-performing sectors still remain in the lead in LQICTagg. Beyond single indicator analysis, ICT Location Quotient enables the understanding of the relative concentration of overall digital performance and by extension possible ICT base of the given sectors. LQs are dimensionless (no unit attached, derived from original percentages of ICT indicators) and indicative of ICT-orientation and specialisation of each sector. If the city performance was 1, a score above this value by a sector would obviously set the top scoring sector apart from the crowd; then such a sector is designated ICT-Basic (with a strong ICT base and concentration above reference region, Kigali City). Hence, such sectors could be designated as achievers (Song, 2008) which means in this case they have a strong ICT base and seen as relative premium spaces(Graham & Marvin, 2001) in terms of digital access (Fig. 4.2).

In Kigali City, 48.6% of the 35 sectors are ICT-Basic (see Annex A3 for status designation of all sectors). The distinctive ICT standing of these sectors is such that the emergent digital culture and economy could be spread from these hubs to the relatively less active spaces or catch up areas, which in this study are referred to as ICT-Non-Basic, with LQICTagg less than or equal to 1. They are Non-Basic because they lack the perquisite urban ICT foundation to be regarded as hubs, where innovation could spread to other sectors. These represent the areas where spread efforts (policy interventions) should be channelled accordingly, to equilibrate any observed spatial divergence in digital access.

Further discussion on ICT hubs based on multiple KPIs and the distinctive spatial clusters of Basic and Non-Basic sectors is available in the next section.

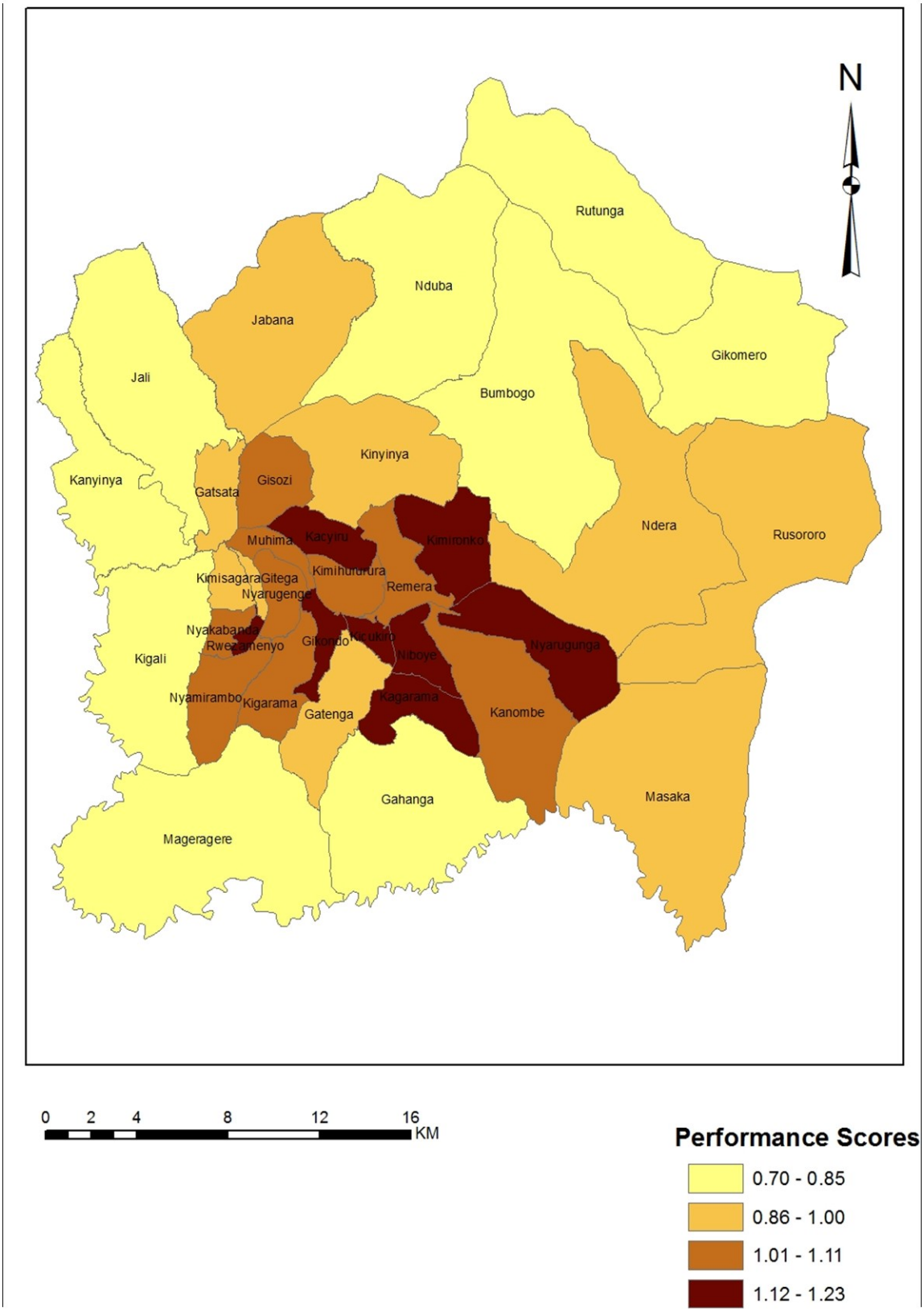

Fig. 4.2 Overall ICT Performance of across Sectors, Measured by Location Quotient of Combined KPIs, Kigali 2012

Input Data Derived from NISR (2015)

4.1.2. Information and Communication Technology Clusters of Kigali

The distinctive ICT clusters of Kigali were mapped using K-means cluster analysis. This helped to group the city into a spatial set of ICT cases with shared characteristics of all the KPIs. Table 4.2 and Fig. 4.3 summarise the characteristics of the clusters.

Table 4.2 Characteristics of ICT Clusters (%), Kigali 2012

KPI	Cluster			
	1	2	3	4
Radio	71.57	74.11	68.97	76.52
TV	12.37	47.87	11.00	56.64
Fixed telephone	.40	1.20	.33	1.78
Mobile	72.60	91.39	68.53	94.32
Computer	2.99	12.89	1.67	24.36
Internet (home)	39.89	44.03	29.57	55.78
Internet (office/school)	50.47	47.10	40.13	57.94
Internet (cyber café)	51.77	61.98	68.43	54.03
Internet (others)	18.37	14.98	16.95	17.30

Data on ICT Asset and Use Derived from NISR (2015)

Fig. 4.3 ICT Clusters/Groupings of Kigali 2012, based on K-means Clusters of KPIs
Input Data Derived from NISR (2015)
1(Medium-Low ICT Cluster), 2(Medium-High ICT Cluster), 3(Low ICT Cluster), 4(High ICT Cluster)

Cluster 1. This cluster is mainly non-core Kigali City sectors located mostly in the northern region. This cluster fares in the ownership of the traditional communication asset, radio at 71.5% in congruence with mobile phone ownership. However computer ownership which is indicative of a more recent ICT asset/resource is low at 2.9%. Households in the cluster rely more on outside (non-personal) Internet connection (offices/schools and cyber cafés) than home Internet connection. It is made up of the sectors where such other access points as mobile internet buses have a relatively marked presence on the suburbs.

Cluster 2. This is an intermediate and well-performing core-cluster of ICT asset ownership and usage. This centre-bordering cluster is typified by such sectors as Gatanga and Nyamirambo which are the closest to the central characteristics of this cluster. A shorter distance to the cluster centre (a dimensionless measure) means a stronger exhibition or embodiment of the characteristics of the focus cluster (see Annex A3, for distance to cluster centre). It maintains a relatively high performance in terms of household ownership of ICT assets (physical access), except fixed telephone which is low across all clusters. From Table 4.2, 91.3% of the households in the sectors in this cluster owns mobile phones, the peak-performing indicator of the cluster. However, mobile phone ownership is not matched with that of computer, which is equally an indicator of modern ICT asset. This is also in contrast to its performance in the traditional communication asset, radio (74.1%). In cluster 2, offices and schools remain the main sources of Internet connection and use. This does not, however, detract from the value of mobile telephone ownership observed for the cluster, since the available connection such as Wi-Fi and /or modems depend on mobile phones and computers to run.

Cluster 3. It is another suburban cluster which shares much with Cluster 1 in geography (outer zones). This cluster is made up of mainly the farthest southern and western Kigali City with two more sectors on the northeastern fringe; the Gikomero-Rusororo axis. This cluster is typified by Kanyinya and Rusororo sectors. Though Rusororo shares geographic boundary with Gikomero in the cluster, the former embodies the cluster's typical centrality, in terms of ICT characteristics of this cluster, with Gahanga which lies south of Kigali City (Annex A3, distance to cluster centre). Collectively, it is the cluster of least ICT access in Kigali City. Similar to the medium-low performing cluster 1, all sectors in the cluster are ICT-Non-Basic (Table 4.2 and Fig. 4.4). It has the least ownership of all physical access and connection/use indicators. Expectedly, it is the most-reliant on Internet café, while it performs least in home connection and use at 68.4% and 29.6% respectively.

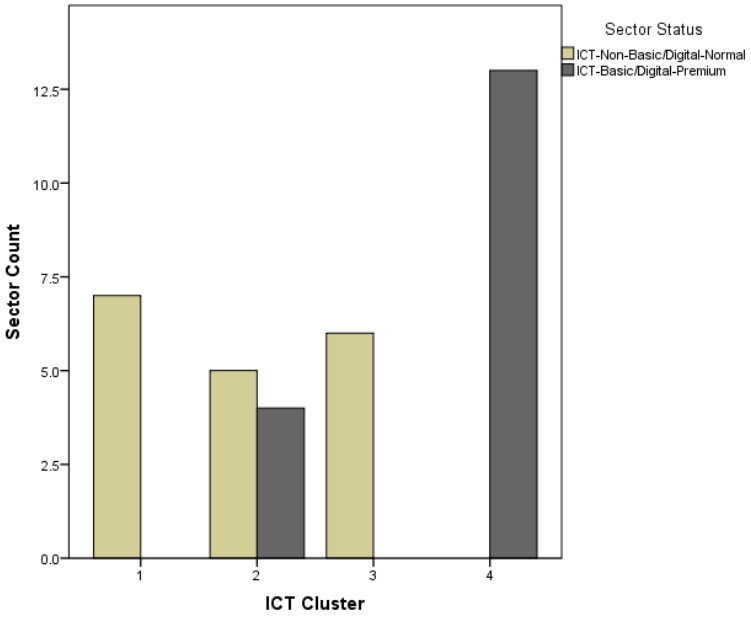

Fig. 4:4 Distribution of Status of Sectors in ICT Clusters of Kigali 2012.
Input Data Derived from NISR (2015)

Cluster 4. The core of kigali City maintains the highest level of performance across all indicators of traditional ICT assets and modern connection (from radio to home and office/school usage). Reliance on cyber café and other connection locations is relatively less than either contribution from home or office/school locations. This quality clearly distinguishes it from the other clusters where Internet connection and use in cyber café is still relatively higher than home sources. Cluster 4 equally maintains a distinctive character in terms of computer ownership at 24.3%. This cluster is typified by Kacyiru and Nyarugenge in terms of shared characteristics. Similar to Cluster 2, the high ownership of mobile telephone also corresponds to high level connection and use in homes, offices and schools. Although Cluster 2 shares similarities with Cluster 4, the latter is distinguished as 100% of sectors in this cluster (all 13 sectors) are ICT-basic compared to 44.4%(4 in nine ICT-basic sectors) in Cluster 2.

Cluster analysis, presented here, is a preliminary pointer to the role of geography in ICT access. The high-performing clusters (4 and 2) are geographic cores and economic agglomerations of Kigali City in contrast to the peripheral and largely rural regions; low-performing clusters (1 and 3). However, the distance to cluster centre (the dimensionless measure and evidence of a sector's typicality of its host cluster) enables the distinction within clusters. This shows sectors which exhibit more of the distinguishing multiple ICT indicators and characteristics of the focus cluster than others within the same ICT-spatial grouping.

The F-statistics in the Analysis of Variance (ANOVA) results (Table 4.3) show the relative influence of each ICT indicator on clustering. The traditional asset, TV contributes most to differentiating the sectors. A strong variation is also contributed by mobile phone and computer ownership at 55.1% and 79.3% respectively. This does not imply bias in the consideration of indicators and their influence but shows the indicators in which distinction among clusters is stronger. As expected "Internet others" contributes the least, which means that the classification is robust. A strong influence of "others", a vague aggregation of irregular and less significant sources of Internet connection and use would mean less representativeness of the indicators used in the classification.

Table 4.3 Analysis of Variance (ANOVA) Statistics Showing the Influence of ICT KPIs on K-Means Cluster, Kigali 2012

ICT KPI	Cluster		Error		F*	Sig.
	Mean Square	df	Mean Square	df		
Radio	90.34	3	4.87	31	18.54	.000
TV	4787.00	3	52.16	31	91.78	.000
Fixed telephone	4.33	3	.101	31	42.84	.000
Mobile	1399.09	3	25.37	31	55.15	.000
Computer	1049.59	3	13.23	31	79.34	.000
Internet (home)	1044.11	3	62.58	31	16.68	.000
Internet(office/school)	489.25	3	51.98	31	9.413	.000
Internet (cyber café)	423.87	3	42.59	31	9.953	.000
Internet (others)	16.81	3	20.84	31	.807	.500

*The F tests should be used only for descriptive purposes because the clusters have been chosen to maximize the differences among cases in different clusters. The observed significance levels are not corrected for this and thus cannot be interpreted as tests of the hypothesis that the cluster means are equal.

Data for ICT Asset Ownership and Use from NISR (2015)

Beyond categorisation of sectors by ICT indicators, cluster analysis is not an inferential statistical test to confirm the true spatial distribution of the ICT performance levels. The test of possible spatial unevenness of overall ICT performance (physical access and usage) is investigated in this study using Moran statistics. This is presented in the next subsection.

4.1.3. Spatial Pattern of Digital Access

In this sub-section the extent of clustering or randomness of distribution is analysed to test whether there is a systematic distribution of digital access based on aggregate performance (LQICTagg) using Moran I spatial autocorrelation statistics. The analysis of intra-urban distribution of concentration or otherwise of performances among neighbouring sectors(Anselin Local Moran I; Local Indicator of Spatial Association, LISA) further disaggregates the spatial pattern to explore the existence of co-types of ICT spaces.

The spatial pattern of overall digital performance in Kigali has a tendency towards clustering, measured by Moran's I (Table 4.4 and Fig. 4.5). The Moran's I statistic shows that the sectors with the highest performance in terms of physical ICT access and use tend to be co-located; as the lowest performing sectors exhibit similar tendency towards co-location. With a Moran's I of 0.44 (positive spatial autocorrelation), the distribution of digital access in Kigali City is spatially clustered. The clustering is significant at 0.01. The index is indicative of the fact that certain areas (groups of sectors) form a concentration of ICT asset ownership and use, in contrast to other areas characterised by sparsity of ICT asset ownership and use.

Table 4.4 Summary of Test for Spatial Pattern of ICT Performance of Kigali 2012, Measured by Global Moran's I Statistics

Moran's Index:	0.44
Expected Index:	-0.03
Variance:	0.01
z-score:	4.65
p-value:	0.00

Input Data Derived from NISR (2015)

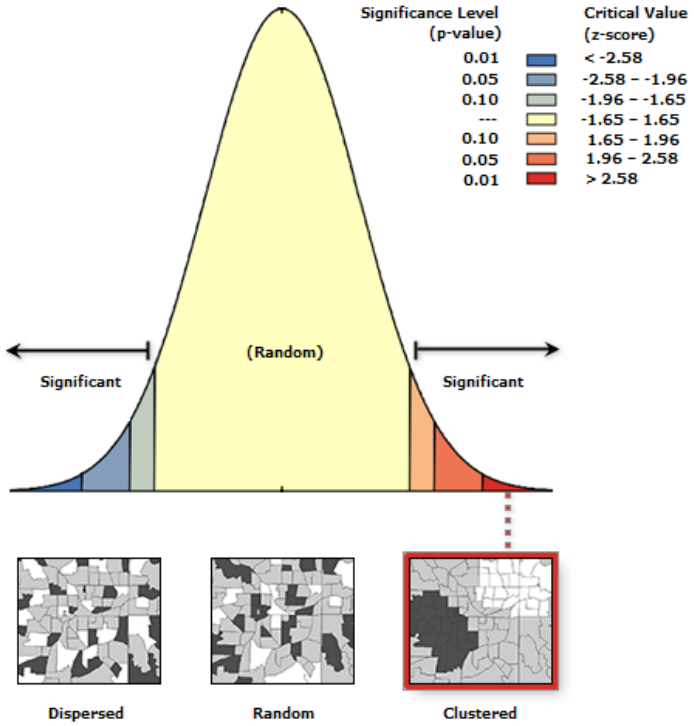

Fig. 4.5 The Observed Spatial Pattern of ICT/Digital Access in Kigali 2012, Measured by Global Moran's I Statistics

Input Data Derived from NISR (2015)

Given the z-score of 4.65(on the far right side of the tendency to clustering), there is less than 1% likelihood that this clustered pattern could be the result of random chance. The observed value is higher than the expected value. Therefore, the observed general spatial distribution of digital/ICT access is clustered.

However, Global Moran's I assumes Kigali City to be uniform as it captured the global distribution of ICT access; the exact spatial units or existence of co-types was not reflected at the intra-urban level. Hence, LISA was employed to show the intra-urban pattern of ICT co-types in Kigali City. The ICT co-types are sectors of similar performance which are also geographically contiguous. With LISA (Fig. 4.6) a pattern of ICT performance emerges within the city such that the inherent digital divide between core and peripheral sectors becomes visible.

At the centre of Kigali City three sectors: Gikondo,Kicukiro and Niboye formed a High-High(HH) ICT cluster(premium space). On the northeastern periphery of Kigali City Bumbogo,Nduba,Rutunga and Gikomero formed a Low-Low(LL) ICT cluster (less active space). The spatial clustering of ICT co-types reveals that all sectors in the HH cluster were found in Kicukiro district. This district is the next to the most populated and densest district, Nyarugenge. It is characterised by predominantly young populations; 58.1% under 25 years old while the other extreme, 60 years and above account for only 2.3% of the district (National Institute of Statistics of Rwanda, NISR 2015). The district has a relatively well-educated population; 51% with at least secondary education and has the highest proportion of population who live above poverty line, alongside Nyarugenge (see subsection 3.1.1), . The specific HH system of sectors (Gikondo,Kicukiro and Niboye) is a relatively upwardly mobile area which hosts a high percentage of foreigners. This system of sectors hosts up to 28% of all foreigners in Kicukiro district (NISR, 2015).

The basic socio-economic characteristics and centrality of the district tends to position it as an ICT hub in Kigali City. In contrast to the high profile Kicukiro ICT cluster is the co-type LL ICT cluster on the periphery of Gasabo district. This district has an age structure with a predominantly young population, 57.6%, similar to Kicukiro. However, it contrasts with Kicukiro in terms of the relative education level of the population as 27.4% of its population attained at least secondary education, that is secondary and tertiary education(NISR, 2015) compared to 51% in Kicukiro District, where the HH ICT cluster was found. The young and educated population segment is partly inductive of a trendy population. This segment has significance for trendiness of lifestyle, digital culture and awareness.

Further exploration shows that the LL ICT cluster of Kigali City lies in the geographically remote areas. This is a system of sectors with a low percentage of foreigners (jointly 0.1%) of the Gasabo district, compared to 28% for the HH ICT cluster in Kicukiro (NISR, 2015). The presence or absence of foreigners is partly indicative of the spatial attractiveness city centres. The upwardly mobile population would naturally seek to live and do business in areas with high profile economic opportunities, find residents with trendy lifestyles and language versatility, and other elements of the global culture. Modern urban hubs, especially in capital cities, are typically sponges of global exchanges and technology-mediated spaces, in contrast to remote and local spaces.

The observed spatial pattern as shown in HH/LL co-type mapping is relevant for at least two reasons. First, the significant clustering LL co-types could form the direct and immediate targets of digital policy initiatives; especially those which combine ICT provision with improvements in accompanying urban service access. The HH clusters stand out as spatially-attractive innovation centres, which could serve as hubs for innovation and technology expansion, especially targeted at business concerns and deliberate ICT cluster consolidation as part of development strategy. Further discussions on these possibilities are presented in the next section, incorporating the findings from analysis of spatial-economic correlates.

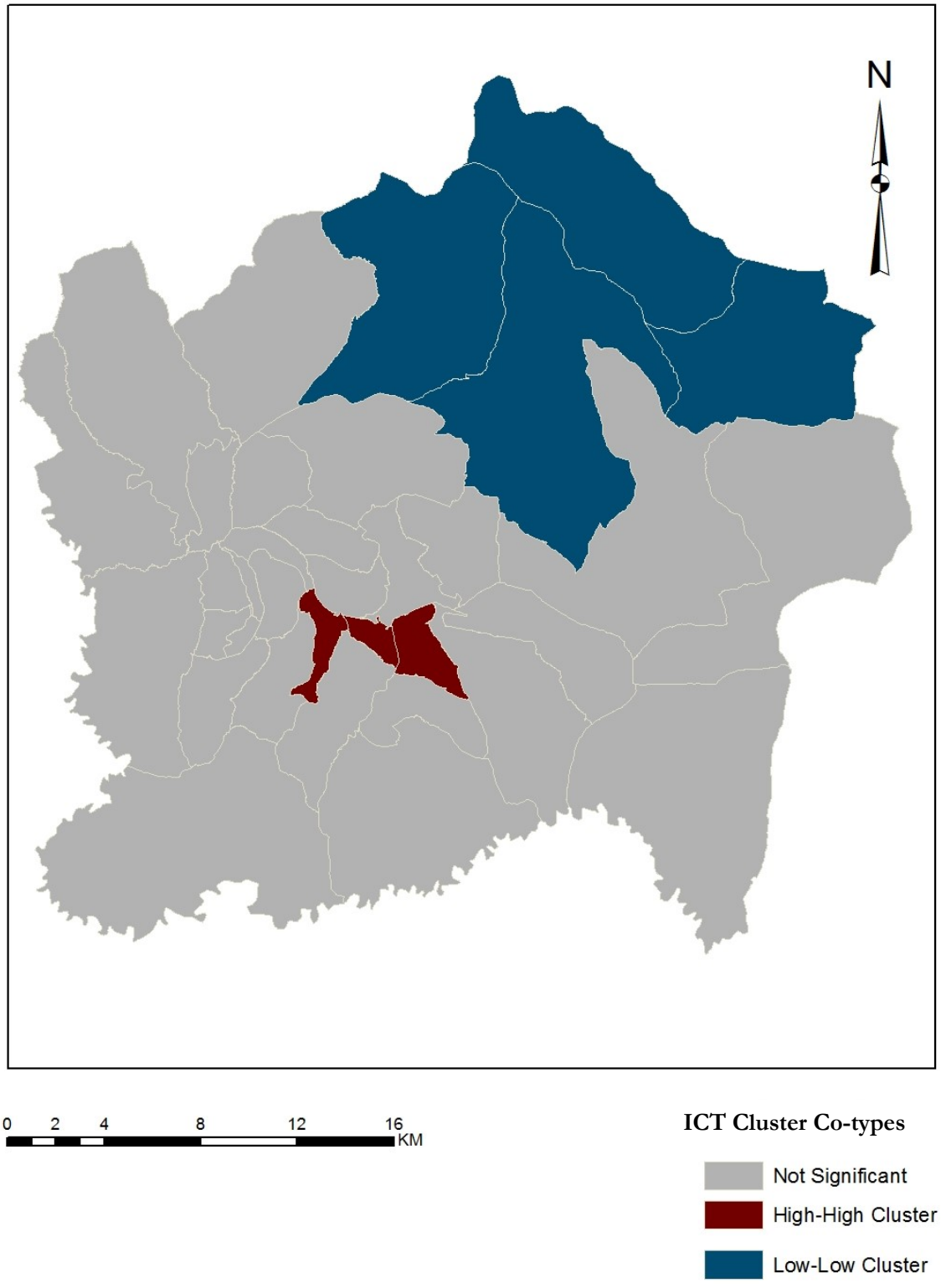

Fig. 4.6 Local Moran's I Cluster Map of Intra-Urban Pattern of ICT Access in Kigali 2012
Input Data Derived from NISR (2015)

4.2. Digital Performance and Spatial-economic Variables

In this section the relationship between sectors' performance in ICT is explored using correlation matrix of confirmatory spatial and socio-economic variables. This is rooted in the premise that digital KPIs have spatial and socio-economic correlates. The discussion on this section draws on results from spatial divergence in ICT access found earlier to buttress the point for and introduces policy intervention in its concluding part.

ICT assets were treated as a surrogate for socioeconomic material ownership for the purpose of preliminary exploration of the mutual statistical association between any pair of ICT KPIs. The two traditional communication assets (radio and TV) were found to be strongly correlated at 0.8 while each showed a statistically strong association with the modern ICT assets, mobile phone and computer ownership. This relationship is stronger between TV and the ownership of these modern ICT assets at 0.9(Table 4.5). The observation is understandable as TV symbolises a more recent development (of two traditional assets), expensive and higher social status. In the acquisition of ICT resources the sectors already atop the existing technologies would possess the newest ICT devices. This is consistent with cumulative causation process (Myrdal, 1957) whereby regions with initial socioeconomic advantage continue to dominate in the share of positive development indicators, provided the existing distribution mechanism persists. Where existing market mechanisms (driven by ICT service providers) target hotspots, which are better economically-equipped, digital inequality would persist.

Table 4.5 Mutual Relationships between ICT KPIs, Kigali 2012

	Rad	TV	Fixd	Mobi	Comp	Inthome	Intofsc	Intcafé	Intoth	LQICTagg
Rad	1									
TV	.813**	1								
Fixd	.699**	.888**	1							
Mobi	.753**	.944**	.819**	1						
Comp	.832**	.914**	.857**	.842**	1					
Inthome	.580**	.681**	.671**	.633**	.777**	1				
Intofsc	.455**	.364	.347	.401*	.611**	.674**	1			
Intcafé	-.248	-.091	-.207	-.143	-.257	-.519**	-.641**	1		
Intoth	.081	-.099	-.056	.024	.009	-.001	.147	-.292	1	
LQICTagg	.831**	.957**	.855**	.929**	.965**	.796**	.575**	-.209	.033	1

**Correlation is significant at 0.01(2-tailed).

Data for ICT Asset Ownership and Use from NISR (2015)

Ownership of mobile phone and computer was found to be associated with Internet use in homes and schools/offices. This connotes that while not all sector households who own ICT devices could be connected to and use Internet, it is also clear that where such connectivity is available in offices and schools, for instance through Wi-Fi, it requires these devices to connect and use it. Therefore physical access or ICT material ownership, and Internet connection and use are mutually re-enforcing.

Where ownership of ICT assets is high and correlates strongly with Internet connection in home and corporate locations, the relevance of paid cyber café becomes less as seen in the inverse relationship between the other digital indicators and cyber café usage**.**

The household status and socioeconomic activity of sectors are associated with ICT indicators, with some interesting relations observed. Table 4.6 shows that household headship is inversely associated with ICT

asset ownership and use. Sectors with higher percentage of households headed by females were found to perform less in ICT ownership and use. Such an inverse association between ICT performance and female status also holds for the population of females in sector and is statistically strong in terms of overall ICT performance (LQICTagg). This is indicative of a gendered structure of ICT access. Although gender skewness in resource access would ordinary be taken as usual especially in cities in developing countries, this is worth highlighting as recent studies in more developed countries posit that gender is becoming a less relevant correlate of the digital divide (Li & Ranieri, 2013). Hence, it would be logical to state that at the rudimentary stages of development gender gap in ICT is stronger; this correlate of the digital divide tends to weaken as general ICT access improves with narrowing socio-economic inequalities. However, Li and Ranieri's (2013) case was based on a direct survey; since users' responses sometimes confirm official data or exhibits dissonance, varied narratives could be found if the data used in Kigali was subjected to user (perception) survey. Such objective-subjective variances have been found in a study on urban service/infrastructure and quality of life in Ethiopia (Berhe, Martinez, & Verplanke, 2014)

Table 4.6 Relationships between ICT KPIs and Spatial-economic variables, Kigali 2012, 2013*

Variable	Rad	TV	Fxd	Mobi	Comp	Inthome	Intofsc	Intcafé	Intoth	LQICTagg
Percfemale	-.413	-.742**	-.775**	-.737**	-.678**	-.594**	-.320	.112	.139	-.719**
Urbanpop	.659**	.918**	.816**	.928**	.804**	.654**	.428*	-.081	-.126	.900**
Electricity	.672**	.961**	.826**	.953**	.828**	.658**	.318	-.032	-.120	.915**
Owner	-.528**	-.889**	-.777**	-.912**	-.716**	-.551**	-.177	-.086	.158	-.821**
Elderpop	-.450**	-.753**	-.591**	-.811**	-.567**	-.491**	-.227	-.034	.174	-.706**
Elderemployed	-.445*	-.734**	-.554**	-.751**	-.619**	-.580**	-.178	-.150	.011	-.734**
Youthpop	.678**	.954**	.857**	.933**	.852**	.685**	.369	-.097	-.081	.920**
Youthsec	.766**	.954**	.889**	.925**	.834**	.625**	.294	-.087	-.101	.897**
Youthuniv	.808**	.912**	.827**	.853**	.987**	.773**	.630**	-.236	-.037	.965**
Youthemployed	-.205	-.459**	-.450**	-.468**	-.406	-.479**	-.087	.020	-.062	-.463**
Youthemployee	.592**	.864**	.767**	.876**	.831**	.806**	.492**	-.201	-.056	.897**
Youthemployer	.252	.560**	.460**	.546**	.517**	.477**	.253	-.108	-.032	.550**
Youthselfemployed	-.505**	-.798**	-.725**	-.807**	-.768**	-.723**	-.344	.073	.076	-.817**
Hholdheadfemale	-.255	-.494**	-.347*	-.533**	-.406*	-.466**	-.348*	.038	.194	-.517**
Planned	.458**	.375	.369	.392	.606**	.519**	.645**	-.317	.130	.534**
Improvedwatersource	.583**	.767**	.683**	.782**	.712**	.457**	.357*	-.041	-.025	.752**
Geoconstraint	-.550**	-.715**	-.671**	-.672**	-.783**	-.634**	-.549**	.287	.128	-.746**
Postprycentre	.005	.133	.209	.150	.211	.261	.238	-.006	-.013	.211
Sharetotalpop	.132	.320	.090	.370*	.117	.112	-.131	.359*	-.225	.264

**Correlation is significant at 0.01(2-tailed).

Data for Spatial-economic Variables from NISR (2015); *Geographic constraint data was based on CoK (2013)

Factors of youth population and education are positively and strongly correlated with ICT performance. The association between youth population and ICT performance is statistically strong across all digital indicators, culminating in a correlation coefficient of 0.92 with overall performance based on LQICTagg. A similar pattern was observed in youth education, exemplified by youth possession of university education, which is statically strong at 0.96. These results are in congruence with earlier studies (Haight et al., 2014; Li & Ranieri, 2013; Várallyai et al., 2015; Whitacre, 2008). Higher percentages of the youth population and education mean a larger share of the digital natives; the millennials who were born into the digital age. The aspect in which the results in this study differ from Li and Ranieri's (2013) observation, which is also in line with OECD (2011), is that while gendering of ICT access matters in this study, they

found that it was becoming less relevant in explaining the digital divide. Hence the behaviour and relevance of factors are geographical case- and development stage-sensitive.

The inverse association between ICT performance and youth employment, age group 16-35, is of especial interest. This relation connotes that the sector of higher ICT performance were found to be of lower percentage of youth employment. If conducted at individual levels such relationship could call for concern. However, the relation found in this study means that the sectors with better Internet access coincide with higher unemployment levels. The reason for this relation is not far-fetched. In the context of African cities, in this case Kigali, the suburban and rural areas typically engage in menial peri-urban farming and other easy-to-start-up informal livelihood support activities which count as employment (see subsection 3.1.1). Where this is the case the highly urbanised areas with more advanced jobs, though have more employed residents, would account for less percentage of the population employed per sector or area. The phenomenon of higher unemployment levels at the city centres is could be intensified by the tendency of the continued attraction of centripetal population flows in quest of economic opportunities which are thought to be in abundance at the urban growth centres, thereby further mounting pressure on available opportunities. The problem becomes complicated as most of the new migrants into Sub-Saharan African cities, especially school leavers, who target city centres are low-skilled and remain unemployed for years (Hove, Ngwerume, & Muchemwa, 2013). The core of such cities are characterised by a small enclave of people in high profile jobs, while others are unemployed or unemployable, in an urban labour market being integrated into the fast-paced and technology-based global economy where the education system is not able to meet skills demand(Grant, 2012). This is capable of worsening the ratio of the employed to the aggregate population of the core city centres, without stripping them of their relative agglomerative and socio-economic advantages, including education, lifestyle, innovation and ICT hubs. In an independent metropolitan analysis conducted on behalf of The Metropolitan Policy Program(me) at Brookings Institution, Kneebone and Garr (2009) found that core/metropolitan unemployment levels were actually 0.9 % higher than those of the suburbs. The metropolitan areas maintained higher unemployment levels for the period in focus, 2001-2009. These corroborate the higher unemployment level at Kigali City core, even in well-developed urban economies (also see Statistics New Zealand, 2004).

Although housing indicator, planning status, has a strong positive association with ICT performance across digital indicators, housing ownership exhibits another interesting pattern. The highly urbanised sectors which recorded higher levels of ICT performance across indicators used were characterised by higher percentages of tenants. In other words, the less urbanised periphery of Kigali were characterised by a higher percentage of home ownership than the core urban areas. Again, caution is needed here. A thatched dwelling in the suburban zone, irrespective of quality (formality or otherwise of housing) is counted as house ownership. Hence, while a high percentage of the comparatively poorer households in peripheral areas of Kigali City such as Gikomero, Rutunga and Nduba may own low quality and informal houses, a high percentage of the better educated, higher income and ICT-equipped households at such Peak Land Value (PLV) areas as Niboye, Gikondo and Kicukiro would be tenants in well-planned houses. Similar to the unemployed-total population ratio, tenant-ownership ratio is higher at the city core of Kigali where ICT access is higher. This pattern is coherent with NISR (2015) where it was reported that the percentage of house owners are 28.2% and 60.2% in urban and rural areas respectively, with equivalent tenancy shares of 67%(urban) and 32.9%(rural).

In the aspect of urban agglomeration and infrastructure correlates of ICT access, sectors' urban population share, share of total population, number of post primary schools (surrogates for innovation centres), improved water supply and electricity exhibit positive associations. Electricity (percentage of households with electricity connection in the sectors) has significantly strong correlation with sectors' ICT

access at 0.91; so does improved water supply at 0.7, albeit number of post primary education centres and share of total population maintain weak associations with ICT performance of sectors (Table 4.6).

Given the multiple socio-economic and spatial indicators explored as correlates of differential ICT access (or the digital divide), Factor Analysis(FA) was applied to reduce the data in order to determine key factors of the distribution. The eigenvalue was set at 1 as cut-off for Principal Components (PCs) selection; the most representative of the dimensions was determined based on Rotated Component Matrix performance. Four components were automatically returned as suitable and sufficient representatives of the observed pattern (Table 4.7). Electricity has the strongest correlation with component 1, youth employment with component 2, share of total population with component 3 and planning status (proportion of sector planned) component 4. Although the factor grouping and representation generally performed well, only the most correlated factor with each component was selected as typically representative of the observed socio-economic and/or spatial variables and isolated for further analysis (Table 4.8). This was intended to reduce noise.

Table 4.7 Key Components in Factor Analysis of Spatial-economic Variables**, Kigali 2012, 2013*

Spatial/Socio-economic variables	Component			
	1	2	3	4
Percfemale	-.808	.234	.021	-.047
Sharetotalpop	.137	-.226	.881	-.032
Urbanpop	.871	-.232	.271	.198
Electricity	.911	-.311	.223	.053
Owner	-.850	.375	-.272	-.009
Elderpop	-.788	.178	-.439	.050
Youthpop	.925	-.312	.091	.030
Youthsec	.813	-.389	.106	.128
Youthuniv	.833	-.232	-.091	.350
Youthemployed	-.241	.908	-.053	-.093
Youthemployee	.784	-.493	.159	.268
Youthemployer	.617	-.110	.205	.076
Youthselfemployed	-.672	.618	-.164	-.262
Hholdheadfemale	-.592	-.137	-.577	-.262
Planned	.365	.024	-.145	.775
Improvedwatersource	.761	.020	.257	.262
Geoconstraint	-.755	.070	.114	-.448
Postprycentre	-.114	-.365	.341	.750
Elderemployed	-.572	.675	-.338	-.071

** In the Rotated Component Matrix rotation converged in 8 iterations. Rotation Method: Varimax with Kaiser Normalization. Extraction Method: Principal Component Analysis.

Data for Spatial-economic Variables from NISR (2015) and *CoK (2013)

Table 4.8 Typical/Representative Variables of Spatial-economic Correlates of ICT Access in Kigali 2012

	Rad	TV	Fxd	Mobi	Comp	Inthome	Intofsc	Intcafé	Intoth	LQICTagg
Electricity	.672**	.961**	.826**	.953**	.828**	.658**	.318	-.032	-.120	.915**
Youthemployed	-.205	-.459**	-.450**	-.468**	-.406*	-.479**	-.087	.020	-.062	-.463**
Planned	.458**	.375*	.369*	.392*	.606**	.519**	.645**	-.317	.130	.534**
Sharetotalpop	.132	.320	.090	.370*	.117	.112	-.131	.359*	-.225	.264

**Correlation is significant at 0.01(2-tailed).

Data for Spatial-economic Variables from NISR (2015)

Given this pattern of representative correlation, the socio-economic and spatial variables of ICT access represented were interpretatively inferred to be the following categories; infrastructure(represented by electricity),household structure/socio-economic activity(represented by youth employment),urban agglomerative strength (share of total population) and planning status/settlement/housing formality (proportion of sector planned).These key factors; electricity, employment, population and planning status were primarily used in interpretative context to unveil and confer names to the otherwise statistically anonymous PCs (Table 4.8). Observation of correlations with other variables in FA analysis validates the nomenclature. See also Pacione (2001) for this type of application in urban socio-economic grouping.

The general performance of sectors in Kigali city as shown in ICT Location Quotients, distinctive spatial grouping of sectors based on ICT performance and correlation exhibit an ICT development pattern in congruence with the classical cumulative causation model (Myrdal, 1957). This pattern of re-enforcement of existing socio-economic and spatial development in ICT performance is corroborated by Zook (2001), also echoed in Song (2008). Their unifying position is that ICT concentration or Internet users and domain names are a reflection of a city's development towards the digital economy. In this process positive indicators of digitality will be concentrated in developed regions or urban cores which already possess exceptional socio-economic and spatial development leverage.

The forgoing is instructive for the observed pattern in Kigali City at least for two reasons. First, stronger dividing factors mean that only the centres will develop into mainstream knowledge based, ICT hubs while the peripheries remain weak, less active in ICT. Second, ICT spread means that the periphery will develop, thereby reaching convergence and well-knit integration of the digital economy. However, a completely unbundled ICT ecosystem, where providers target only ICT hubs or digital-premium spaces, lacks the perquisite to reduce the digital divide, with all its corollaries of socio-economic and spatial inequalities. Hence, policy intervention becomes critical for stemming divergent factors from turning cumulative effects. Checking the strong forces of geography and demographics, (recall Villasenor et al., 2015) in section 2.3 of this report, entails employing policy intervention and collaborative instruments. In this case, the gap-closing digital interventions relevant to Kigali City are examined given their roles, spatially-and demographically-targeted strategies, their potentials for stemming spatial-economic divergence in ICT performance and engendering inclusive ICT-based city development. This is examined in the next section.

4.3. Digital Bridge Policy Efforts: Institutional Adaptation to Universal Access Provision in Kigali City

The third sub-objective of this study is to understand the nature of policy initiatives or projects targeted at bridging the gap in ICT access in Kigali (Rwanda). It is based on the primary data collected from seven

corporate actors in ICT policy and service provision (ICT policy-making organisation, regulator, operators/service providers and NGOs) and important policy documents.

National ICT Infrastructure NICI I-IV, 2000-2020 is the policy anchor of all ICT development projects in Rwanda. It is targeted at transforming Rwanda from an agrarian economy in the lower income category into an information-based economy in the middle income category in world bank ranking (Ministry of Youth & ICT Rwanda, 2015a). The NICI is a multi-year rolling ICT plan which is reviewed every 5 years. This plan has evolved through periods; 2000-2005, 2006-2010, 2010-2015 and 2015-2020(NICI IV/NICI-2020). The short-term goals have also evolved from creating the enabling policy environment to consolidation, using the Smart Rwanda Master Plan 2015-2020 as the framework (also see section 3.3; Fig 3.2 for the trajectories and integration of policies). Ministry of Youth & ICT Rwanda (2015a) succinctly summarises the efforts of Government of Rwanda (GoR) towards digital economy in NICI-2015:

> " GoR has established institutions and mechanisms to create an enabling environment for ICT development, deployed critical world-class infrastructure and is continuously developing skilled human resource base in its quest to become a knowledge-based economy and regional hub"(p. 6).

The statement has key words which connote concrete interventions. These key terms are *institutions* (in the context of this study policy initiatives or observable projects with actual goals and participating actors), *mechanisms* (activities or means of translating goals into outcomes), *infrastructure* (actual equipping of these projects, sometimes invisible, for example wireless broadband), *skilled human resource base* (especially digitally-inclined workforce and education/potential talent pool who form the foundation for transferring skills and implementing ICT policies/projects) and *knowledge-based regional hub* (indicative of the place of the innovative cities; complex geographies or network of premium/ICT-Basic Clusters).

The following subsections will help find evidence for this ICT policy initiatives and efforts targeted at promoting ICT access in Kigali City. First, the characteristics of the ICT policy initiatives are considered in order to reveal certain key elements. The main points are the projects, spatial level of the project conceptualisation and actors involved. Second, drawing on the same Project Matrix presented in this work, the next subsection is a discussion on the outcomes or achievements and constraints of the projects. Finally, building on the understanding of the ICT access and project environment of Kigali City, a SWOT Matrix is presented as a synthesis of the current condition and what is possible if all observed elements are combined in strategy.

4.3.1. Universal Access Project Setting: Nature of Projects and Actors Involved

Understanding the ICT intervention ecosystem of Kigali means finding evidence for these efforts through relevant projects aimed at achieving the overall goal of universal access and transformation into a knowledge-based regional hub, represented in this case by Kigali City. However, transformation into a regional hub means checking divergence in access in terms of geographies and demographics since a hub would naturally entail a network of spatially attractive or premium clusters. From the available data(through policy documents and field accounts account, see Table 4.9), the ICT projects in Kigali were found to be deliberately oriented towards factors which are associated with the digital divide in Kigali City; geography and demography/socio-economic characteristics. The initiatives were both spatially- and demographically-targeted to ensure the seamless integration of the peripheral areas (mainly the ICT-Non-Basic Clusters) into the mainstream ICT-based urban services and economy**.** This therefore links the ICT policy-intervention/project context to the observable pattern of access distribution and critical variables of ICT access considered earlier in this study (see subsections 4.1 and 4.2). Evidence for the geographical targeting was reflected in the accounts by the actors interviewed (see Field Interview Quote, FIQ 1 and Annex, Digital Bridge Buses).

"We have normal trainings we target rural people. Actually ICT buses do not go to the key urban areas they are intended to go where there are no infrastructures like electricity; we intend to boost skills where access to electricity is difficult somehow. We do it in two ways as per the request of the community also as per our plan. We target different groups of people like students, doctors and even the persons who are not educated. What we do is to show them how ICT can facilitate their needs by training them. We use the key people educated as trainers for others in the communities." (FIQ1, RDB)

Given the role played by geo-demographics in the ICT project strategies and orientation towards regions lagging behind the relevant projects can be described as being socially-progressive. This applies since the key projects ideally target backward areas specifically (for example RTN and Mobile Buses and RTN operation) and/or incorporates them in the overall access strategies (Access Network and SchoolNet).

Besides geographies and demographics which address distribution pattern and targeting strategy, the ICT projects surveyed could be classified into four main thematic categories; **community development, education/skills, business promotion/urban economic competiveness** and **e-government.** These thematic foci equally have relevance for the access channels examined earlier. Community development has relevance for Business Service Development Centres (BSDCs) and provision of public cyber café as an accompanying service (Ministry of Youth & ICT Rwanda, 2015a). PSD and e-government projects influence access through office channels as skills/education-focused projects have potentials for improved access through school channels while addressing digital literacy concerns.

Madon et al. (2009) recognise institutionalisation of digital inclusion projects, phrased in this study as digital bridge policies/projects, to be one in which *established structures are linked to shared symbols, supported by material resources through which social activities are promoted* (section 2.3) These elements were found to be characteristic of the Kigali UAP projects. For instance, **Irembo** is emblematic as it symbolises gateway or open access in Kiyanruwanda (Rwanda Online Platform, 2017). By this *symbol* the project has become representative of the vision and strategy of GoR to transform the country in general and Kigali City in particular into an ICT hub through digitilisation of citizen services in collaborating Ministries, Departments and Agencies (MDAs), the *established structures* of government which in turn have partner actors. It has become a symbol recognised and adopted across MDAs and shared by the citizens as a medium of modernised service develivery. Infact the number of government services on Irembo Platform, that is e-government , is one of the KPIs for benchmarking Smart Rwanda Master Plan 2020 (Ministry of Youth & ICT Rwanda, 2015b). Projects such as telecentres , OLPC computer distribution across schools and multiple streams of funding(internal and external) are some of the *material resources* through which digital bridge (access-gap closing), or digital inclusion is physically supported. These are carried out through *social activities* which are centred on digital natives/mainly millennial students (see OLPC projects in Table 4.9) and areas of relative geographic and demographic disadvantage (see RTN and Mobile Bus, for instance).

The projects involve collaboration among governmental and non-state actors with complementary roles (see Table 4.9 and 4.10). The actors in the projects recognised the existence of a collaborative ICT policy-intervention environment in Kigali City (see interview-generated accounts FIQ3-5, RURA, RICTA/RINEX, and RDB)

This project analysis gives credence to the assertion of the efforts in the policy paper (NICI) of GoR cited above on the critical components of institutions, mechanisms, infrastructure and skills as the policy interventions/projects in actual reality take these into consideration. Some of the projects are built around skills development with infrastructure provided for positive movement towards ICT-based services, albeit

with challenges observed. The outcomes and challenges of the projects are presented in the following subsection of this report.

4.3.2. Project Outcomes and Challenges

One of the research questions under sub-objective two is ascertain the achievements, strengths, constraints and prospects of the ICT access intervention projects in Kigali City. The rationale behind this formulation is that the strength of the projects could provide basis for achieving the goals or at least progress(towards the goals) while worsening of constraining aspects could limit achievements and dim the prospects of reducing the digital divide across geographies and demographics.

The ICT Project Matrix (Table 4.9) summarises the main outcomes of the interventions surveyed. The outcomes/achievements reported (policy papers and field interviews) were in line with the themes of ICT projects; mainly in the domains of Community Development (CD), education and skills, Private Sector Development and e-government. Reaching ICT-Non-Basic Communities is a strong policy focus. Since, in this study, the recognised main access channels (apart from homes) are offices/schools and cyber cafés the linking of the gains of intervention in CD projects with those of education and business improvements has relevance for the communities. All activities take place in space (communities). Activities targeted at improving access in schools and offices typically translate to improved ICT access in communities and households since these are also recognised household access channels. On the **inter-theme linkages**, for instance, it was found that the major outcome of RDB Mobile Bus/Digital Bridge Project was in awareness campaigns across remote communities while transferring digital skills through agents. In this context, CD meets digital skills, since there is a linkage between awareness campaign for behaviour change and digital literacy (education and skills) across communities through provision of mobile access points for transactions. Such activities are semi-formal and informal digital skills acquisition channels are driven by the RDB Mobile Bus Initiative and RTN. While the former achieves results through itinerant digital service provision across remote communities the latter achieves outcomes through acting as a stationed and multi-location government-citizen access intermediary mainly in ICT-Non-Basic Communities.

Inter-theme linkages were also found in the collaboration between RTN and BDSCs as access points including provision of cyber café services. Partnering with the BDSCs helps reduce cost while expanding spatial coverage since RTN does not have to build every telecentre to reach the remotest communities. This also enables it to tap the digital skills and embedded local experience of such partners, especially in communicating with and training the communities. This aspect is critical to the sustainability and outcome of RTN. It is not driven by profit, hence cost reduction is important. RTN relies on a network of stationed access centres and channels across communities. These are vital for driving the digital culture and providing diverse e-services. The services range from e-government (also working with Rwanda Online on Irembo) to e-commerce (especially Mobile Money in conjunction with telecommunications operations or their authorised trade and technical partners, see Table 4.9 and Table 4.10). Hence **innovation networks** are at the root of the positive outcomes of ICT initiatives in Kigali City (see also Gloor, 2006, for collaborative innovation networks). In the context of Kigali City, innovation networks are intricate linkages of actors across geographies, ICT-projects and themes in a policy-supported ICT environment (Kigali), which form the foundation for **positive outcomes** of ICT interventions (see Table 4.9). These kinds of linkages are vital to bridging the digital divide in terms of geography and social strata. The continued improvement of the outcomes of such innovation networks could be a strong factor for checking the divergent and cumulative forces, (recall Myrdal, 1957), which favour access in premium spaces only and worsen the already existing digital inequality and social exclusion (see other evidence of these divergent tendencies and consequent spatial patterns in the literature section on ICT for Inclusive City Development and, Digitality and Spatiality). Also refer to section 2.3 for evidence of the

instrumentality of policy-environment in improving digital access and bridging the digital divide; for example (Odufuwa, 2012; Villasenor et al., 2015; World Bank Group, 2016). This becomes clearer when placed within the context of the influence (possible or actual) of their activities on the socio-economic and spatial correlates of ICT access channels/points of households. These projects can be linked to the spatial-statistical analysis of state of ICT access presented earlier (see sections 4.1 and 4.2) considering their themes and geographic and demographic targets (relevant for the socio-economic correlates of digital access), channels (schools, firms/offices, café/BDSCs) and goals (increased ICT asset ownership and use). Also recall that the conceptual framework of this study (see section 2.1; Fig 2.1) proposes an intra-spatial unravelling of the digital divide and the underlying correlates in an environment where policy intervention could help modulate the current pattern of ICT access and these spatial-economic correlates.

Similar policy-initiative and collaborative strengths of the ICT interventions which account for the reported outcomes are shown in Table 4.9 (**Primary and Secondary Actors**) and Table 4.11(Strength component of SWOT Matrix). GoR through the Access Network project has provided fibre, across the country for easy access, especially targeted at public buildings and businesses. This has implication for strengthening the system. First, it ensures that individual operators do not have to start from the scratch in deploying broadband infrastructure which reduces times and cost required for connectivity and expansion. Given that GoR cannot deliberately force down prices (except such prices are deemed extortionate), this mechanism (ready fibre optic network) makes for easy universal coverage and reduced broadband user charges. When asked if they had influence on the rates (prices) charged by the private operators, MYICT, the parent ministry of the telecommunication regulators gave this response:

"I would say we may but we do not regulate the prices. What we do is to promote the access to Internet and it will help to increase the traffic and more revenues which is going to affect the prices, we are also encouraging the investors to invest in ICT and if there are many investors, then the price will be reduced". (FIQ2, MYICT).

Provision of material resource support was also acknowledged by one of the agency respondents. The regulator, RURA, painted a picture of favorable policy-environment for UAP (promoting ubiquitous and affordable coverage) when asked about the impact of UAP projects:

"The setup is through telecentres as I said for families that do not have connectivity at their homes they use telecenters,… there is also the project of building computers here. Its target is to manufacture the computers locally and put them on low cost. There is also the program of putting fiber optic in the districts that will help the rural areas to be connected… also with the Ministry of Education to connect the schools to the fiber…bringing the 4G penetration, coverage to the target of 70%, also the government tax free policy for ICT in order to make it affordable, the universal access is helping us do some specific projects…" (FIQ3, RURA)

A triangulation of claim (an independent account to enrich understanding, not necessarily to validate or invalidate claims) with some actors corroborated RURA's intervention efforts and the instrumentality of collaboration among the regulator, operators and non-governmental intermediaries. When asked about their knowledge of UAF in Rwanda, the actor responded:

"The universal access sits in the office of the regulator [RURA]. I know that it comes from the proceedings of the telecomm operators which are used to promote the accessibility of ICT or other projects in disadvantaged areas. We benefited from that fund last 3 or 2 years. The regulator provided that fund for the first 2 years of operations and in the third year we were able to generate our own revenues and move forward. Actually when we started we were generating money for our revenues but we were not using it, we were creating the buffer… we need to be sustainable." (FIQ4, Anonymous)[5]

[5] This quote was anonymised, even at agency level, because it was specific in terms of financial benefit received from the agency. Where no sensitive issue is raised the agency, not individuals, were cited.

"…We have other initiatives that support the policy because the Universal Access Fund was initiated by RURA. RURA was working with different telecommunication operators and they give some funds to be part of funding the projects." (FIQ5, RDB)

Ambitious ICT policies and network of actors and projects mean inevitable implementation challenges. Table 4.9 summarises the challenges/constraints. From the accounts and policy document screening these constraints manifest in the various dimensions; **Weak ancillary/support infrastructure, paucity of funds, self-exclusion, curse of multi-actor participation, inadequate skill base** and **local content deficiency**.

Ancillary infrastructure has two components; electricity and computers (including the soft sub-component). In the spatial-statistical analysis presented earlier in this work it was found that electricity is a strong correlate of ICT access across Kigali City. The triangular recognition of this factor by the three independent sources; spatial-statistical analysis (based on data from NISR), policy documents (especially from MYICT) and multi-actor interviews (governmental and non-governmental) makes it one of especial interest in the study. This is particularly strong given the fact that all ICT-intervention projects depend on electricity to function effectively, which makes it one cross-cutting constraint of ICT access and intervention projects, especially in the remote areas (see Table 4.9). The account of some of the actors interviewed in the field when asked about the main challenges pointed out power issue:

"The main challenge that we have is people but I can categorize …You know ICT infrastructure depends on other infrastructure like power. That is the challenge that we have because it is still a challenge in some rural areas, also funding in a sense we need more than what we have, also the private operator or investors that can invest in ICT, also the level of understanding of local people is still a challenge". (FIQ6, RDB)
"In general the improvement is needed in terms of infrastructures like electricity, improvement is needed in activities which must be affordable and also improvement is needed in content. Also the awareness of people in ICT needs some improvement, but the first one is connectivity." (FIQ7, RTN)

In the case of computers, where these are limiting it becomes difficult to reap the advantages of vast broadband coverage (Access Network), especially among the existing and potential participants in the Irembo Platform. The recognition of the challenge informed the strive of GoR to intensify efforts at deploying computers to sector offices, though this is far from universal availability and adequacy. Besides, this ancillary infrastructure is vital for access and use in homes, offices/schools and cyber cafés.

Funding as a constraint of any project implementation is arguably a given. However, it becomes a stronger factor where a relatively less-resourced, low-income country in Africa births the vision of jumpstarting service development into the middle-income category. The constraint of funding was well-acknowledged among the actors interviewed. This factor is naturally intertwined with and at the root of those of ancillary infrastructure or material resources required to support UAP.

From the interviews conducted **self-exclusion** was found to be a strong constraint of ICT use. According to an account by one of the ICT-CD project implementing actors the poor and less educated, especially in peripheral areas perceived ICT to be a thing for the rich only. Such an adverse perception cannot be said to be rooted in income alone but also education since a segment of the poor who have some education and are digitally-literate would at least have the motivation to use ICT services. Besides, similar demographic groups in different areas could have varied levels of motivation owing to socio-spatial network-effects or ICT-co-types such that, for instance, continued interactions with digital natives in an ICT-premium environment could stimulate interest and reverse adverse perception. A strong influence of

parents' education levels on household use and skills is documented elsewhere(see Li & Ranieri, 2013). The essence of education (combined with affordability) for inclusiveness in community-oriented ICT projects, based on a South African case, is reflected in Butcher(1998) as reported earlier in this study (see section 2.4). Hence, self-exclusion thrives with the adverse socio-economic correlates of ICT access. Similar to the case of deficient infrastructure the spatial statistical analysis part of this study corroborated this relation (See section 4.2, Table 4.6), which was equally acknowledged by ICT-CD actors.

It was reported earlier in this study that innovation networks were instrumental to the quest for bridging the digital divide in Kigali City. The various actors were found to have collaborated effectively in pursuit of the UAP-relevant projects. However, a complexity of actors and projects equally means conflicting interests even where there is shared vision and symbolic policy initiatives. This is the **curse of multi-actor participation**. In fact, the strongest constraint of multi-actor participation was associated with the iconic Irembo (owned by GoR but managed by Rwanda Online Platform in e-network of MDAs offering up to 44 services, Table 4.9). The challenges are those of perception of the ownership of Irembo services given its Public-Private-Partnership (PPP) arrangement, difficulty in reaching understanding/signing Memorandum of Understanding (MoU) with some of the participating MDAs, slowness of service digitalisation and poor interoperability among partner MDAs. While the issue of MoU is one of administration (also associated with economic motive) that of digitalisation relates to **competitive technology and skills** (see FIQ8, MYICT on the challenge of skills to explore ICT) as interoperability relates more closely to technology, internal bureaucracy and inter-agency rivalries.

"[The challenge is] in skills or citizen empowerment, the challenge is how much skills people have to explore this ICT." (FIQ8, MYICT)

The challenges of MoU and interoperability in Kigali agree with an earlier study by Criqui (2015) of socio-technical innovations in two cities: water and sanitation in Lima(Peru) and electricity in Delhi (India). Those projects involved technology adoption and upgrade in the urban utilities provision in a co-production (multi-actor) environment. While that of Lima recorded a modicum of success built on faster, less chaotic, more flexible and incentivised environment, that of Delhi encountered stifling draw backs owing to a "complex situation where public authorities compete to pass burden and responsibilities, and politicians interfered with decision-making process" (p 97). This constrained the expansion of utilities network, consequently compelling the electricity service providers in Delhi to by-pass regulation in order to provide services. In the context of Kigali City, the account of the operator interviewed (FIQ9, AIRTEL) relates more to the challenge of ensuring regulatory fairness in spectrum allocation to all operators (without politically-mediated undue advantage for some) though the efforts of the governmental actors in mass fibre connectivity reported earlier were acknowledged:

"What I know is that government sets some initiatives to make sure that all communities have access to ICT services…There is also the initiative of government where government is trying to lay fibre across all sectors of the country and it will help access to Internet… Improvement is needed in having spectrum where all operators can have the same capacity in the market." (FIQ9, AIRTEL)
"…the problem is how to bring the operators to the part of business; the best improvement to do is content because content attracts people to use ICT that is the one still on a low level." (FIQ10, RURA)

The challenge of **local content** (FIQ10, RURA) is one that equally presents *prospect*s as the development of service content adapted to the peculiar environment and need of the ICT users in Kigali means an added value. It also entails the incorporation of more services and package which are useful and usable by the citizens. RTN and RINEX/RICTA strongly acknowledged this constraint. More on the prospects of the observed condition is summarised in the *opportunities* component of the SWOT matrix (Table 4.11).

Table 4.9 Digital Access Project Matrix, Kigali (Rwanda) 2016 (Cont.)

Feature / Project	Spatial Level	Theme	Geo-target	Demographic target	Goal /Strategy	* Type	Pri. Actor	Sec. Actor	Reported Outcomes	Challenges /Constraints
Mobile Access Bridge Bus Initiative (Part of Smart Rwanda Initiative) (P)	National (*)	CD (*)	Mainly Rural/ Semi-Urban (*)	Low-income, ICT less-educated, less-equipped population (*)	Empower and transform communities through access to ICT services using mobile itineraries (*)	Gov.	RDB (*)	MYICT, RURA, RTN, WB (*)	-Increased ICT awareness in remote regions -ICT Training -empowerment of community ICT agents -Improved participation in ICT-based governance	-Poor electricity (*) -Low funding capability(*) -Poor private sector participation, in CD-oriented ICT(profitability-affordability/ universality divergence) (*) -Perception of ICT among the poor/ less educated as a service for the rich and educated(*)
Rwanda Tele-centre Network (P)	Intra-Urban/ Organisational	CD	Mainly Rural/Semi-Urban	Low-income, ICT less-educated, less-equipped population	Reduce rural-urban digital gap through public access centres where people can use Internet, acquire digital skills, access financial services and government information	NGO	RTN	AED, USAID Banks** Operators ELEC-TRO-GAZ	-Over 400 centres operational(*) -Each centre has an average of 3 employees - 100 online visitors per day -Local ICT certification -Improved ICT opportunities -BDSCs availability -Increased participation in ICT policy; 1000 Telecentres Project in NICI	-Poor electricity -Relative poor interest/perception among local people -Paucity of funds -Emergence of competitors providing training -Low literacy;, even where there is motivation to learn
.RW Internet exchange (RINEX) (P)	National	Cc	X-geographies/ Cross-geographies	Mainly corporate; High-profile users	Register and maintain domain names and internet exchange points	Joint	RITA /RDB, RICTA**	SIDA, KTH, NUR, KIST, RURA, WB, AU, UNDP	-Over 11 providers peered -Maintenance of local Internet back bone for shared route server to facilitate new entrants -Improved interface speed, up to 100 mb-1g/s Ethernet -Improved reachability, connectivity solution and Internet user experience due to proximity to end-users -Affordable domain names, even for personal and SME users, as low as 4USD/year -Integration of local content	-Low level of ICT immersion in education and corporate services(*) -Poor understanding of the sector among well-resourced investors who could be financiers(*) -The issue of doubts among actors, including citizens that "it can be done"
EduNet/ School-Net (P)	National	SD	X-geographies	-Mainly primary school children (case of OLPC/ SchoolNet) -All education levels	-Inculcate ICT usage at early life stages through increased access at all education levels	Gov. PPP	MINEDU	OLPC, POSITIVO	-56, 000 laptops: 113 pri. schools -Students' competitiveness -Device cost savings for schools: recycled equipment -100 % tertiary schools connected. -Domestic computer assembly POSITIVO	-Poor access to electricity in schools; -Many primary schools, up to 80% depend on the headmasters' personal phones for official communication - shortfalls in technical support -inadequate funding to meet demand

Table 4.10 Digital Access Project Matrix, Kigali (Rwanda) 2016 (Cont.)

Feature / Project	Spatial Level	Theme	Geo-target	Demo-graphic target	Goal/ Strategy	* Type	Pri. Actor	Sec. Actor	Reported Outcomes	Challenges /Constraints
IREMBO Rwanda Single Integrated e-govt Platform (S)	National	e-gov	X-geographies	Cross-demo-graphics	Provide/promote open and fast single platform access to government online services	Gov.	GOR** Rwanda Online Platform Ltd	RTN	-44 services available on Irembo - More than 432 Irembo centres -Improved e-gov efficiency (reduced citizens' document processing time and crowd) - ICT service solution through PPP mechanism: reduced running cost -Stronger motivation among MDAs for service digitalisation	- Unreliability and unavailability of Internet access, in remote regions (connectivity /speed) -Inadequate number of computers in MDAs -Erratic electricity -Limited awareness of services among citizens -Difficulty In MoU with multiplicities of agencies targeted; poor interoperability among MDAs -The burden of training multiple MDAs in the specialised, sophisticated and recent e-services -Delay in payment digitalisation among MDAs: politics, motivation and technical capacity
Rwanda Access Network (S)	National	PSD	X-geographies	Cross-demo-graphics(mainly commercial /government offices; public buildings including schools and hospitals)	Extend Internet access across country to bridge digital gap between backbone nodes and end-users' premises by means of fiber optic or wireless broadband (WIBRO)	Gov.	MYICT, RDB	Operators, RURA	-Estimated connectivity of at least 40%;key public end-users targeted as at 2015 -Extended broadband connectivity; up to 2,300 km -Improved corporate digitality -Increased mobile penetration; up to 31.5% (2015), 5.3% (2010) -At least 38% broadband presence: MDAs -Increased innovation and start-ups; up to 71 (2015) -Increased operator revenue streams -Broadband price reduction following universal deployment	-Fund -High-end technologies deployment amidst relatively less technologically-inclined workforce, especially in public sector

Data for Project Matrix from actors' accounts (2016) and MYICT (2015)

(*): Information derived from the designated agency interview(s)/project experience account (Field Interview Quote, FIQ), distinct from policy/strategy papers.

X-geographies: Cross-geographies; spatially non-discriminatory/rural and urban,

**: Various; for example, in the case of financial services, multiple banks involved.

*: Classification based on primary actor, goal and operational modalities ,

(P): Primary focus during field work; key/primary actor(s) directly and formally interviewed during study,

Cc: Cross-cutting, CD: Community Development,

SD: Skills Development, (S): Important service/initiative but key actors not directly and formally interviewed,

e-gov: e-government

PSD; Private Sector Development, Pri/Sec Actor: Primary /Secondary Actor

Table 4.11 Digital Access Key Actors in Kigali (Rwanda) 2016; Main Role and Mechanism

Actor	Role	Mechanism	Relation
MYICT	Policy formulation	Strategy/paper work/envisioning/target-setting	Direct with RDB, RURA, OLPC; others indirect
RDB	Digital bridge project design & implementation	Wi-Fi/public access facilitation, internet-enabled mobile buses mainly targeted at fringes, training of key community digital literacy agents(future trainers)	Direct with MYICT, RURA, RTN, AIRTEL; others indirect
RURA	ICT service regulation	Standard setting , enforcement, spectrum allocation, QoS and contributory commitment from operators and intermediaries	Direct with MyICT(agency under MYICT), AIRTEL, RTN, RINEX/RICTA; others indirect
AIRTEL	Telecommunication service provision	Individual user and corporate service, technology deployment, physical expansion, content development, innovation	Direct with RURA, RTN, RDB; others indirect
RTN	Government/operator-community intermediary	Establishment/recruitment of multi-purpose telecentres, community awareness creation	Direct with AIRTEL, RDB
RINEX/ RICTA	Internet gateway/access point data management/data exchange	Domain registration, multi-operator data warehouse/exchange	Direct with RURA, AIRTEL, MYICT
OLPC	Child/School computer delivery and instrumentation/training	School-to-school delivery, Children's content development and customisation	Direct with MYICT (also closely with MINEDU on SchoolNet)

Data for Role Specification Derived from actors' accounts (2016)

4.3.3. Possible Policy-Initiative Measures from the Current Analysis

SWOT matrix is presented in Table 4.11 It is a sorting of the strengths, weaknesses, opportunities and threats (based on the integrated ICT ecosystem analysis of Kigali City) into concise and workable groupings. This is intended for a deeper understanding of the challenges and prospects of digital access performance improvement. It is possible to draw on the observed situation for potential policy choices and the sustainability of the digital access gap-closing initiatives. Hence, the primary SWOT components can crystallise into prospects in strategic combination.

The basic features of the thriving ICT-enabled urban services are currently found in Kigali City. This has commenced with policy formulation to inspire the need for individual and organisation change to fit with emerging digital culture. Naturally, the mass mobilisation, connectivity, multi-actor co-optation and long-term ICT-project resourcing have given the vision of a regional ICT hub and transformation to a knowledge-based economy a tangible expression in form of projects.

However, the current and possible challenges in these mass ICT access initiatives in the quest for digital transformation are enormous and have been sorted into weaknesses and threats. Challenges may appear vague and difficult to spot. By sorting seemingly chaotic challenges into groups of the typically internal and external factors (see SWOT Matrix, Table 4.11), information becomes coherent for problem-solving and strategies. In challenges lie prospects as long as observed weaknesses and strengths are optimally combined with opportunities and threats in problem-solving for sound policy choices and sustainability. These possible combinations are documented in the SWOT matrix which shall be explored further in proffering recommendations at the later stage of this report. This tool (SWOT matrix) is particularly unique and effective as it enables deep sensing of the ICT-project environment and specific-system-generated inputs for policy and research rather than generic strategies drawn from unrelated cases; hence it is relevant to the problem context and geography.

Table 4.12 SWOT Matrix for Digital Access Policy-Initiatives in Kigali (Rwanda) 2016

Internal Factors / **External Factors**	**Strengths (S)**	**Weaknesses (W)**
	- Growing revenues from start-ups and scale-ups as well as e-gov. and urban development services on Irembo Platform -Well-articulated policy initiatives -Established MDAs as ICT policy channels -Emerging/dynamic operators -Access network; Broadband foundation -Responsive workforce; open to innovation (across regulatory, operating organisations) -Deep understanding of policy initiatives among ICT-actors -Basic/baseline data on ICT KPIs access available for performance Monitoring & Evaluation(M&E)	**-**Top-down initiatives/bureaucracy; inefficiency/slowness; ICT policy initiatives conceptualised at national levels in all but one case -Inadequate power supply for service support -Slow broadband speed -Inadequate self-funding capacity; over-reliance on development partners -Shortage of digital assets in MDAs to support innovative ICT platform; case in point Irembo -Shortage of high-profile human capital and skills to domesticate technology transfer -Conflicts: Challenge of MoU and interoperability among MDAs -Deficiency of local content -Relatively poor UAP initiative understanding and immersion among operators -Target KPIs not aligned with official/NISR key ICT KPIs
Opportunities (O) -Robust innovation networks -Dominance of youth population; digital natives -Presence of policy support; SRMP/NICI, ICT/Computer-related items production tax exemption -Cross-cutting adoption of ICT across MDAs; public service digitalisation through symbolic projects -Growing/mass adoption of WIBRO; Relevance for affordability -Technology & skills transfer; local/foreign development partners -Funding from external sources(WB and others)	**SO-Strategies/Policy Measures** -Use well-established regulatory, policy initiatives and organisations to co-opt and educate operators on UAP -Tap potential of the digital natives by launching more channels supported by cutting-edge operators -Use the Access Network, increasing digitalisation, pervasive ICT adoption to keep digital culture well-resourced and embedded -Stiffen the competition(beyond the current monopoly of computer assemblage) in hard components manufacturing using the instrumentality of existing tax incentive -Ensure precise geo-based mapping of project opportunities using available baseline data; away from present generic geo-targeting	**WO-Strategies/Policy Measures** -Resource the projects through sustainable revenue capacities of the innovation networks -Stimulate operators to participate more in local ICT/UAP initiatives by continued enlightenment on initiatives and long-term returns on investment -Loosen the top-down/bureaucratic practices to accommodate the perspectives of local MDAs and Non-State Actors early; obviate MoU tussles. -Consolidate the increasing mass adoption and digital natives/EduNet for future talent pool, technology retention and sustainability -Combine the possibilities of improved resource and talent bases to scale up signal strength and speed -Profile future opportunities in line with base data for robust M&E and policy-initiative relevance to need
Threats (O) -Dissatisfaction among partners with MoU and the risk of contagious disaffection among targeted users, especially citizens -Growing relevance of secondary cities in Rwanda; risk of GoR and partner investment/funding switch from Kigali City -Affordability-profitability divergence; operators' profit target determined by external forces(executives and trends) -Over-reliance on external partners; stiff competition from other LDCs -Proliferation of informal activities; difficult to integrate into platforms -The self-excluding segments of the population; adverse perception	**ST-Strategies/Policy Measures** -Consolidate shared culture and policy initiatives to enlighten self-excluding citizens -Keep partnership with operators to widen connectivity and uphold downward price trends; avoid demotivating operators by direct price regulation -Use heavy presence of enlightened, committed and dynamic workforce who are also well-versed in the local culture to reach and enlighten the locals	**WT-Strategies/Policy Measures** -Ensure poor QoS does not result in users' paying for service not rendered; implication for affordability -Decentralise system to enable local authorities and intermediaries conceptualise ICT-initiatives and integrate the mainly informal activities into the platform -Encourage more local operators for community/regional/ small scale services for deeper local knowledge, better content development, affordability and less external influence on profit target

Data for SWOT Analysis derived from actors account and MYICT (2015)

5. CONCLUSIONS AND RECOMMENDATIONS

This chapter draws on the findings and discussion presented earlier to conclude on key objectives of the study and contributions to existing research, policy implications, and reflections on limitations and scope for future research.

5.1. Conclusions

This study explored ICT access in order to establish the digital divide in Kigali City. The research was placed within the context of spatial and socio-economic correlates of digital access and the role of policy intervention in improving access. Hence, it adopted a mixed method of analysis; Quantitative-qualitative Method. In order to establish the existence or otherwise of the digital divide it examined the digital key performance indicators of ICT asset ownership and use by location. It presented a spatial grouping of indicators, explored relations with correlates across space and tested the spatial pattern of overall performance. Key projects targeted at universal access were examined to find evidence for policy efforts.

The digital divide does exist in Kigali City. It is manifested in two ways; ICT access dimensions (assets and use by location) and space, both embedded in existing socio-economic conditions. The study reveals the dominance of household ICT asset ownership of TV and mobile phones. Internet use by location (home, offices/schools, cyber cafés and others) does not match physical ICT asset ownership. Such a mismatch represents dimensional digital divide (subsection 4.1.1). Of all Internet access outlets, cyber café still remains dominant. When this is added to the fact that Internet use is less than household ownership of assets required for Internet it becomes clear that the Kigali City is at the rudimentary stage of digital access. On spatial-digital divide, Location Quotient analysis shows administrative sectors with ICT utilisation concentrations, the ICT-Basic sectors, which account for 48.6% of all 35 sectors of Kigali City. The spatial grouping of the city into clusters reveals one dominant and high performing cluster at the core of the city, the Kicyiru-Nyarugenge region, 100%-composed of sectors of ICT-Basic status. Still within the core, but westwards, lies the intermediate and medium-high performing cluster, composed of a mix of sectors of ICT-Basic and ICT-Non-Basic statuses. Two clusters of medium-low and low performance are found mainly in the north-eastern and south-western peripheries of Kigali City, represented by Bumbogo-Rutunga-Nduba and Gahanga-Kanyinya regions respectively. The overall access performance, using aggregated Location Quotient, shows that the spatial distribution of ICT access and use is significantly clustered. This test indicates the existence of the digital divide in Kigali City. Further analysis using Anselin LISA/Local Moran's I has enabled the identification of specific co-types, High-High clusters at the core and Low-Low ICT clusters at the northeastern periphery; thereby revealing the actual intra-urban digital divide. This gives insights into areas that are favourably-inclined to ICT and are well-resourced to acquire emerging technologies; with potential for playing a key role in the technology-mediated urban services while others lag behind. Such disproportionate spatial concentration of ICTs corroborates earlier findings in digital divide studies (Nishida et al., 2014; Pick et al., 2015; Song, 2008; Zook, 2001).

Based on the results it is concluded here that geography and socio-economic conditions do play significant roles in ICT access of the city. Analysis of spatial-economic correlates of ICT access in Kigali indicates that existing conditions which typically underscore the distribution of urban services and opportunities are replicated in this context. Principal factors associated with access are the existing infrastructure (typified by electricity), socio-economic activity (employment), agglomerative strength (share of total population) and planning status or settlement informality (proportion of sector planned). Besides, gendering of access is still significant in Kigali City and should be taken into consideration for demographic targeting, at variance

with a recent observation of less significant gender correlate of digital access in response to narrowing gender gaps (see Li & Ranieri, 2013), albeit their investigation was based on direct user survey. Therefore, in ICT access, the significance of gender, a typical socio-cultural construct, varies with the case under investigation.

The policy initiatives are anchored on National Information and Communication Infrastructure Plans. The research finds the ICT policy initiatives to be rooted in innovation networks of actors working across themes and geographies. Key actors are MYICT (policy formulation), RDB (implementation), RURA (ICT market regulation), Airtel and other operators (service provision), OLPC, RTN, RINEX (not-for-profit ICT intermediaries) and Rwanda Online (e-government solution partner). Most of the projects are socially progressive, based on the accounts of the actors and official documentation, as they are mainly geo-demographically-targeted at ICT-deficient clusters. However, they are challenged by poor electricity, paucity of funds, low-level local skills pool to domesticate and/or develop technology and content, and self-exclusion tendencies among certain segments of the target population. With these institutional characteristics, in line with Madon et al. (2009), the efforts at closing gaps in ICT access in Kigali City are institutionalised; they are built on structures linked to social activities and materially-resourced, in a policy-supported environment. The key gap-closing institutions, mechanisms and resources are being adaptively applied to bridge the gap in ICT access evidenced by a change-driven and change-driving ICT master plan, with tangible expressions in projects, albeit mainly conceived at the centre.

In addition to the contribution to the study of the digital divide at the **micro-spatial level or intra-urban scale**, this study applied robust spatial pattern/distribution test to establish the existence of the digital divide in Kigali. This contributes to existing research on the topic in two ways. First, it is an **objective investigation of spatiality and digitality**; that location or geography plays a role in digital access and emerging technology-mediated urban culture, service and economy. The physical-spatial divide replicates itself in cyberspace, in form of the digital divide. This contributes to the ongoing debate on the spatiality of technology-mediated urbanism (Graham, 2011, 2015; Graham & Marvin, 2001). It draws from and redounds to the multi-disciplinary theoretical and methodological perspectives on technology and the city; the spatial-econometric thinking of technology use, innovation and the networked economies (Arribas-Bel et al., 2015; Johansson et al., 2007). Second, the core of spatial analysis is to establish the local patterns that actually exist, beyond what seems to exist (Anselin, 1995). As most studies typically focus on the description of the digital divide and socio-economic correlates (see section 1.1), the present study redounds to recent efforts(Nishida et al., 2014; Pick et al., 2015; Tranos et al., 2014) at **spatial testing of the actual patterns of digital access** that do exist in the case in point. Given that the phenomenon (object of analysis) occurs in space, this study has added concrete spatial context to the discourse on the digital divide, beyond demographics and abstract statistics. It incorporates and addresses **the where component** and **spatial interdependence** of the digital divide.

Furthermore, at a time when multidisciplinary approaches and mixed methods are gaining ground, this current study contributes to the Quant-qual research community. The contribution is linked to the research findings and insights that are rooted in empirical quantitative analysis (**state/pattern and underlying factors of the digital divide**), while incorporating qualitative analysis of problem context in aspects that entail exploring policies, projects, actors and situated issues in bridging the digital divide (**policy response**).

Beyond methods and perspectives, the study contributes to understanding and incorporating **emerging dimensions (ICT asset and use) of urban inequality**, an issue of especial significance to the social and spatial sciences. It contributes to conceptualising unequal access with focus beyond traditional urban infrastructures, services and opportunities. This point is cogent in view of the increasing role of

information and cyberspace in modern urban services and daily life, in which old inequalities are being replicated.

5.2. Contributions to Policy

This research has implications for planning, policy and research. The spatial analysis of ICT access in Kigali City provides scope for understanding ICT opportunities at the intra-urban levels. Hence, it can help planners, policy makers, providers and project development partners recognise the need and subsequently integrate ICT dimensions with traditional planning and provision of urban services. It therefore recommends that standards be developed for incorporating access network into building design from the beginning in planned residential and public buildings, including schools. This means in the emergent digital economy and e-urban services, it should be considered an irreducible minimum integrating ICT access with planning for physical infrastructure, fibre access network and public spaces. Internet access points are a tool for digital inclusion and should be incorporated in the design of new public spaces and/or review of existing ones to ensure access across space and groups since the cyber space is fast becoming the new public space. This kind of integration becomes critical when viewed against the background that digital indicators and policy initiatives analysed here confirm that existing infrastructure access and socio-economic strata are correlates of ICT access.

The study is of especial relevance to urban space-based policy as it disaggregates ICT access, at intra-urban levels, a further research effort previously recommended in the literature (Pick & Nishida, 2015).The current study is a Spatial Level Analysis improvement on the existing studies at national and regional scales (see section 1.2). Hence, beyond generalised national and regional analyses for macro-spatial policy, the ICT-deprived within the city can now be targeted by local authorities. Besides, premium ICT clusters can serve as the hubs for driving innovation and spatial attraction of the private sector operators while the less penetrated clusters become priority targets for ICT interventions and niche markets for the operators. This contribution has been made possible by the application of the Local Moran I, which disaggregates data and spots the target clusters of concentration and sparsity. These inherent spatial disparities in ICT performance would seem non-existent with descriptive statistics and visualisation. The research therefore provides scope for evidence-based ICT-intervention programmes. Intra-urban disaggregation of ICT-indicators can be used for future panel data analysis for policy performance assessment. Taking the current study as the baseline, ICT performance monitoring can track the trends to ascertain how ICT-Non-Basic sectors or clusters improve overtime. This is relevant for ICT-Project Monitoring & Evaluation by such agencies as RDB, MYICT and RURA.

Interoperability needs to be considered for policy focus as regards ICT performance indicators. This will entail integrating the household access indicators (available at National Institute of Statistics, Rwanda) with official and broader key performance indicators of ICT policy (at Ministry of Youth and ICT, Rwanda) in goal setting and monitoring. This is currently amiss and disjointed.

The issue of affordability was frequently recalled during the survey of policy initiatives. This is a complicated case since the regulator has no power over pricing. It is recommended that the ongoing mass connectivity, tax exemption for computer and ICT equipment producers and assemblers be intensified. However, the current dominance of a single computer manufacturer lacks the potential to reduce price. Hence, it is recommended that local and smaller players be motivated even if at regional scales to bridge the gap, obviate the situation in which external forces play significant roles in setting private sector goals and determining prices. In addition, it was found that the operators were comparatively less aware about the policy initiatives than any other actor, thereby obfuscating the affordability/universality-profitability divergence. It is therefore recommended that operators be specially informed about government ICT

visions and projects, in order to have them key in to the initiatives, using various incentives such as low-cost sites and fast tracked permit in ICT-Non-Basic communities. This has potential for long-term affordability since it is agreed and expected that incremental investments and ubiquitous broadband access would force down prices.

Furthermore, the tendency of self-exclusion among some target groups, found during policy initiative analysis, goes beyond quantitative geo-demographic correlates of ICT in research, policy-making and project implementation. This gives credence to the value of the mixed method (Quant-qual analysis) applied in this study. Such factors as level of education, electricity and population can be more easily identified and quantified from census data. Conversely, the tendency for adverse perception that ICT is designed for the rich and educated (self-exclusion) is better captured qualitatively. Hence understanding this aspect through qualitative problem detection for targeted awareness creation could redound to the outcomes of policy initiatives.

5.3. Limitations and Future Research Directions

This study set the goal of analysing digital access at an intra-urban level to check that there is a divide associated with socio-economic and spatial correlates amidst institutional efforts to improve access. Though it has achieved this goal, which could aid space-based ICT policy initiatives and research, it aggregates household data based on National Institute of Statistics of Rwanda (2015), with its typical census data publication time lag and has not considered ICT access at household or individual levels. While it shows variations within urban spatial units and serves as an improvement on the existing macro-spatial studies, further intra- spatial variations (finer Spatial Levels of Analysis, SLAs, than the current SLA) are equally important and should be explored to reduce the risk of ecological fallacy: assumed evenness of access within each spatial level of analysis.

Another limitation, which is tied to data availability, is the absence of time-series data that could have enriched the research in terms of spatial-temporal analytics. This could have helped to understand the changing geographies of ICT-penetration over time. However, this study, having not found any such synchronous data at the intra-urban levels, becomes the foundation for future space-time ICT research in Kigali City.

The third limitation is the type and diversity of ICT indicators. The indicators agree with the existing census data and are in line with the current level of ICT development of Kigali City. However, elements of user-professed motivation or barriers to access such as affordability, digital skills, cyber security concerns and regulatory restrictions on use and content could be treated. These were mitigated, indirectly, by actor interviews through which affordability and motivation elements were revealed. The studies of these elements are important in order to understand behavioural aspects and find possible objective-subjective mismatches; possible users' contentment amidst officially-reported/census-based low access performance or dissatisfaction amidst census-based high access performance(Berhe et al., 2014). Besides, the actual activities of the users can be explored. However, embarking on a user survey means the spatial coverage of all 35 sectors of Kigali, the original design of the research, is unfeasible within the current research framing and timeline; hence the trade-off between spatial-demographic coverage and dimensions of ICT KPIs. Besides, the alternative source of big data for micro-spatial and broader KPIs, which is mobile phone service providers, is typically expensive, if ever made available. The hording of such data is mainly due to competitive market intelligence and regulatory concerns among the operators.

Overall, in those limitations lie prospects for designing future ICT utilisation research. A realistic research proposal recognises that not all constraints can be fixed in a single study. One of the possibilities is to

explore finer levels, trading off some indicators where data is limiting. It is also possible to accommodate more indicators at finer levels using primary data survey, where secondary data is limiting, but with spatial coverage trade-off. Another possibility is to consider indicators in space-time analytics to monitor ICT-cluster status change taking the current work as a baseline, trading off some indicators and finer levels. On the part of digital bridge policy analysis, there are also opportunities. Further analysis should map the actual spatial pattern of the ICT programmes and investments. Another policy research potential is the analysis of ICT policy performance; tracking trends, drivers and emerging challenges overtime. As research builds the body of knowledge with the development and application of improved technology and methods more could be achieved across space, time and dimensions.

Certain aspects of the qualitative data used in this study need to be placed in context. Actors' views were limited to their knowledge of the existing condition and possibilities of ICT in Kigali City at the time the fieldwork was conducted. In addition, their personal and/or organisational standing on the issues being discussed could also have had some influence on their responses, within the circumstance and manner in which the questions were presented to them. However, seeking similar answers from respondents who belonged to different groups (triangulation of actors' responses) helped to ensure diversity and consistency.

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ANNEXES

Household Information and Communication Technologies Asset Ownership and Use in kigali City

A1 Asset Ownership and Use for ICT Indicators

District	Sector	Rad	TV	Fixd	Mobi	Comp	Int home	Intofsc	Intcafe	Intoth
Gasabo	Bumbogo	70	11.7	0.3	72	1.6	40.5	45.7	56.4	12.8
	Gatsata	75.1	46.7	1.4	91.6	9.3	42.9	38.3	61.6	18.5
	Gikomero	69.3	0.4	0.2	50.3	0.3	25	48.2	64.3	12.5
	Gisozi	70.1	40.4	0.8	90	14.3	50.7	62.6	56.6	18.2
	Jabana	71.9	19.2	0.5	73.3	6.7	53.7	50.6	47.5	20
	Jali	72.4	13.3	0.6	67.4	3.5	47.1	53.5	46.7	16.5
	Kacyiru	76.5	58.9	2.2	94.4	25.2	57.4	58.7	49.2	15
	Kimihurururа	73.8	49.1	2.3	92.6	19.2	50.5	55.5	44.7	10
	Kimironko	77.5	56.1	1.3	94.6	29.2	62.7	66.1	56.5	14.7
	Kinyinya	69.3	31.8	1	85.4	7.9	51.3	52.8	50.5	18.9
	Ndera	68.5	16.8	0.6	76.9	3.7	36.6	55.1	58.8	17
	Nduba	71.9	5.7	0.3	63.3	0.8	49.2	46.2	49.2	14
	Remera	74.3	48.5	1.4	92.6	18.4	51.1	55.7	50.9	15.8
	Rusororo	71.2	18.1	0.6	76	5.2	37.5	44.1	67.5	16.2
	Rutunga	73.5	0.7	0.1	76	0.3	18.2	58	42	29.5
Kicukiro	Gahanga	67.7	12.8	0.3	74.6	1.6	38.8	47.7	66.6	20.7
	Gatenga	74.6	46.9	0.7	91.5	11.1	45.3	48.8	57.8	12.7
	Gikondo	76.6	57.1	2.2	95.6	24.9	51.3	52.7	65.9	22.3
	Kagarama	77.5	48.4	1.5	92.9	24	59	67.9	47.5	24
	Kanombe	76.4	48.4	1.3	91.4	21.1	61.6	63.8	51.8	15.3
	Kicukiro	77.6	60.2	1.4	96.1	25.6	54.8	60.5	61	11.5
	Kigarama	74.3	51.1	1.5	92.6	16.3	48.2	46	67.8	16.4
	Masaka	72.8	19.2	0.4	79.3	4.3	33.9	44.2	61.8	18.8
	Niboye	79.9	65.7	1.6	97.1	35	62	65.9	50.9	19
	Nyarugunga	78.4	59.2	1.7	94.5	25.6	55.9	63.2	57.2	18.5
Nyaraugenge	Gitega	74.2	54.3	0.9	93.4	12.5	29.1	43.2	69.9	8
	Kanyinya	70.1	12.3	0.2	72.1	1	23.3	35.3	69	19.9
	Kigali	67.7	18.9	0.4	75.2	1.6	35.9	33.3	62.6	20.6
	Kimisagara	75.8	51.4	1.3	92.1	8.9	36.6	37.8	72.3	11.2
	Mageragere	67.8	3.5	0.3	63	0.3	16.9	32.2	80.6	11.8
	Muhima	74.5	55.6	1.9	94.6	19.4	55.5	52	58.8	20.5
	Nyakabanda	78.3	56.8	1.6	94.1	17.5	46.3	45.4	60.8	15.5
	Nyamirambo	75.3	51.4	1.6	91.8	18.2	45.9	49	60.5	15.4
	Nyarugenge	72.4	58.6	2.3	93.6	23	56.3	49.7	52	13
	Rwezamenyo	79.4	70.5	2	96.1	26.1	47.1	41.5	56	25.3

Location Quotients by Information and Communication Technologies Indicators in Kigali

Location Quotient (LQ) as applied in this study is explained below:

$$\text{Location Quotient (LQ)} = \frac{(x/X)\times 100\%}{(y/Y)\times 100\%}$$

Where x is the number of households who own or use the ICT asset/Internet by location relevant to focus digital indicator in a given administrative sector; X is the total of households in the given administrative sector; y is the number of households who own or use the ICT asset/Internet by location relevant to the focus digital indicator the focus digital indicator in the reference city(Kigali); Y is the total of households in the reference city(Kigali).

The composite measure of ICT concentration, Location Quotient Aggregate (LQICTagg) is the ratio of the sum of percentage scores for all indicators in the given sector to the sum of percentage scores for all indicators at the reference city level (Kigali). For the purpose of context illustration:

$$\text{ICTLQagg of sector A} = \frac{(\%\text{Radio}+\%\text{TV}+\%\text{Fixed phone}+\%\text{Internet Home}\ldots+\%\text{others})\,for\ sector\ A}{(\%\text{Radio}+\%\text{TV}+\%\text{Fixed phone}+\%\text{Internet Home}\ldots+\%\text{others})\,for\ \ the\ city}$$

Hence location quotient compares the local share of the focus ICT indicator to that of the reference region, Kigali City. Where ICTLQ (for individual indicator) or LQICTagg(for the composite ICT measure) equals 1, it indicates that the sector ICT cluster or share is the same as the city share. An ICTLQ or LQICTagg greater than 1 indicates that the sector is specialised or unique in terms of the focus indicator or all indicators in the case of LQICTagg. Such sectors have higher concentrations of ICT asset and/or use by location. Sectors with ICTLQ or LQICTagg less than 1 are low concentrations and less specialised.

A2 Location Quotients for ICT indicators

District	Sector	LQ rad	LQ tv	LQ Fixd	LQ mobil	LQ comp	LQ Inthome	LQ Intofsc	LQ Intercafé	LQ Intoth	LQ ICTagg
Gasabo	Bumbogo	0.95	0.31	0.27	0.84	0.12	0.91	0.85	0.98	0.79	0.8
	Gatsata	1.02	1.22	1.27	1.07	0.72	0.97	0.71	1.07	1.13	0.99
	Gikomero	0.94	0.01	0.18	0.59	0.02	0.56	0.9	1.12	0.77	0.7
	Gisozi	0.96	1.05	0.73	1.06	1.1	1.14	1.17	0.98	1.12	1.04
	Jabana	0.98	0.5	0.45	0.86	0.52	1.21	0.94	0.83	1.23	0.88
	Jali	0.99	0.35	0.55	0.79	0.27	1.06	1	0.81	1.01	0.83
	Kacyiru	1.04	1.54	2	1.11	1.94	1.3	1.1	0.86	0.92	1.12
	Kimihurururа	1.01	1.28	2.09	1.09	1.48	1.14	1.04	0.78	0.61	1.02
	Kimironko	1.06	1.46	1.18	1.11	2.25	1.42	1.23	0.98	0.9	1.18
	Kinyinya	0.94	0.83	0.91	1	0.61	1.16	0.99	0.88	1.16	0.95
	Ndera	0.93	0.44	0.55	0.9	0.28	0.83	1.03	1.02	1.04	0.86
	Nduba	0.98	0.15	0.27	0.74	0.06	1.11	0.86	0.86	0.86	0.77
	Remera	1.01	1.27	1.27	1.09	1.42	1.15	1.04	0.89	0.97	1.05
	Rusororo	0.97	0.47	0.55	0.89	0.4	0.85	0.82	1.17	0.99	0.87
	Rutunga	1	0.02	0.09	0.89	0.02	0.41	1.08	0.73	1.81	0.77
Kicukiro	Gahanga	0.92	0.33	0.27	0.87	0.12	0.88	0.89	1.16	1.27	0.85
	Gatenga	1.02	1.22	0.64	1.07	0.85	1.02	0.91	1.01	0.78	1
	Gikondo	1.04	1.49	2	1.12	1.92	1.16	0.98	1.15	1.37	1.15
	Kagarama	1.06	1.26	1.36	1.09	1.85	1.33	1.27	0.83	1.47	1.14
	Kanombe	1.04	1.26	1.18	1.07	1.62	1.39	1.19	0.9	0.94	1.11
	Kicukiro	1.06	1.57	1.27	1.13	1.97	1.24	1.13	1.06	0.71	1.15
	Kigarama	1.01	1.33	1.36	1.09	1.25	1.09	0.86	1.18	1.01	1.07
	Masaka	0.99	0.5	0.36	0.93	0.33	0.77	0.82	1.07	1.15	0.86
	Niboye	1.09	1.72	1.45	1.14	2.69	1.4	1.23	0.89	1.17	1.23
	Nyarugunga	1.07	1.55	1.55	1.11	1.97	1.26	1.18	0.99	1.13	1.17
Nyarugenge	Gitega	1.01	1.42	0.82	1.09	0.96	0.66	0.81	1.22	0.49	0.99
	Kanyinya	0.96	0.32	0.18	0.85	0.08	0.53	0.66	1.2	1.22	0.78
	Kigali	0.92	0.49	0.36	0.88	0.12	0.81	0.62	1.09	1.26	0.81
	Kimisagara	1.03	1.34	1.18	1.08	0.68	0.83	0.71	1.26	0.69	1
	Mageragere	0.92	0.09	0.27	0.74	0.02	0.38	0.6	1.4	0.72	0.71
	Muhima	1.01	1.45	1.73	1.11	1.49	1.25	0.97	1.02	1.26	1.11
	Nyakabanda	1.07	1.48	1.45	1.1	1.35	1.05	0.85	1.06	0.95	1.07
	Nyamirambo	1.03	1.34	1.45	1.08	1.4	1.04	0.91	1.05	0.94	1.05
	Nyarugenge	0.99	1.53	2.09	1.1	1.77	1.27	0.93	0.9	0.8	1.08
	Rwezamenyo	1.08	1.84	1.82	1.13	2.01	1.06	0.77	0.97	1.55	1.14

Sector Information and Communication Technologies Statuts and Cluster Membership

A3 Sector ICT Status

District	Sector	Cluster	Distance to Cluster Centre	LQ ICTagg	Status
Gasabo	Bumbogo	1	8.99	0.8	ICT-Non-Basic/Digital- Normal
	Gatsata	2	10.32	0.99	ICT-Non-Basic/Digital- Normal
	Gikomero	3	23.87	0.7	ICT-Non-Basic/Digital- Normal
	Gisozi	2	19.99	1.04	ICT-Basic/Digital-Premium
	Jabana	1	16.52	0.88	ICT-Non-Basic/Digital- Normal
	Jali	1	10.92	0.83	ICT-Non-Basic/Digital- Normal
	Kacyiru	4	6.15	1.12	ICT-Basic/Digital-Premium
	Kimihurururа	4	16.38	1.02	ICT-Basic/Digital-Premium
	Kimironko	4	12.34	1.18	ICT-Basic/Digital-Premium
	Kinyinya	2	23.97	0.95	ICT-Non-Basic/Digital- Normal
	Ndera	1	11.47	0.86	ICT-Non-Basic/Digital- Normal
	Nduba	1	16.33	0.77	ICT-Non-Basic/Digital- Normal
	Remera	4	12.19	1.05	ICT-Basic/Digital-Premium
	Rusororo	3	14.28	0.87	ICT-Non-Basic/Digital- Normal
	Rutunga	1	30.08	0.77	ICT-Non-Basic/Digital- Normal
Kicukiro	Gahanga	3	14.19	0.85	ICT-Non-Basic/Digital- Normal
	Gatenga	2	5.64	1	ICT-Non-Basic/Digital- Normal
	Gikondo	4	14.69	1.15	ICT-Basic/Digital-Premium
	Kagarama	4	16.37	1.14	ICT-Basic/Digital-Premium
	Kanombe	4	12.82	1.11	ICT-Basic/Digital-Premium
	Kicukiro	4	10.41	1.15	ICT-Basic/Digital-Premium
	Kigarama	2	8.84	1.07	ICT-Basic/Digital-Premium
	Masaka	1	16.45	0.86	ICT-Non-Basic/Digital- Normal
	Niboye	4	18.14	1.23	ICT-Basic/Digital-Premium
	Nyarugunga	4	7.13	1.17	ICT-Basic/Digital-Premium
Nyarugenge	Gitega	2	19.88	0.99	ICT-Non-Basic/Digital- Normal
	Kanyinya	3	9.37	0.78	ICT-Non-Basic/Digital- Normal
	Kigali	3	15.58	0.81	ICT-Non-Basic/Digital- Normal
	Kimisagara	2	17.16	1	ICT-Non-Basic/Digital- Normal
	Mageragere	3	22.09	0.71	ICT-Non-Basic/Digital- Normal
	Muhima	4	9.91	1.11	ICT-Basic/Digital-Premium
	Nyakabanda	2	11.65	1.07	ICT-Basic/Digital-Premium
	Nyamirambo	2	7.20	1.05	ICT-Basic/Digital-Premium
	Nyarugenge	4	10.69	1.08	ICT-Basic/Digital-Premium
	Rwezamenyo	4	24.90	1.14	ICT-Basic/Digital-Premium

Clarifications/Notes on Data

ICT/Digital Indicators

All ICT KPIs used are based on data percentage of households whose at least one member has the referent indicator; physical access indicators are ICT assets/devices (television, radio, fixed/land phone, mobile phone, computer). In the dimension of use by location, the fundamental indicators are applied; percentage of households whose at least one member has access to Internet by location (home, school/office, cyber café and other places). Other places may not constitute a significant and regular household access outlet. For example using other people's phones sometimes may not constitute a regular access location. Computer may be desktop, laptop, tablet or similar handheld computer.

Internet access is irrespective of the device used; digital TV, tablet, mobile, computer and game machines). Access window is defined normally as three months. Online inactivity more than three months is defined as no access to Internet.

Spatial and Socio-economic variables

Youth employment: Youth is defined in Rwanda as the population aged 14 to 35. But working age is 16-64. The youth employed fall within age range 16 and 35. This is not household-based but individual residents in this group aggregated at sector levels. Employment is any productive, legal engagement, in the last seven days preceding the census. Those who are not engaged are in the last seven days are considered temporarily inactive. The percentage of the youth employed or in a particular type of employment (employee/employer/self-employed) is used in this study. The elderly belong to the age group 60 and above.

Youth indicator was deliberately applied as the group plays a role in the digital use environment. This enables the examination of the possible co-existence of youth factor and ICT access. Taking the other extreme of youth (the elderly) makes for a clear comparison as those should naturally unveil any age-divide in digital access. However, any possible lopsidedness is evened out since the actual ICT KPIs used are based on cross-cutting age groups in households (irrespective of age). The extreme groups were applied only as socio-economic correlates for relationship test, not ICT KPIs.

Secondary school age is 13-18 in Rwanda. The percentage of the population within this group who have attained secondary school (as highest level of education) was used. For university as highest level of education, the share of youth population who attained university education was used.

Post primary education centre is any formal school above primary school; this includes formal vocational institutes where certificates are awarded, recognised by GoR. In this study it is the number of such centres in a given sector. It was used as surrogate for possible innovation centres.

Share of total population is a given sector's population expressed as percentage of its host district. This makes it useful for local context. Comparison is applicable since it has been regularised as a percentage. Note that these computations were the official statistics. Where the author computes figures these are clearly stated; for example Location Quotients.

A4 Variables in Analysis

Variable Label	Full Name of Variable*	Category	Source	Year
Rad	Radio	ICT asset	NISR	2015
TV	Television	ICT asset	NISR	2015
Fixd	Fixed telephone	ICT asset	NISR	2015
Mobi	Mobile phone	ICT asset	NISR	2015
Comp	Computer	ICT asset	NISR	2015
Inthome	Internet at home	ICT/Internet use	NISR	2015
Intofsc	Internet in office/school	ICT/Internet use	NISR	2015
Intcafé	Internet cyber café	ICT/Internet use	NISR	2015
Intoth	Internet others	ICT/Internet use	NISR	2015
Percfemale	Percent of females in the total population	Socio-economic	NISR	2015
Electricity	Electricity	Socio-economic /Infrastructure	NISR	2015
Owner	Home Owner	Socio-economic	NISR	2015
Elderpop	Elder population	Socio-economic	NISR	2015
Youthpop	Youth population	Socio-economic	NISR	2015
Youthsec	Youth with secondary school education	Social/education	NISR	2015
Youthuniv	Youth with university education	Social/education	NISR	2015
Youthemployed	Youth who are employed(status)	Socio-economic	NISR	2015
Youthemployee	Youth who are employed(type)	Socio-economic	NISR	2015
Youthemployer	Youth who are employers(type)	Socio-economic	NISR	2015
Youthselfemployed	Youth who are self-employed(type)	Socio-economic	NISR	2015
Elderemployed	The Elderly who are employed(status)	Socio-economic	NISR	2015
Hholdheadfemale	Household headed by female	Socio-economic	NISR	2015
Improvedwatersource	Improved source of water	Socio-economic /Infrastructure	NISR	2015
Planned	Planned habitat	Socio-spatial/formality	NISR	2015
Geoconstraint	Geographic constraint	Spatial/agglomerative	CoK	2013
Postprycentre	Post-primary education centres	Spatial/agglomerative	NISR	2015
Sharetotalpop	Share of total population	Spatial/agglomerative	NISR	2015
Urbanpop	Urban population	Spatial/agglomerative	NISR	2015

*Read accompanying clarification/note on data for description.

Those variables that typically tend to have spatial footprint and distinguish the core from the periphery have been conceived in this context to be spatial. Some variables have elements of social and economic constructs (socio-economic); for example female household heads who are typically the providers of the household needs; status which could as well limit access to resources where gender is a strong factor. Education as used here is primarily a social indicator relevant for understanding, partly, the digital natives, awareness and general literacy. There is no hard and fast rule for this kind of categorisation and none is being set in this study. Nomenclature has only been applied for the purpose of contextual understanding of the underlying condition of ICT access in Kigali City.

Percentage planned is given in the official data and based on proportion of households in the type of habitat (in sectors) considered to meet the planning standard required to be classified as planned, spontaneous or others.

Urban population is defined as urban percentage of the total population. It is on the basis of settlement type and other elements considered as dominantly urban in the given sector. It is individual resident-based, not household. Since the data was used mainly as a spatial-statistical indicator, not directly collected from urban planning authorities, this is expected to be generalised and sufficient for the purpose of analysis; where the study is not particularly one of land use or settlement analysis.

Home ownership considers household tenure. It is the percentage of households who live in their own homes. This is a (social) indicator of tenure security. "Owner" may include inheritance, not necessarily self-financed but distinguishable from tenant, free lodging, hire purchase or staff housing. Hence, quality or formality plays less role in this case; an urban fringe household in own apartment without the modern facilities and furnishing, which may be available in a well-manicured home at the core, is considered an owner and enjoys the security thereof.

Electricity is a subset of household sources of energy for lighting, with others being candle, firewood and kerosene lamps mainly used in the remote/rural areas, which are most affected by power outage or in some cases not connected to the national grid. It is the percentage of households who use electricity as the primary source of lighting.

Improved water source is aggregated from households and simply classified as either improved or unimproved, taking into account local quality standards not specified in the statistical data. As used in the study, it is the percentage of households who have access to improved water source.

Geographic constraint is the proportion/percentage of a given sector that is unfavourable for development purposes. Geographic constraint refers to limitations associated with land: unfavourable steepness/topography, soils, wetlands and forests ill-suited for new development based on scientific and ecological principles (City of Kigali, 2013). Hence, a sector's share of these physical-ecological ills may be indicative of relative backwardness, which could as well be a correlate of performance in emergent technology availability and use. For example difficulty in laying fibre optic, base transceiver stations or poor signal due to geographic constraints could reflect in poor ICT ownership and use in the affected sector.

Mobile Access Bus

A5 One of the Mobile Access/ICT Buses, Kigali

Field Interview Guide

Interview Guide for Universal Access Provision (UAP) in Kigali

I am conducting a research on ICT access in Kigali. Universal Access Provision, particularly via Multipurpose Telecentres (MTCs)/Telecentre Networks, is important for ICT access different geographical areas and demographic segments of the city. This interview is intended to collect information on UAP in Kigali, the different groups involved and the working of the project(s). Kindly note that this is an academic study, as such the information provided by any individual respondent will be treated with utmost confidentiality. The final information can be made available to the respondent for confirmation before publication. Your collaboration is highly appreciated.

Introduction/ background

1. Could you briefly tell me what your work is about in this organisation and the current project(s) in which you are engaged?

Universal Access Provision in Kigali – project governance and setting

2. Could you describe the Universal Access Provision Project in Kigali?
3. Please describe how the UAP projects influence ICT access in homes, schools, city wifi points and e-learning centres including e-libraries outside regular schools.
4. Who is/which organisations are involved in UAP in Kigali and what is their role?
   -Government please mention relevant agency/agencies
   - GSM operators (mention how many but name of operator not important)
   - Communities
   - NGOs (mention how many or use many if more than 5, Local/International)

-International development partners; other agencies not NGOs (please mention relevant partners known to you).

5. Kindly describe how you arrange for meetings among the different groups involved in UAP/MTCs/RTNS in terms of formality/informality, meeting time, venue and choice of who should preside.

-How often do you work together in these group projects and/or share results or data from UAP/MTCs/RTNs among these groups?

6. What do you think of the future of the UAP in Kigali? (Please base this on your experience in the project(s), relationship between groups, socio-economic realities of the city/central government and others)

UAP- positive outcomes

7. State in which of the public access points (homes, schools, central Wi-Fi points etc) above you think the UAP has worked best.

8. Why do you think that the aspect(s) you mentioned are where the UAP has worked best?

UAP – challenges ahead/ limiting factors

9. Discuss the aspects of UAP in Kigali you would need to improve in relation to the following issues:
For example funding, knowledge of role and cooperation among groups (eg. clarity of goals and roles, awareness, group mobilisation/empowerment, *also skills, urban economy*), community participation, private sector investment and other organised private sector support (please specify).

10. Which of the constraints would you consider the strongest of these limiting factors stated above?

Thesis Work plan

No	Activities(Aug. 2016-Feb. 2017)	Aug.				Sept.				Oct.				Nov.				Dec.				Jan.				Feb.			
	Week	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1	Proposal writing																												
2	Proposal presentation																												
3	Literature review																												
4	Fieldwork preparation																												
5	Fieldwork																												
6	Data check, cleaning & preliminary analysis																												
7	Mid-term presentation																												
8	Spatial statistical analysis																												
9	Institutional analysis																												
10	Compilation of output																												
11	Report writing																												
12	Thesis presentation																												