

‘Is There an App for That?’ Tapping into Mobile Technology to Facilitate Urban Climate Change Resilience in Nairobi

Michelle W. Martey

**Division of Risk Management and Societal Safety
Lund University, Sweden**

**Riskhantering och samhällssäkerhet
Lunds tekniska högskola
Lunds universitet**

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Misse Wester(PhD)

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Abstract

Kenya's rapid, unplanned urban development and rising pressure for cities to adapt to climate change and become more climate change resilient has led to the realisation that more needs to be done. In Nairobi, increasing access to mobile technology and internet access, faster internet speeds, and the growing technology sector could be possible means to facilitate urban climate change resilience (UCCR) and reduce vulnerability. This thesis considers how mobile technology can be used to facilitate urban climate change resilience in Nairobi. Guided by a framework that outlines seven entry points to UCCR – through key informant interviews and literature review – the thesis analyses how mobile tech is currently being used; what gaps can be exploited and what challenges are faced by Nairobi City County officials, developers and users in adopting mobile technology for UCCR. The findings show that residents, community based organisations, the private sector, innovators and other stakeholders are pioneering and adopting innovative ways to address the various challenges in Nairobi. This facilitates more resilient development, by lowering the vulnerability of the city, its residents, infrastructure and services. Climate change is however not often explicitly or extensively addressed by many of the innovations; further, the County has not fully prioritised UCCR. Thus, while the technology may be available to address various challenges, there isn't a holistic vision about the County's resilience objectives by all stakeholders. This means that while to some extent vulnerability at various levels is being addressed, it is difficult to determine if overall climate resilience is being developed.

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Riskhantering och samhällssäkerhet
Lunds tekniska högskola
Lunds universitet
Box 118
221 00 Lund

<http://www.risk.lth.se>

Telefon: 046 - 222 73 60

Telefax: 046 - 222 46 12

Division of Risk Management
and Societal Safety
Faculty of Engineering
Lund University
P.O. Box 118
SE-221 00 Lund, Sweden

<http://www.risk.lth.se>

Telephone: +46 46 222 73 60

Fax: +46 46 222 46 12

DEDICATION

I dedicate this to my mother, who has been the best example of what strength and perseverance should be; whose encouragement to pursue my dreams and step away from my comfort zone has brought me this far. Thank you mum.

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ACRONYMS AND TERMINOLOGY

Acronyms

ADB	Asian Development Bank
App	Application
AURAN	African Urban Risk Analysis Network
CAK	Communications Authority of Kenya
CBOs	Community Based Organisations
CC	Climate change
CCK	Communications Commission of Kenya
CRO	Chief Resilience Officer
CSOs	Civil Society Organisations
ICPAC	IGAD Climate Prediction and Application Centre
ICT	Information Communication Technology
IGAD	Intergovernmental Authority on Development
JICA	Japan International Cooperation Agency
KCIC	Kenya Climate Innovation Centre
mHealth	Mobile Health
NCC	Nairobi City County
NCCA	Nairobi City County Assembly
NIUPLAN	Nairobi Integrated Urban Development Plan
NUDP	National Urban Development Policy
RAN	Makerere University College of Health Sciences School of Public Health
	ResilientAfrica Network
Tech	Technology
UCCR	Urban Climate Change Resilience
Urban ARK	Urban Africa Risk Knowledge Network
WaSHMIS	Water Sanitation Hygiene Management Information System

Terminology

- Apps** Short for applications, are software that allow users to perform specific tasks and enhance existing functionality. Apps for mobile devices are referred to as mobile apps and can be downloaded at a price or for free from websites or built- in app stores that are integrated into the phone's operating system. (Adapted from <http://www.techradar.com> and www.gcflernfree.org)
- Innovation** The implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations. (Adapted from Eskelinen et al., 2015)
- Shocks** Sudden, sharp events that threaten a city, they could be climate change related, such as hydrometeorological events (floods, droughts), economic shocks or antagonistic events such as terrorism (adapted from Bahadur, Tanner and Pichon, 2016)
- Stresses** Factors that weaken the fabric of a city on a daily or cyclical basis, which could build up over time or as an indirect result of climate change (adapted from Bahadur, Tanner and Pichon, 2016)

1. INTRODUCTION

1.1 Background

Kenya's urban population has risen from 8% at independence to 34% in 2011 (GoK, 2012a) and it is projected that 50% of Kenya's population will be living in urban areas by 2030; the country's urbanization rate of 4.4% is one of the highest in the world (Chaudhuri, Erasmus and Appleford, 2015). The rapid urbanisation has led to the increasing number and size of unplanned settlements with a rapidly increasing population of urban poor. This population pressure presents further challenges to the city, such as water scarcity, poor solid waste and sewerage handling (Abdulla, MacAuslan & Schofield, 2011; TISA, 2012; Chaudhuri et al., 2015) which the National and County governments are unable to keep up with. Further, threatened by climate change and its impacts, there is great uncertainty caused by the complexity of the systems and impacts of development. According to the draft National Policy for Disaster Management (GoK, 2010), over 70% of the natural disasters in Kenya are related to extreme climate events, which could also contribute to some emergency situations that escalate to disasters.

Recognising the need to address urbanization, manage urban development and address emerging issues such as climate change and disaster preparedness, the draft National Urban Development Policy (NUDP), (GoK, 2012a) and the Urban Areas and Cities Act (GoK, 2012b) were developed. Specific objectives in the NUDP are to "Enhance climate change resilience through infrastructure design [...] and to promote technological innovation for climate change adaptation and mitigation" (GoK, 2012a). The policies however, do not put forward effective strategies to accomplish these objectives or further address the increasing pressure. It is therefore imperative to consider more flexible and dynamic and 'out of the box' approaches to facilitate building urban climate change resilience.

With growing realisation of the importance of information communication technologies (ICTs) and the roles they play in economic development, Kenya embarked on a campaign to introduce ICTs into its development strategies (Mwaniki, 2017). The growth of mobile technology (tech), particularly, is of interest as studies have shown Kenya's mobile penetration is high as compared to other forms of ICTs such as computer access in the

form of laptops and desktops (Waema & Ndung'u, 2012). The Communications Authority of Kenya (CAK), at the end of the second quarter of the 2016/17 financial year, reported that mobile penetration stood at 88.2% of the population, equal to 38.9 million subscribers (CAK, 2016). Nairobi alone, has almost universal mobile phone penetration and over 60% internet coverage (Mwaniki, 2017). Tapping into these numbers could provide a platform for increasing the resilience of urban city dwellers and the urban support systems, while matching already set-out development policy objectives. With these figures in mind, and basing on the National and County Acts and Policies in place, this thesis aims to investigate how urban climate change resilience can be further bolstered by applying mobile technology in various ways through addressing the related risks climate change poses on the society.

1.2 Scope and Limitations

This study will focus on urban areas particularly, Nairobi City County (NCC), Kenya. The county, made up of 17 constituencies 85 electoral wards, has a current population estimated at around 3.5 million people (NCCA, 2015). Nairobi is officially referred to as the Nairobi City County, however in this thesis Nairobi County, Nairobi City, the County, NCCC or the City are also used. The city, having the largest share of the country's ICT infrastructure, a large number of ICT professionals, a youthful tech savvy population and a growing international spotlight on its rising ICT development (Mwaniki, 2017), provides a good platform to assess the role mobile tech can play in building urban climate change resilience. Further, due to its ubiquitous mobile coverage and high internet coverage, Nairobi's residents have higher probabilities of relying on technology to address issues that affect them.

Regarding mobile technology, this study aims to assess the enabling environment supporting the adoption of mobile technology, its drivers, the actors and their various roles as well as the avenues to introduce mobile technology into the various identified sectors. It is not the aim of this study to develop a comprehensive list of current applications (apps) in use, but to provide an overview of the present situation.

1.3 Research Question

How can mobile technology facilitate urban climate change resilience in Nairobi?

To address the main research question, the following investigative questions were used:

1. What factors influence the city's climate change resilience?
 - a. What are Nairobi's vulnerabilities and challenges?
 - b. What present factors contribute to resilience in Nairobi?
2. What mobile technology is being used to facilitate resilience to climate change and its associated risks?
 - a. Who are the key players in developing technology and ideas?
 - b. How is the technology implemented, and at what levels?
 - c. How is the technology meeting the overall aim?

1.4 Research Aim and Objectives

1.4.1 Research Aim

To understand the impact of urban climate change in Nairobi and identify how mobile technologies can be used to enhance the city and its residents' resilience through an assessment of the enabling environment surrounding mobile technology.

1.4.2 Research Objectives

- a. Identify the drivers of urban risk in Nairobi and the factors contributing to stronger urban resilience
- b. Analyse the conditions that make it favourable to use mobile technology
- c. Identify the potential gaps that can be filled using mobile technology
- d. Identify and analyse the challenges related to mobile technology

1.5 Justification and Significance

Due to rising pressure from population growth and climate change, there is a need to adopt more flexible and dynamic approaches to facilitate urban climate change resilience. With the complexity of interlinked city systems and the uncertainty brought about by development and how climate change will affect urban areas, this study acts as a nexus

between the quickly developing ICT and mobile technologies sector, rapid urban development and the need for resilient urban planning. By bringing these three aspects together, the study will provide a basis to address the needs of cities such as Nairobi, which are faced with various unique challenges and growing pressures.

ICTs have been greatly studied broadly within the field of development¹, with researchers such as Heeks & Ospina, (2010a, b) beginning to analyse how they can be tailored into the climate change and resilience discourses. However, more in-depth studies on mobile technology in particular are quite limited, as most use ICTs as an umbrella term to include not only mobile technology, but computers, television, radio and others (Heeks & Ospina, 2010 b). This study aims to focus mainly on mobile technologies, it is acknowledged by the researcher that the mobile systems do not function independently from other ICTs, and that their application in partnership with other systems makes the entire system stronger. However, it would be a good starting point to understand particularly the roles that mobile technology could play, and look at the factors driving mobile tech development and adoption forward.

Through the analysis of the available support structures in place and the challenges currently faced by developers of the mobile technologies, this thesis will provide a gateway to facilitate discussions between urban municipalities and tech developers, towards the creation and adoption of the discussed technologies. Further, it should act as a catalyst towards more research into the impacts of mobile technology on urban climate change resilience. Especially with the aim of creating databases with empirical data on the impacts technology is having on the various levels of community and overall changes in resilience.

1.6 Thesis Outline

This report is divided into five main sections. This first section (*1 Introduction*) provides the setting of the study, presenting the research question, the study objectives and justification of the study in the broader context of resilience and climate change

¹ ICTs for Development (ICT4D)

adaptation. Section two, (*2 Literature Review*) is a review of existing literature relevant to urban climate change resilience and mobile technology. The third section (*3 Methodology*) covers the methodology that was applied to frame the study; based on a framework of seven entry points to UCCR and its action points. Data collection methods employed were: qualitative, semi- structured interviews and secondary data analysis; the section concludes with a discussion on the data analysis process, challenges and limitations to the study. Section four (*4 Findings and Discussions*) presents the findings from the key-informant interviews and further supported by literature. The section is divided according to the study objectives and framework. Finally, the report concludes, (*5 Conclusions and Recommendations*), with key observations from the researcher's perspective and some further research recommendations.

2. LITERATURE REVIEW

This section begins with a discussion on vulnerability and resilience which provide a basis to conceptualise urban climate change resilience (UCCR). The overarching aim of urban climate change resilience is to build more resilient cities which are also discussed in relation to the seven entry points to enhance UCCR. Through an analysis of the descriptions and characteristics of a resilient city and a smart city, the chapter creates an understanding of where and how ICTs and mobile technologies are critical. Finally, the section is wrapped up with an analysis on the role of mobile technologies in reducing vulnerability, urban resilience, disaster risk reduction and preparedness.

2.1 Vulnerability and Resilience

The Intergovernmental Panel on Climate Change (IPCC) defines vulnerability as the predisposition to be adversely affected, encompassing the lack of coping and adaptation capacity as well as the susceptibility to risk (IPCCC, 2014a). Measures and initiatives to reduce vulnerability in natural and human systems brought forward the notion of climate change adaptation, according to earlier climate change reports by the IPCC (IPCC, 2007). The approaches used to address the rising challenges posed by climate change were ‘predict and prevent’ approaches based on making policies, practices and plans for climate change adaptation reliant on prediction (Tyler & Moench, 2012). Tyler and Moench (2012) in their paper argue (through other supporting literature) that these approaches were criticised for not being able to handle ‘surprises’. Further, through interventions to address the specific impacts, the approach “ [...] neglected the indirect effects, systemic weaknesses and institutional constraints” (Tyler & Moench, 2012 pp. 312; da Silva, Kernaghan & Luque, 2012).

Based on this argument, building resilience was perceived as a better, more effective approach for cities as compared to taking more reactive measures to the perceived future climate risks (Tyler & Moench, 2012). As a concept, resilience has been discussed over the years in various fields of research and application. The IPCC defines it as: “*the capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function,*

identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation” (IPCC, 2014a) while in the disaster risk perspective resilience is “*the ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner..*” (UNISDR, 2009). Resilience can be considered as an approach to reduce vulnerability at the societal and household levels by taking the necessary steps to ensure that the adaptation measures put in place properly identify the vulnerabilities and their exposure to hazards (Baker, 2011). However, as argued by da Silva, Kernaghan & Luque, (2012), it requires a behavioural change within the system and communities, going beyond tackling specific vulnerabilities and specific community needs in an emergency. Resilience, in the city context, has therefore acted as a bridge between disaster risk reduction- with its basis on hazard specific risk assessments- and climate change adaptation, by accepting that despite the broad range of disruptive events, they are not necessarily predictable (Arup, 2014). By focussing on enhancing the system’s performance, resilience overcomes the multiple hazards that could disrupt the system and avoids working towards preventative or mitigative measures for specific events. (Arup, 2014).

In Kenya, efforts to address urban vulnerability are focussed on improving rural areas, with the outlook that reducing poverty in rural areas will reduce the need for rural-urban migration, thus effectively the pressure on the urban areas (Abdula et al., 2011). These initiatives, though helpful for developing rural areas, have not been sufficient to achieve the intended outcome of reducing urban vulnerability by curbing rural-urban migration (Abdula et al., 2011). Given the complexity and uncertainty of the urban areas coupled with the multi-faceted challenges that face urban residents, more so the urban poor, it is critical that various steps are taken to address the vulnerabilities (Abdula et al., 2011; Baker, 2011). To achieve this, it would be critical to understand the determinants of resilience within the society and identify the factors that drive the community to adapt and change. Slum populations particularly, are more vulnerable to repeated stresses and shocks (Beyer, Chaudhuri & Kagima, 2016) which affect the various levels of the community from the household all the way to the broader community.

While the literature does provide some perspectives on resilience in Nairobi (see Beyer et al., 2016), many studies are focussed on poor or unplanned settlement areas, leading to

gaps in areas that could be classified as middle to high income areas. Further, urban resilience is still relatively understudied, especially in relation to climate change and disaster preparedness.

2.2 Urban climate change resilience and Resilient cities

Kenya's definition of urban areas, including cities and municipalities, is mainly based on criteria about the population size, the administrative structure and roles, infrastructure, service delivery and institutions, according to the Urban Areas and Cities Act (GoK, 2012b). This description does not consider the complexities and interdependencies of systems which are also critical to a city, as argued by da Silva, Kernaghan & Luque (2012). In recognising the multidimensionality of the urban space and cities, more holistic approaches need to be taken to address the challenges facing urban areas (da Silva, Kernaghan & Luque, 2012).

Stemming from this, urban resilience takes into consideration the ability of cities to tolerate disruption and re-organise structures and processes, making them able to adjust to uncertainty (Drobniak, 2010) while still fulfilling the historical functions of a city to support the well-being of its citizens, provide safety and protection from environmental change and disasters (da Silva, Kernaghan & Luque, 2012; Wamsler, 2014). In planning and systems theory, the inter-linkages between communities and environmental systems have led to the view of cities as 'complex, adaptive systems' in the resilience discourse (Wilkinson, 2011; da Silva, Kernaghan & Luque, 2012; Mehmood, 2015). This is due to the ability of cities to self-organise and recover from shocks as well as their adaptability to learn from past experiences which is critical to the resilience of the system (ADB, 2014; Mehmood, 2015). The latter literature emphasises that resilience does not only stem from recovering from disturbances in the system, but also the reiterative processes of learning, adaptation and self-organisation within the system (ADB, 2014; Arup, 2014; Munene, 2015).

Integrating this iterative learning, adaptation and self-organisation processes together with the shocks and stresses from climate change into the discourse of urban resilience, the field of urban climate change resilience has emerged. UCCR is defined by the Asian

Development Bank -ADB (2014) as “...the capacity of cities to function, so that the people living and working in cities, particularly the poor and vulnerable, survive and thrive in the face of stresses or shocks related to climate change.” This integrates climate change adaptation, climate change mitigation and disaster risk management while recognising the complexity of rapidly developing urban areas and the uncertainties of climate change (Bahadur, Tanner & Pichon, 2016)

To distinguish a “resilient city from one that is simply liveable, sustainable or prosperous” (Arup, 2014 p.8) seven qualities have been put forward in literature and practice to act as a guide. These qualities which could be used to describe a ‘resilient city’ are: reflective, robust, redundant, flexible, resourceful, inclusive and integrated (Arup, 2014; Bahadur et al., 2016). By ensuring that a city’s systems adhere to the qualities, resilience can become better articulated; for example, integrating systems and institutions facilitates consistent decision making and provide platforms for resource sharing among actors (Bahadur et al., 2016).

Based on extensive research on UCCR literature and consultations including the analyses of the qualities discussed above, Bahadur, Tanner & Pichon (2016) put forward entry points for action that also draw from good development practice and key principles of resilience. The intended outcome is to use the entry points as a tool to translate the theoretical concept of UCCR into practice, especially when approached with the perspective of the resilient city qualities outlined above. They thus provide opportunities to build resilience over time (Bahadur et al., 2016).

These entry points are:

- i. Climate Information and Urban Growth Data,
- ii. Urban Planning,
- iii. Infrastructure services,
- iv. Institutional capacity,
- v. Community Development,
- vi. Private Sector and
- vii. Catalysing Finance.

An examination of the qualities of a resilient city shows several key similarities to another concept discussed in current literature - the '*smart city*'. The term 'smart cities' arose due to pressure on cities to come up with innovative ways to deal with energy consumption, urban climate change adaptation and development (Papa, Galderisi, Vigo Majello & Saretta, 2015). These cities are generally characterised by the inclusion and extensive use of ICTs in various sectors to facilitate easier interaction between human and social capital (Papa et al., 2015). Through an extensive review of the use of smart and resilient cities in literature, Papa et al. (2015) discuss how these two concepts of resilient and smart cities could align to approach urban challenges in the face of climate change. They argue that the similarities in their key qualities are key strengths in merging these two concepts. This intersection between 'smart' and 'resilient' cities provides an optimal gateway to study the role of mobile technology in facilitating urban climate change resilience. Framing the thesis within the resilience discourse provides a platform to bring together climate change, development and technology in a dynamic, cultural environment and highlights the strengths of the technologies being discussed, further it considers the various qualities of resilience as discussed in the above sections.

2.3 ICTs and Mobile technology

Heeks & Ospina (2010a) present a trend in the emergence of literature linking ICTs² within the climate change field, beginning around the early 2000s. Research during this period aimed at addressing issues exploring ICTs in the context of sustainable development and the Millennium Development Goals (MDGs), while not addressing climate change explicitly, it was identified as a potential platform to monitor environmental targets (Heeks & Ospina, 2010a). The direct impact of ICTs on climate change, particularly carbon emission from the production, use and disposal of ICT equipment was also a key consideration (Akoh, Bizikova, Parry et al., 2011).

A second research field arose with increasing awareness of the increasing levels of carbon dioxide and a need to reduce emissions and mitigate climate change. ICTs were thus a

² ICTs at this point are a term used broadly to encompass telecentres, mobile phones, broadband smartphones and others, Heeks & Ospina (2010a, p.30) later discuss '*low-cost and emerging technologies such as community radio, mobile phones and participatory videos*' as part of ICTs applied in climate change adaptation.

potential channel to reduce carbon dioxide emissions through efficiency in energy production, transportation, the service industry among others (Heeks & Ospina, 2010a; Akoh et al., 2011). At this stage research was primarily driven by developed countries and it wasn't until 2007, after the IPCC report was released, that research began to shift towards climate change adaptation and the needs of developing countries (Heeks & Ospina, 2010a).

Climate change, vulnerability and the potential of ICTs began to reflect more in research. Further, the increasing evidence relating climate change and disaster risk (see also Akoh et al., 2011; Wamsler, 2014; IPCC, 2014a) coupled with the increasing prioritization of climate change on the international arena (Heeks & Ospina, 2010a) further drove research on the ICT sector's roles.

In Africa, ICTs were recognized as an important pathway to address climate change adaptation and vulnerability reduction efforts (Akoh et al., 2011). The growing ICT sector, including its infrastructure, and internet penetration on the continent unlocked opportunities in various sectors (Akoh et al., 2011; Aydin, Tarhan, Ozgur et al., 2016). It was observed particularly, that mobile phone usage had a strong influence on social behaviour and could provide opportunities for Africans (Akoh et al., 2011).

Mobile technology includes devices that are both portable and allow for instant access to information (Hussain & Adeeb, 2009). They include cell phones, E-book readers, tablet computers, laptops, smartphones, iPads and Personal Digital Assistants (PDAs) (Hussain & Adeeb, 2009) which "*promote and enhance opportunities of advanced communication*" (Hussain & Adeeb, 2009, p. 48) and can store and transmit data and information in text, sound, pictures, video or all the mentioned formats. Mobile technology also includes Bluetooth, General Packet Radio Service (GPRS), 3G (Third Generation), 4G (Fourth Generation), Wireless Fidelity (Wi-Fi), Multimedia Messaging Service (MMS), Short Message Service (SMS), Unstructured Supplementary Service Data (USSD)/Short Codes, Wireless Application Protocol (WAP) and Global Positioning System (GPS) through which various forms of data can be transmitted (IGI-Global, 2017). Additionally, by using applications (apps) which are downloaded by the user or come pre-installed on phones, tablets or computers, the number of tasks and services that can be performed increases.

Recently, there have been an increasing number of studies carried out on the role of mobile technology in emergencies, disaster management and disaster resilience with focus on disaster preparedness, vulnerability reduction and easing humanitarian response [such as through cash transfer mechanisms] (Hallow, Mitchell, Gladwell, et al., 2012; UN Global Pulse, 2014; Aydin et al., 2016; Wachira, 2016). Literature on mobile technology usage for urban climate change resilience is however quite limited. Despite the conceptual gaps on the quantitative impacts of mobile technology on enhancing urban climate resilience, literature supports that there is potential to utilise mobile technology for various indirect quantifiable methods that can increase climate change resilience (American Red Cross & IFRC, 2015; Rynecki, 2015). In addition, based on supportive studies on the role of mobile technologies in learning such as by enhancing connectivity and collaboration (see Hussain & Adeb, 2009; Cochrane, 2010 and Sharples, 2013), it can be concluded that these technologies can have positive influence on users and can be an optimal channel to address issues related to climate change awareness and community resilience. An additional advantage is that urban areas have better infrastructure and higher mobile phone usage as supported by Bahadur, Tanner & Pichon, “...cities are unique for their high mobile phone service penetration and communication infrastructure.” (2016, p.10). Based on these arguments, a theoretical assumption made in this study is that the key factors that make mobile technology applicable for disaster management, vulnerability reduction and education, as discussed by various researchers, would be transferable to urban climate change resilience.

3. RESEARCH METHODOLOGY

3.1 Process

To address the research question, this study was guided by a framework adapted from the *Enhancing Urban Climate Change Resilience: Seven Entry Points for Action* part of the Asian Development Bank’s Sustainable Development Working Paper Series (Bahadur, Tanner & Pichon, 2016). These seven key points guided the selection of data and informants who supplemented the literature review. The following graphic visualises the Seven Entry Points to UCCR, showing some key areas where mobile technology could be introduced.

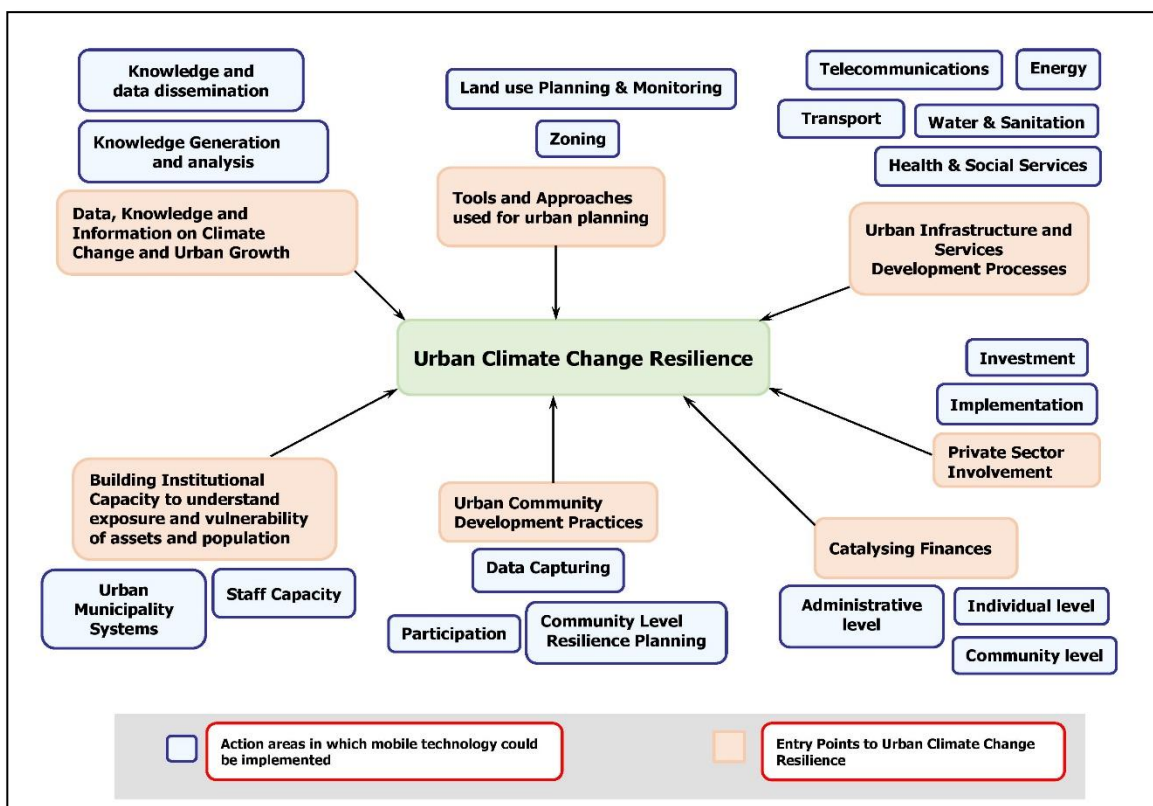


Figure 1: Visualisation of UCCR Entry Points and potential Action Areas to implement Mobile Technology

3.2 Data Collection

To answer the research questions two main data collection methods were used. Literature on Nairobi’s urban challenges and the use of mobile technology being applied to enhance climate change resilience was reviewed. Parallel to this, qualitative semi-structured interviews were conducted with key informants identified as guided by the framework entry points and the study objectives.

3.2.1. Literature review

A key source of data was a meta-analysis review, which is a qualitative literature review method. The meta-analysis review technique is best suited to evaluate, integrate and interpret multiple qualitative studies and combine the findings to create new interpretations (Cronin, Ryan & Coughlan, 2008). Literature selection was guided by three major themes which were identified based on the research question i.e. urban resilience, mobile technology, and the entry points from the framework. The three major themes were then sub-divided to answer questions tied to the guiding research questions. Literature from different levels was reviewed- global, Africa and local (Kenya or Nairobi). The search included the use of databases including LOVISA and Scopus to identify peer reviewed literature related to the identified thematic areas. Additionally, grey literature such as policy briefs, government bills, reports and budgets and white papers from private institutions, companies and service providers were also used. Literature reviewed about mobile technology was limited to between 2007-2017 due to the rapidly changing nature of the technology, in exception of literature about the ICT sector in Kenya- which was analysed to provide an understanding of the growth and trends in the ICT and mobile tech sectors in Kenya thus improving the context by adding the historical foundations of the sectors.

This was important in identifying and comparing the global and regional best practices in the use and application of mobile technology for climate resilience in urban areas. After screening summaries, irrelevant literature was excluded, additionally, other significant studies were identified using snowball sampling of the references³.

3.2.2. Interviews

Semi-structured interviews were conducted to supplement literature and to incorporate the opinions of actors from different sectors. Informant selection was guided by the entry points in the framework described above. Semi-structured interviews are based on a

³ The search parameters applied resulted in a substantial number of papers, articles and reports to be reviewed linking climate change resilience, urban areas and ICTs. However, as research in the field of mobile technology for UCCR is still emerging, an in-depth look through the literature showed that most did not contain in-depth analyses on the application of mobile technology but based on theoretical assumptions and current trends.

predefined set of questions addressing the main area of research. However, they also allow the interviewer to adjust the interview to address an issue more in-depth (Gill, Stewart, Treasure, & Chadwick, 2008). Additionally, they provide the opportunity for the interview to address issues that had not previously been identified by the interviewer that could be important to the overall research (Gill et al., 2008). In this case, because the interviews aimed to capture the perspectives and actions of actors from various sectors to address various identified themes in UCCR and mobile technology, the semi-structured format proved effective in combining the various views.

An interview guide was used (See Appendix A) however, follow-up questions were added during the interview depending on the flow of the interview. Each interview guide was developed based on the informant's position or role as guided by the framework. A brief outline of the general themes of the interview was sent to the interviewees to allow for their adequate preparation. Of the four interviews conducted: two were Skype calls and one a WhatsApp call due to the busy schedules of the informants, the fourth was a group interview held with the staff at the Makerere University College of Health Sciences School of Public Health **ResilientAfrica Network** (RAN) offices based in Kampala, Uganda. Each interview was approximately an hour long and was recorded for later analysis. Hour long interviews were identified as a reasonable length based on the pre-interview communication with each interviewee, additionally, it would provide the required time to go through the questions in the interview guide with sufficient time for important points to be explored deeper.

Table 1 presents an overview of the respondents, their backgrounds and reasons why they were important for the research.

Table 1: Key informant fields and motivation

Informant Background	Motivation for interview
Android App Developer (Informant Q)	<ul style="list-style-type: none"> • Developed free Climate Change in Kenya Awareness app • Factors supporting app development • Motivations for development of awareness apps • Challenges faced in development, financing and marketing of apps
ICT Consultant; Created online platform for Community participation (Informant R)	<ul style="list-style-type: none"> • Founder of FixMyWard- an online platform for community participation and awareness • Factors supporting app/platform development • Motivations for development of platform • Impact of platform on community • Challenges in development and use of platform • Perspectives on how mobile technology can enhance urban resilience
Makerere University College for Health Sciences School of Public Health Resilient Africa Network (RAN)	<ul style="list-style-type: none"> • The network acts as a central platform for research and data collection related to resilience in the Region • They were a key supporting partner to recent competition on climate change and mobile technology • The network also supports innovators through various means • Key source of data to meet the action points in the framework
Urban Planner in Nairobi; Community Based Organisation founder (Informant T)	<ul style="list-style-type: none"> • Perspectives on Nairobi's Urban Planning and development • Perspectives on community participation • Perspectives on how mobile technology can enhance urban resilience

3.3 Analysis

The interviews were transcribed using an online, free transcribing platform- oTranscribe, it allowed for easy transcription due to a user-friendly interface that also allowed users to adjust audio playback speeds. The transcriptions were verbatim, however fillers such as 'uhm', 'you know' and other sounds such as laughter were eliminated. In the case of this study, it was the informational content that was the priority thus more focus was put on the accuracy of the transcript, an argument further supported by Stuckey, (2014). Scratch-notes were also taken, and proved significantly helpful when one of the interview audio files was lost.

3.4 Research Limitations and Obstacles

One of the major obstacles to data collection was non-response from potential informants. In the case of no-response from the City County departments, the alternative was to identify an informant with ties to the County and its functioning- thus a Nairobi based urban planner was interviewed. Other sources such as YouTube videos and podcasts substituted information gaps from various sources. They provided some insights into the working of the organisation and were used as a primary data source.

An important aspect was that some informants requested the omission of some information due to it being protected by contract or proprietary information regarding future innovations. This was not included in the analysis. One potential information source for the research had initially been the users of some of the apps, particularly those downloaded from online app stores. This however proved challenging as there was reluctance by the app developers to identify the users who they were aware of (such as through the comments and complaints made about the app). Additionally, there was reluctance in giving exact user numbers, thus estimates had to be made in the analysis.

Despite the recognition of the role ICTs and mobile technology could play in sustainable, resilient development, there is a limited number of peer reviewed studies that analyse their application for urban climate change resilience. This is a major limitation to this research, as it not only involves a review of the mobile technology being developed and implemented in the city, but also attempts to complement these practical aspects with empirically proven literature resources.

This study assumes that technology should be adaptable to meet the needs of different users if it addresses similar challenges. Thus, applications developed outside Nairobi could be adapted to meet Nairobi's needs. This also contributes to addressing the need to find replicable and scalable technologies that will lead to the overall development of urban climate change resilience.

Finally, looking at the needs of low income urban areas and urban informal settlements, such as discussed by Beyer et al. (2016); these areas may require even more tailored

solutions to facilitate climate change resilience and general societal resilience. This study however did not fully delve into all the options for this economic group which was also a critical point mentioned by some informants.

4. FINDINGS AND DISCUSSION

This section divided broadly into two sections (*Findings* and *Discussions*) presents the results of this study and discusses their implications. It is organised based on four themes: *i) Nairobi's risk landscape and factors contributing to stronger urban resilience, ii) historical development and trends in the ICT and mobile sector, iii) the Seven Entry Points to UCCR Framework - opportunities and pathways for mobile tech and UCCR, and iv) Challenges in the development, adoption, and use of mobile tech.*

FINDINGS

4.1 Nairobi's Urban Risk Landscape and Factors Contributing to Stronger Urban Resilience

An understanding of the factors that contribute to vulnerability is an important first step to address the issues systematically and comprehensively (Beyer et al., 2016). This section is based on findings from literature and the key informant interviews, addressing factors that contribute to vulnerability in Nairobi and its residents.

4.1.1 Nairobi's Urban Challenges and Risks

Nairobi is susceptible to shocks and stresses which impact on the residents lowering their resilience. The climate related shocks affecting the city is mainly flooding from heavy rainfall. It also results from the urban built-up patterns and unplanned or un-monitored construction which are not "...taking into account the climatic needs of the area" according to Informant T (Interview, March 14, 2017), an urban planner in the city. This is further supported by literature (Thorn, Thornton & Helfgott, 2015; Beyer et al., 2016; 100 Resilient Cities, 2017). Fires are another major challenge especially in slum areas, where the structures are semi-permanent and not properly constructed (Beyer et al., 2016).

Stresses impacting the city include: food price fluctuations (resulting from drought and delayed rains), water shortages, disease outbreaks, environmental pollution and degradation (NCCA, 2015; Beyer et al., 2016; 100 Resilient Cities, 2017). Informant T, and Informant R also highlight the increasing severity of water shortages in Nairobi (Informant R, Interview, February 2017; Informant T, Interview, March 14, 2017). Informant T further describes the increasing influence poor solid waste management has

on Nairobi's drainage. (Interview, March 14, 2017) Other challenges that increase vulnerability include insecurity, terrorism, high levels of youth unemployment, aging infrastructure, infrastructure failure and high levels of poverty (NCCA, 2015; Beyer et al., 2016; 100 Resilient Cities initiative, 2017).

The city has the largest share of the country's informal settlements, about 62.4 % according to the 2009 Population census (KNBS, 2012). This further increases its vulnerability due to the fragile position of these socially and economically marginalized populations. The increasing size of these areas causes more strain on the aging infrastructure and increases the planning and urban development challenges, further it poses threats such as environmental degradation (Thorn, Thornton & Helfgott, 2015). Social resilience is further affected especially due to the need for lower income earning populations to survive, causing increased crime, school dropouts and increased drug and substance abuse (NCCA, 2015; Beyer et al., 2016).

4.1.2 Present Factors Contributing to Nairobi's Resilience

Despite Nairobi facing a multitude of challenges, there are some factors that to various extents, contribute to the city's and its residents' climate change resilience.

4.1.2.1 Increasing International, Regional and Local Awareness on Urban Risk, Resilience and Sustainable Urban Development

Africa's cities have some of the fastest urbanisation rates in the world, however despite this, urban areas have been understudied, with only recent scholars and practitioners beginning to focus on the issues faced in Africa's urban areas (Munene, 2015). Additionally, there has been a steady increase in the number of research networks on risk and resilience such as the African Urban Risk Analysis Network (AURAN), Urban Africa Risk Knowledge Network (Urban ARK) (Munene, 2015) and RAN. These channels support researchers and practitioners whose focus is on urban risk and resilience and in so doing have propelled resilience further up on the agenda, and the research feeds into the policies and strategies developed continent wide. It has led to increasing awareness of the need for urban areas and cities to incorporate resilient planning and sustainable development,

cities such as Dar es Salaam, have begun introducing resilient initiatives into their city planning and strategies.

One of these initiatives, of which NCC is a member, is the 100 Resilient Cities initiative under the Rockefeller Foundation. Through this initiative, participating cities, such as Nairobi, are eligible to receive various forms of support that will allow for more resilient city planning and development. This support comes in the form of support to hire a Chief Resilience Officer (CRO), who will oversee the resilience efforts, expertise and guidance in developing a “robust” resilience strategy (Rockefeller Foundation, 2017), access to a broad range of technologies and services through the initiatives partners and a collaborative network of cities to facilitate inter-city learning and act as a platform for sharing (Rockefeller Foundation, 2017).

At the regional level, networks such as the RAN provide platforms for research, collaboration innovation and strengthening of resilience in cities of participating countries. RAN is made up of a network of 18 African universities in 13 countries whose research fields have been divided into key thematic areas to guide development of innovative solutions to address challenges affecting resilience across the continent. With deeply entrenched values of community inclusion and engagement into its research, RAN can support activities in Nairobi through its Regional offices in Kampala and other collaborating partners (RAN interview, February 21, 2017).

4.1.2.2 Increasing Recognition of Climate Change and Sustainable Urban Development in National and County Planning and Policy

The promulgation of the New Constitution in August 2010 signalled radical changes in Kenya’s governance at the national and local levels. Laws and regulations related to urban development were reviewed and developed to include the inclusion of the new Constitution’s requirements. Figure 2 below illustrates some key urban development policies under the new regime as summarised by Munene (2015). With the support of the Japan International Cooperation Agency (JICA), Nairobi has also drafted the Nairobi Integrated Urban Development Plan (NIUPLAN), which it aims to use as a blueprint to guide the city’s development (JICA, 2014).

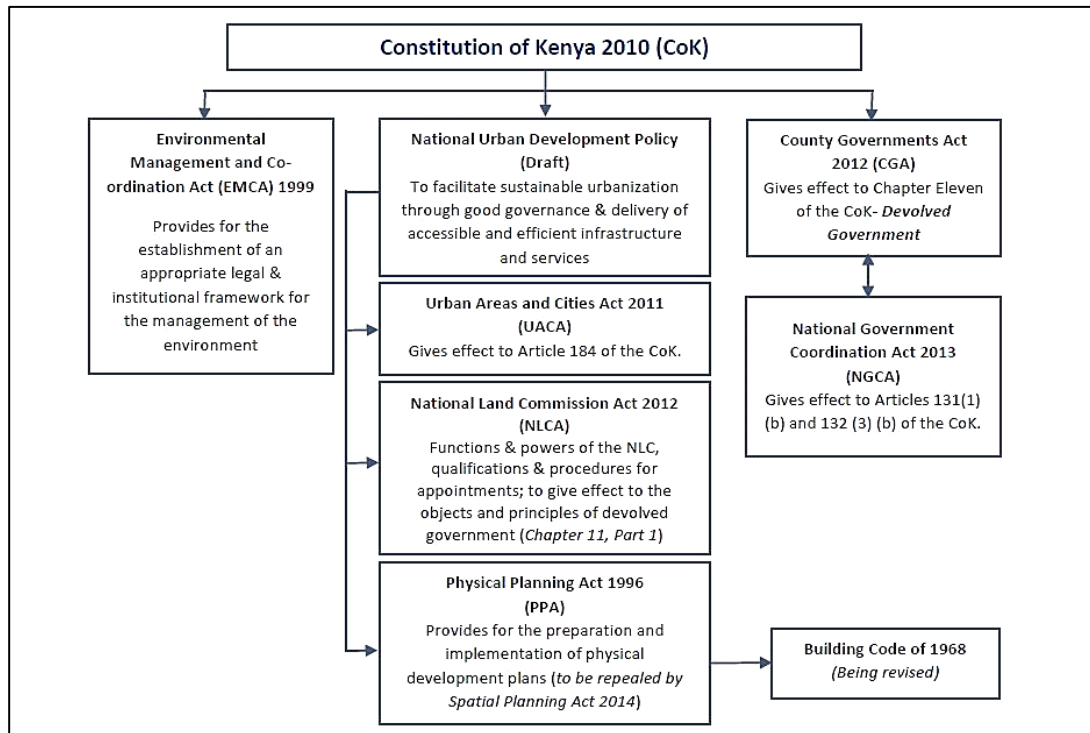


Figure 2: Laws and Plans Associated with Urban Planning Development in Kenya (Munene, 2015)

According to Informant T (Interview, March 14, 2017), factors that are contributing to Nairobi's resilience in relation to policies and by-laws are tied to an increasing acceptance by county authorities on the need to transform urban areas and the important role communities play in this. The changes require a transformation in planning and zoning laws which greatly influence how and where construction is carried out. Shifting to options such as micro-zoning would allow for planning and development that takes better account of the city's terrain and activities in the area, thus reducing the extreme impacts experienced in some areas, such as flooding during heavy rainfall (Informant T, Interview, March 14, 2017). A key observation Informant T makes is that some city residents are still reluctant in accepting that these transformations need to occur (Interview, March 14, 2017).

4.2 Trends in the ICT and Mobile Sector in Kenya

This section presents an assessment of trends in the ICT and mobile technology sector of Kenya and how these changing trends have influenced the use of mobile technology and adoption of ICT into national and county plans and policies. Through this evolution, we

begin to understand how mobile technology can be streamlined to address UCCR and contribute to increased resilience.

4.2.1 Historical Evolution of the Mobile Sector

The Kenyan ICT revolution in the early 2000s resulted from the need to develop better policy for the ICT sector, not only at the local level in Kenya, but also on the global scale (Informant R, Interview, February 9, 2017). Informant R, an ICT professional, explained how Kenya's ICT industry evolved from a monopoly as changes in the regulatory framework catalysed market liberalisation which fostered competition that facilitated the growth of the ICT sector (Interview, February 9, 2017) this is also supported by studies conducted by Foster (2013) and Omae, Langat, Ndung'u (2015).

A critical development step taken in 2008 was the objective by the Kenyan government to provide universal access to ICTs under the Vision 2030 initiative (Apoyo Consultoria, 2011). ICTs were envisioned to contribute to economic growth, facilitate the improvement of education standards and information access as well as enable accountability by government officials (Apoyo Consultoria, 2011). Vision 2030, as a long-term national development strategy is therefore critical in all sectors and at all levels, including in Nairobi's planning and development strategies.

In terms of policy specific to the mobile sector, the Kenya Communications Act, 1998 (GoK, 1998) led to the creation of the independent industry regulator- the Communications Commission of Kenya (CCK)⁴ (Waema & Ndung'u, 2012; Foster, 2013). Through the CCK's regulation and licensing, the mobile sector saw extensive growth and innovation driven by a competitive mobile environment (Foster, 2013). According to Informant R (Interview, February 9, 2017), in addition to better industry regulation and room for competition, the new policies were more supportive of public participation, which led to the emergence of many locally led initiatives adopting ICTs and mobile applications to address issues on the ground.

⁴ Now Communication Authority of Kenya (CAK)

4.2.2 Climate Change in Kenya's Present ICT and Mobile Environment

The government of Kenya, through a sectoral brief, outlined key strategies aiming to mainstream the National Climate Change Action Plan into the ICT sector (GoK, 2012c). This was done to address the lack of integration of climate adaptation and mitigation within the sector. A recommended action included in the brief is to make '*ICT-centric investments*' where mobile phone applications are listed as a potentially viable option that needs exploring for application in the 'most vulnerable sectors' including agriculture, health and water. Mobile-phone based apps are viewed as tools to act as sensors to generate and transmit climate data and information for analysis and dissemination. The end-users of this data could then receive the climate related information via their mobile phones in their local languages. An important observation throughout the brief is a lack of focus on urban areas, which are not mentioned at all in the brief.

There has been an explosion in number of technology and innovation programmes, hubs and spaces in Kenya which support innovators in various ways. They include: Accelerators- programmes that include mentorship and educational components to facilitate the growth of an innovator and their innovation or start-up, culminating in a product pitch, examples include Savannah Fund, Synopsis Group and The Growth Hub. Another avenue is through incubators- where new start-ups or businesses can receive services such as management training or office space, they include: iLab Africa, Nailab and mLab, and finally co-working spaces where innovators can share office space and other available resources- such as Business Lounge, Nairobi Garage, Genius Executives and iHub. Many of these may provide multiple services such as both incubation and acceleration programmes. Some hubs have also focussed on supporting women in technology and development including: Akirachix and Safaricom WIT (Women In Technology) which are based mainly in Nairobi. Through these various platforms, innovators work to help address various social, economic, political, health and other challenges that increase vulnerability. Key to note is that many of these hubs are not uniquely addressing climate change or resilience directly or exclusively.

With a focus on climate change adaptation and mitigation, the Kenya Climate Information Centre (KCIC), provides incubation services for innovators working to

address climate change. Its key focal areas being in the fields of clean technology (clean tech), water and sanitation and agriculture. In 2016, KCIC was supporting more than 130 start-up Kenyan companies working on innovative technologies for the climate sector (Lee et al., 2016) it is uncertain how many had a mobile tech component however. A major service that the KCIC offers to the innovators admitted to its programme is the provision of 'proof of concept grants' (KCIC, 2013). According to the CEO, Mr Edward Mungai, they are used to reduce the project's risk with the aim of attracting angel investors who will be more incentivised to buy into an innovation if they see that the innovators have reduced the investment risks in the company (KCIC, 2013).

The RAN on the other hand, provides both accelerator and incubation support to its innovators or interested stakeholders. Through a crowd-sourcing strategy, RAN identifies teams or individuals with already existing innovations who then go through an acceleration programme which entails an "*intense mentorship and capacity building programme*" (RAN Interview, February 21, 2017). After this accelerator programme, the individuals or teams can advance their innovation further or seek additional funding from donors (RAN Interview, February 21, 2017). RAN's incubation support includes mentorship and capacity building for its innovators who mainly include students and professors. They mainly require improved skills in research, grants writing and project pitching, and to develop tools that can be used in partnership with their target communities to come up with scalable innovations which meet the end users' needs, thus building community resilience (RAN Interview, February 21, 2017). Further RAN provides free working space to innovators and developers for meetings and research. A key component noted from RAN's processes is the importance it places in capacity development for its innovators. After training at RAN, innovators are better equipped to create more community focussed innovations and have higher chances while seeking funding to develop and launch their products (RAN Interview, February 21, 2017).

4.3 The Framework: Opportunities and Pathways for Mobile Technology in UCCR

The following section presents the findings of the role mobile tech can play in the UCCR Framework adopted in this thesis. I present several solutions that could be cross-cutting

across the various entry-points, it is not intended that each application or platform discussed is unique to only one entry point, with some providing multiple solutions.

4.3.1 Data, Knowledge and Information on Climate Change & Urban Growth

Based on the data analysed, several key themes were identified under this entry point. First there are actors who generate data on climate change and those who disseminate data on climate change. RAN fell under both categories as they not only conduct research to support climate change resilience, but they also disseminate climate resilience data as an organisation and through initiatives by their innovators. The network however does not limit their support to mobile tech innovators, and in fact have so far (at the time of interview) only had 2 mobile-based innovations aimed at agricultural support, and others aimed at health diagnostics had a mobile phone component (RAN interview, February 21, 2017).

Mobile app developers mainly played a key role in information dissemination as exemplified by the 'Climate Change in Kenya' app, available for free download from Google Play Store and other Android based app-stores. This app particularly, was developed based on its developer's personal interest in environmental conservation issues (Informant Q, Interview, February 12, 2017). It is centred around data from the UNEP-Kenya Atlas of Our Changing Environment (2009), through various 'pages' the app presents data on environmental action, climate change challenges in Kenya and general awareness raising (see screenshots in Figure 3). There are various other apps that also have similarly designed layouts and objectives- such as presenting simplified explanations of National climate change policies and strategies as exemplified.

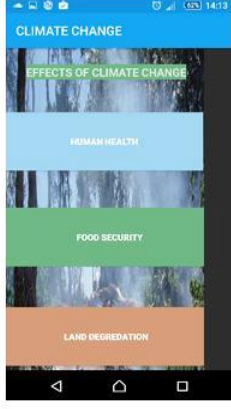



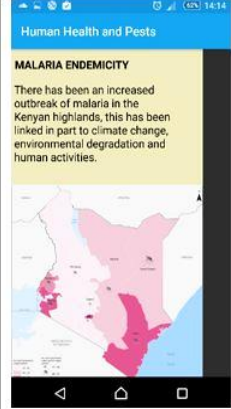

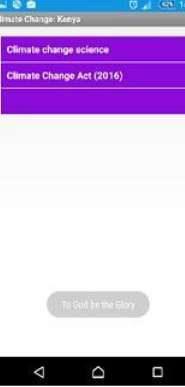

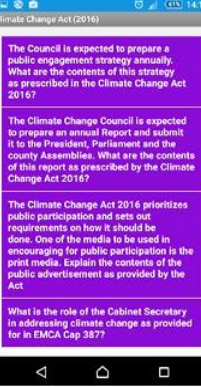

App Name & Details	Screenshots				
<p>Climate Change Kenya</p> <p>Source: Google Play Store Version: 1.0 Last Update: 10/02/2016 Downloads- 50+</p>					
<p>Climate Change: Kenya</p> <p>Source: Google Play Store Version: 1.0 Last Update: 07/02/2017 Downloads- 10+</p>					

Figure 3: Screenshots from climate change focussed apps

A major observation from these apps is a lack of a ‘focussed’ target group, as they seem to convey general information. This makes it quite difficult for users not actively seeking apps with the information to come across them as pointed out by Informant Q, one the developers (Interview, February 12, 2017). Further, they do not necessarily prompt any resilience related behaviour or thoughts and present solely as a medium of information communication. In order to effectively communicate the message and make it more usable, the app developer should take more consideration on their target users and the influence they want to create from the app, whether it is in the form of actionable prompts or activities or as an information communication platform.

An alternative channel to transmit climate change data and raise awareness is through mobile based video games. The significance of this can be exemplified through the winners of the UNDP-IGAD Hack4Climate competition, held in Nairobi, Kenya with the support of the RAN. The winning team developed a mobile-based video game that aims to promote environmental protection and management strategies. According to one of

the game developers, the target group will be 11-12 year olds who will, through the game, learn about climate change and greenhouse gases. They will also learn to fight climate change through planting trees and get education through other ‘cool game mechanics’ that the age group can relate to (ICPAC, 2016).

It would be possible to develop apps or technologies that support climate and urban development data collection, this however would have to be a feature consciously built into the technology to support this (Informant Q, Interview, February 12, 2017). From the apps and tech the researcher identified, user data and the impacts or influence of the app on the user cannot be directly determined without the developer’s direct contact with users who had downloaded the applications. To analyse changes in user behaviour or evaluate if the tech is in fact enhancing resilience at either the individual or community level, some form of monitoring and evaluation (M&E) features would have to be built into the technology.

Innovators supported by RAN are by default required to include M&E criteria into their project pitches, guided by the needs assessments which support the innovation (RAN interview, 2017). This requirement can then be used to measure trends in the community where the tech or innovation is deployed based on the innovator’s objectives.

4.3.2 Tools and Approaches Used for Urban Planning

NCC to some extent uses mobile technology to facilitate easier service delivery, such as provisions to make various payments. However, these approaches, though convenient to city residents and county staff, do not contribute to climate change resilience building. According to Informant T, creating awareness among the authorities is a critical factor in determining if mobile tech can be used to support climate resilient urban planning (Interview, March 14, 2017). It has been noted within other circles, such as the private sector and civil service, that various vulnerabilities in the city can be addressed by introducing mobile based technology- such as environmental monitoring tools. The challenge however as outlined by Informant T is that the County has not placed enough value in this data, thus they do not act on it effectively. Informant T proposes that to get the County to buy into the value of data collected by the public, dis-incentives such as

losses in revenue to the county could be tied into the data (Informant T, Interview, March 14, 2017). For example, poor air quality could be a deterrent to investors, leading to a loss in investment revenue for the county. This approach, although not directly addressing climate change, creates a domino effect that results in actions taken by the relevant authorities to address issues highlighted by the city residents.

Another approach that can be taken, is exemplified through Informant R's FixMyWard Platform. It is a mobile and computer based technology platform that uses social media and messaging applications (mainly Twitter, Facebook and WhatsApp) to allow its users to report issues within the community. Its main aim is to connect its users to key players in service delivery according to its founder, Informant R (Interview, February 9, 2017). These service delivery agents include water & sanitation providers, electricity and the overall ward and county representatives. Evolving from a previous SMS-based platform that aimed to facilitate communication between constituency residents and their political representatives (Bunge SMS)⁵, FixMyWard has now incorporated channels through which members of the community can not only transmit information about their ward to each other, but also prompt ward representatives and the county to act on issues affecting their area (Informant R, Interview, February 2017).

The shift from an SMS based platform to include various social media channels also broadens its reach and channels of communication. Through this, the public can participate in the decision making important for the development and planning of their ward. FixMyWard provided a channel for informal conversations amongst the residents that raised awareness on the 2015/16 *El Nino* period; through its actions it provided a better platform for the County to respond due to the awareness raised amongst the South C Ward Residents (currently the main users of FixMyWard). The '*El Nino* Survival Kit' resulting from this joint community and county collaboration led to increased awareness and improved flood preparedness and mitigation (Informant R, Interview, February 2017).

⁵ See <http://www.wainainamungai.com/bungesms/index.html>

The platform is primarily focussed on the residents of South C ward, whose estimated population is 47,202 (Elimu Online, 2017); the researcher was not able to obtain a more accurate estimated number of users of the platform, as further attempts to contact its developer were un-answered. However, basing on the Facebook and Twitter followers alone, the platform reaches at least 3000⁶ users, which is only approximately 6% of the Ward's population. This value does not include other media platforms/channels which Informant R also mentioned were used, such as WhatsApp Messenger and ordinary SMS based communication (Interview, February 9, 2017). A further limiting factor to its reach is that the platform is primary aimed at users with internet connectivity.

Mobile based video games have also been trialled as a channel through which community participation can contribute to improved urban planning. *Minecraft* was used as a test on how technology could be used as an innovative channel to facilitate participatory urban planning and design. The project, spearheaded by UN Habitat and Ericsson concluded that games could be a good channel to include 'non-traditional stakeholders' (UN Habitat, Ericsson & ITU, 2014, p.8) such as the youth, in decision making process; especially in issues they would not commonly be involved in, such as urban planning (UN Habitat, Ericsson & ITU, 2014).

4.3.3 Urban Infrastructure and Services Development Processes

Urban infrastructure and services cover six critical sectors under the Fifth Assessment Report of the IPCC (Revi et al., 2014), they are water and sanitation, health and social services, energy supply, transportation and telecommunications, green infrastructure and ecosystem services and the built environment. The provision of good quality services enhances resilience of urban residents and enables them to overcome climate change related shocks and stresses.

Facilitating the provision of these services in Nairobi using mobile technology could be an innovative step taken by the county and its service providers. The term used in the ICT

⁶ This value may include some double-counted individuals i.e. users following the platform on both Twitter and Facebook as well as parties who are not directly influenced by the Ward's activities, such as external interested individuals.

sector to refer to this is ‘Enhanced Utility Solutions’ which is defined by Nique & Arab (2013) as “the use of mobile technologies, either through Machine to Machine (M2M) usage, and/or mobile services, i.e. SMS/USSD and mobile payments, to improve access to energy and water for the population without a formal utility connection.” Presently in Nairobi, the most common systems in place are the use of mobile payment platforms (such as M-Pesa, Airtel Money and others) to facilitate easier utility bill payments such as water and sewerage services, electricity, solid waste handling and so on; this generally means that the user must already have access to the service. For many of the residents living in Nairobi’s unplanned settlements, service delivery is unreliable or even non-existent, further increasing their vulnerability due to insufficient access to safe water supplies, and more money spent on unclean, non-renewable fuel sources for lighting and cooking. Various private sector actors such as non-governmental organisations (NGOs), business and even individuals are attempting to fill this gap in service provision; sometimes in collaboration with the necessary county service provider.

An instance of an initiative using mobile technologies to address vulnerabilities in the health sector to facilitate health service delivery (mHealth) is TotoHealth⁷. This is a mobile based platform that provides health and nutrition information to pregnant women and parents, thus reducing their vulnerability and lowering maternal and child mortality rates and help predict early childhood development challenges. Through SMS and voice based mobile services, registered users receive messages about nutrition and health and other reproductive health related services throughout the various stages of the pregnancy and child’s development. Additionally, county partners can use the app to communicate directly with the residents in the county to deliver important health information to its residents such as vaccination reminders.

In the sector of energy services, various pay-as-you-go (PAYG) solar energy providers are connecting many off-grid users to clean energy across the continent by using mobile based payment services. Pioneered by M-Kopa Solar⁸ in Nairobi; ‘Kopa’ a Swahili word meaning ‘borrow’, allows users to purchase solar lighting systems which they can install

⁷ See <https://totohealth.org/homepage>

⁸ See <http://www.m-kopa.com/>

in their homes or businesses and pay for the system over a one year period. Chad Larson, one of the founders, highlights how M-Kopa Solar revolutionised the energy sector through its innovative payment plan that enabled users who could not otherwise afford solar energy to access the company's services (Masuku, 2016). M-Kopa developed a proprietary platform that combines a sim card and a modem installed into the solar system allowing the company to monitor payments made over M-Pesa, a mobile money⁹ based platform (Masuku, 2016). Through the platform, M-Kopa can also collect user data which is used by the company for service improvements. The system comes with a variety of accessories and a solar panel, thus the users have options based on their financial abilities. The company has so far connected over 500,000 households across East-Africa with markets in Kenya, Uganda and Tanzania. Further, sales of its proprietary PAYG software to various other companies across the continent will facilitate the provision of renewable, clean energy to households across the continent.

The transport sector is also evolving to include mobile tech as a solution to daily challenges in the city. Various mobile apps have been launched in Nairobi to facilitate carpooling or ride sharing such as 'Carpooling KE', 'JazaGari'¹⁰ or even through social media platforms such as '*Carpooling in Nairobi*' on Facebook. Carpooling has numerous benefits not only leading to cost savings on fuel and public transportation, but on a broader scale, contributes to reduced carbon emissions by lowering the number of cars on the road. Further, Nairobi, a city constantly plagued with heavy traffic jams, requires more sustainable transport alternatives, thus carpooling provides a workable solution to reducing the number of cars on the road. In fact, the Nairobi County government estimated that in 2014, traffic in the city cost the County over USD 570,000 in lost productivity daily (McGregor & Doya, 2014), while an IBM study in 2012 identified that 75% of Nairobi's 1.5 million commuters drive alone (Mwaniki, 2017).

With regards to telecommunications, numerous mobile based apps have been created to assist in emergency relief, thus reducing community vulnerability stemming from natural disasters, accidents, insecurity and other vulnerabilities in the city. Apps such as 'iRelief

⁹ Mobile money refers to mobile phone based money transfer services (Foster, 2013)

¹⁰ 'Jaza Gari' literally translates to 'fill a car' from Swahili

and the 'Kenya Red Cross' app provide methods to respond to an emergency, either through management of relief stock and distribution or as a platform to raise awareness and crowdfund in response to a disaster. Additionally, other platforms seek to improve emergency response from health service providers such as ambulance services and hospitals, as well as the police and fire departments. Two examples of these are the soon to be launched 'Flare' and 'Usalama Technology' which through the various platforms connect users to ambulance services and in the case of Usalama Technology, other emergency service providers also receive notifications. All these innovations, contribute to overall resilience of residents living within the city, and lowers their vulnerability to shocks.

Other initiatives facilitate effective and efficient service delivery by county providers; one example is WaSHMIS¹¹ (Water Sanitation Hygiene Management Information System). It aims to assist water and sanitation service providers in Kenya to minimise losses due to ineffective strategies, monitoring and resource management. It uses smart phone based data collection services in collaboration with other tech applications such as Geographical Information Systems (GIS). Through the collection of data, including GIS data, pressure, flow, level and performance, customer identification and tracking and other services, WaSHMIS enables utility providers to deliver effective services, monitor water delivery, keep track of payments, prevent defaulting and illegal connections and facilitate easier maintenance of delivery systems through warnings about system faults and automatic meter reading. The platform has been tested in Kericho County in western Kenya. It provides a scalable, replicable example of how simple technology, and analytics can lead to better resource management, hence contribute to enhanced resilience of urban support systems.

Water supply, management and sanitation monitoring is also highlighted by Informant R as a potential area where mobile technology could be used to coordinate better service provision through improved data collection and analysis that could improve decision making at the domestic, County and National levels (Informant R, Interview, February 9, 2017).

¹¹ See <http://www.washmis.com/>

4.3.4 Building Institutional Capacity

According to Bahadur, Tanner, & Pichon (2016, p.24), building the capacity of the County authorities on understanding climate-related shocks and stresses in the urban development context, “...can help bring urban climate change resilience (UCCR) to life.” Capacity building can be conducted through various means as exemplified in the study conducted by Wandera, Kang’ethe & Davies (2015) to assess the lessons learnt from mNutrition¹² and IBLI¹³-two projects that applied mobile technology- driven capacity development processes. Through a blended-learning approach, the members in the study project can utilise both a traditional classroom set-up and customised lessons through ‘eModules’ to deliver capacity building to the projects’ target groups. E-Learning is flexible and allows the users to pace themselves, thus county staff would not have to take long breaks from work to attend UCCR capacity building classes. Further, by using the blended-learning approach, the traditional classroom sessions could act as a platform for sharing perspectives, thus act as an additional platform for discussion about the County’s strategies, development plans and the role of climate resilience.

Adopting innovative avenues to enhance learning is critical in urban development and in climate change resilience. As Wamsler argues, “the establishment of learning mechanisms and iterative decision- making is essential to enhance action, including creative and effective forms of knowledge transfer and exchange” (2014, p.285). Through its membership in the 100 Resilient Cities Initiative, Nairobi will have access to various supporting partners and other participating member cities (Rockefeller Foundation, 2017). County staff, under the Chief Resilient Officer’s leadership, can gain insights from these partners and internalise the best practices applied in other cities. This is an opportunity for Nairobi to introduce innovative mobile- based learning and sharing

¹² mNutrition- an initiative to develop and scale up the delivery of nutrition messages through the use of agriculture and health mobile platforms to improve the nutritional status of women and children in poor households. It aims to reach people in 13 African countries including Kenya and 4 South Asian countries. (Wandera, Kang’ethe & Davies ,2015)

¹³ IBLI- Index-Based Livestock Insurance- a project aimed at designing, developing and implementing market-mediated index-based insurance to protect livestock keepers from drought-related asset losses in the arid and semi-arid lands of Kenya and Ethiopia (Wandera, Kang’ethe & Davies ,2015)

platforms, through which staff can keep track of the various goings-on in the 100 Resilient Cities Network.

4.3.5 Urban Community Development Practices

Community-based organisations (CBOs) and the civil society are key actors in urban climate change resilience building and urban development. This is a key theme identified by most the key informants interviewed, both Informant T and Informant R play significant roles in the organisation and management of CBOs in their respective areas. One of the key drivers for increased public participation was the Constitution of 2010 that provided for public participation in the governance of counties for connected purposes (under Cap II of the Constitution, 2010). Further, under the devolution strategy, public participation is a requirement at various levels, including the ward level, which is the lowest county governance level (Informant R, Interview, February 9, 2017). According to the Urban areas and cities Act (GoK, 2012), residents of a city, municipality or town have the right to make proposals and deliberate on issues related to county and national policies, legislation and development plans, plan and propose strategies to engage various levels of government, monitor activities of their elected representatives and make contributions and recommendations to the county boards about issues regarding the management of the urban area or its jurisdiction. This encouragement for community participation has been viewed as a major driver towards urban resilience (Informant R, Interview, February 9, 2017; Informant T, Interview, March 14, 2017).

Access to information is an important aspect of the Public Participation Act governing Nairobi County (NCC, 2015). This is also emphasised in literature, according to Wamsler (2014, p.285), "*All urban stakeholders, not least city dwellers, have the right to information on risk reduction and adaptation that is tailored to them.*" Informant T identified that although there is generally some degree in openness of information access and delivery to Nairobi's residents, the County indirectly relies on informal channels such as information or news sharing through various WhatsApp group messages (Interview, March 14, 2017), this is similar to FixMyWard's approach. The mobile based nature of these platforms eases and speeds up information transmission.

The role of the Civil Society in Nairobi's urban resilience and development was studied by Munene (2015), he concludes that despite the broad and diverse nature of CSOs in Nairobi, their impacts are felt mainly in the 'Economy & Society' and 'Health & wellbeing' aspects, while 'Infrastructure and environment' is not very successful. Further, despite the more inclusive new regulatory frameworks developed that broaden the space for contribution by the public and CSOs (such as the New Constitution, 2010 and devolution), regulation is still not "...adequate to boost urban resilience and participation of the citizens" (Munene, 2015, p.49) as it gives broad strategies, heavily reliant on technocratic wisdom, which does not foster much change. This is supported by Informant R, who adds that, "Technological change and innovation have outpaced policy processes... [which] may be the reason for the vague non-committal policy statements at county level" (Informant R, Personal Communication, February 11, 2017). In his study, Munene (2015), recommends that the enabling environment supporting and enabling creativity in the development and application of plans such as the NIUPLAN, would be better to facilitate community participation in urban resilience unlike the "...rigid, prescriptive resilience plan" (Munene, 2015, pp. 49-50).

Informant T stresses that public education is critical to achieving urban resilience and improved community participation (Interview, March 14, 2017). This flow of information between the administration working to develop the city's resilient strategies and action plans and the community will facilitate better understanding and promote contribution from the various stakeholders, including regular residents, who may feel excluded (Informant T, Interview, March 14, 2017). According to Informant T, public education can be approached using SMS based informative campaigns or in collaboration with the media (Interview, March 14, 2017).

A major theme throughout the interviews is the need for tools that people can engage with and relate to. RAN requires their innovators to carry out in-depth studies amongst their target communities, and develop tools well suited to their needs (RAN interview, February 21, 2017). This is also echoed by the mobile technology developers who stress that the well planned, more interactive and user-friendly technologies facilitate better information transmission and response from the users (Informant Q, Interview, February 12, 2017; Informant R, Interview, February 2017). Informant Q, adds that this is critical if

trends on the influence of the app on its users needs to be analysed, providing a deeper understanding of the impacts of the technology on the community's resilience and to improve the delivery of the service (Interview, February 12, 2017). The developer must therefore ensure a well-balanced app, that is focussed on a specific 'niche' or target to obtain the best results (Informant Q, Interview, February 12, 2017). This can be achieved by studying the intended target group's current behaviours and personality traits; developers could then be able to adopt their innovation to better fit their users' needs (Informant Q, Interview, February 12, 2017). Informant R further articulates, that innovators must learn to tap into what people need, even if they (the public) may not realise they need it. It is important that developers need to find ways of integrating channels to learn from the user and then release technology that is better adapted to their needs, such as through user locations, timestamps etc. (Informant R, Interview, February 9, 2017).

In addition, mobile platforms should not only be used as information receptors, according to Informant T, but they should also allow users to report issues within their communities. He adds that through well curated databases of reporting and responses between the community and the County authorities, reports can be developed which would act as a good accounting tool to the community (Informant T, Interview, March 14, 2017). This means that using well developed mobile technology, vulnerabilities in the community can be identified by the community, communicated to the relevant authority or service provider, addressed by the responsible party and feedback reported back to the community. This data provides the County a form of evidence based-accountability to its residents and electorate thus ensuring improved resilience in the system.

While not currently being applied in Nairobi, the Citizens Interactive Platform (CIP), designed by Savana Signatures, is a mobile-based platform that provides marginalised persons, such as women, youth and people living with disabilities, the capability to participate in local governance (Savana Signatures, 2017). The platform which has been tested out in various districts across Ghana provides a channel for the local authorities to reach out to the community and vice versa, allowing participatory development planning and decision making. According to Savana Signatures (2017), the platform was developed in response to complaints brought up by the authorities on the financial, logistical and

human resource constraints which hinder them from better citizen engagement for the development of the area. This platform can therefore act as precedent for NCC officials to facilitate better citizen engagement and tap into the city's mobile tech sector.

4.3.6 Private Sector Involvement

Involving the private sector in UCCR is a beneficial strategy for the county's urban resilience strategy as they are a critical driver of economic growth, wealth creation and physical expansion of urban areas (Bahadur, Tanner and Pichon, 2016). According to Parameshwar, Pellech, et al. (2014) the key sectors for private engagement include micro-insurance, healthcare, water, sanitation and waste management, affordable housing, off-grid renewable energy, microfinance, ICT and livelihood promotion. An analysis of the major players in UCCR building in Nairobi shows that majority of the actors involved in the various sectors are from the private sector. Most technologies and apps discussed in previous sections of this thesis have stemmed from the response by the private sector to address Nairobi's or the country's vulnerabilities and shortfalls in service delivery and livelihood improvement.

Access to basic financial services has been greatly boosted throughout Kenya with the use of mobile money services. First launched in Kenya by Safaricom- a mobile phone service provider, in 2007, M-Pesa was aimed at meeting the banking needs for the majority of Kenyans who did not have access to formal banking services (Foster, 2013; Cook and McKay, 2015). The service allows users to send and receive money via SMS, without the need for a bank account (Foster, 2013). In addition, a collaborative partnership between the Commercial Bank of Africa (CBA) and Safaricom (M-Pesa) created a mobile-based bank account, M-Shwari, it allows users to make savings and receive loans (Cook and McKay, 2015). M-Shwari has enabled customers to save for short term, with increased future credit options, the funds saved earn interest and users are rewarded for 'good behaviour' (Cook and McKay, 2015, p.1) through a scheme that lets faster loan repayments and more savings lead to higher loan limits.

The effectiveness and ubiquitous nature of M-Pesa has also made it a preferred option by humanitarian responders for cash-transfer responses, especially to people who cannot be easily accessed (see ALNAP, 2008; Abdulla et al., 2011). Generally, it has improved the

financial stability of many Kenyans, especially the less vulnerable communities such as households in un-planned settlements (Beyer et al., 2016). Mobile money and other mobile banking services are now provided by numerous service providers country wide. From the ICT sector, the key actors who could be involved with UCCR and mobile technology include the various accelerators, incubators and innovation hubs that foster and support innovators to develop and promote their innovations. The growing number of actors willing to facilitate mobile development as discussed in Section 4.2.2 are a good starting point that the County and other interested stakeholders can tap into to try and address Nairobi's vulnerabilities while harnessing the skills and capacities available through these channels.

The business community are a key component to the city's overall resilience. Informant T emphasised the need for the urban planning that involves the business community in the city, not only due to the environmental impacts some of the businesses may pose, but also as influencers on how the County makes decisions (Interview, March 14, 2017). If the County's resilience and development strategies are not aligned with those of investors willing to work with the County, it could herald losses in investment in Nairobi (Informant T, Interview, March 14, 2017) a situation which is not envisioned by the County's authorities. Therefore, it is up to the County to ensure it streamlines its objectives to keep up with the demands of its residents and investors.

4.3.7 Catalysing Finances

Operationalising the framework requires a reasonable injection of finances. This requires a deep understanding of the value of climate change and resilience within the county's authority to facilitate better financial allocation (Beyer et al., 2016). Nairobi's current budget (Nairobi City County, 2016) has no provisions for any climate change adaptation or resilience activities which is an indicator of the low priority UCCR holds at that level. 'Fire and Disaster Management' is however covered, which perhaps to some extent may address some County vulnerability concerns. For private developers and investors, climate change resilience may hold higher esteem, based on the amount of investment made to address the County's shortfalls and the number of innovations developed to improve livelihoods, as well as a need to protect their own individual interests.

In the context of using mobile technology, financial services may be beneficial at lower levels such as at the individual or community level, where residents could then invest in improving their livelihoods thus reducing their vulnerability to climate related shocks.

4.4 Challenges to The Use and Application of Mobile Technology

The following section presents the challenges surrounding the development, marketing and use of mobile technology as identified through the key informant interviews and literature. It particularly focusses on the development, marketing or promotion, adoption and use of mobile based technologies to address urban climate change resilience and enhance social or individual resilience.

4.4.1 To Nairobi City County

As previously discussed, Nairobi County faces various challenges that increase the vulnerability of its residents to climate related shocks, however, the County is still not prioritising climate change adaptation and urban resilience as evidenced by a lack of dedicated County budgetary allocations as well as the lack of interest to contribute to this study. This means that many key areas remain un-addressed. Positively, the city's admission to the 100 Resilient Cities Initiative may act as a catalyst and drive the city towards better resilience planning and further, according to Informant T, there seems to be some recognition by the County authorities that urban areas need to be transformed (Interview, March 14, 2017). This observation is supported by increased budgetary allocations for 'urban renewal' and 'urban planning' (NCC, 2016). However, according to Informant T, there are still some conservative groups in Nairobi that are not willing to embrace the change that the city needs (Interview, March 14, 2017)

Overall, the general hesitancy on the County's part is the largest challenge to address, and requires shifts in political will which may take time. Further, Informant T observes that County staff may not be 'keen' to adopt mobile technology as it could be viewed as "more work" (Informant T, Interview, March 14, 2017).

To address these challenges, a key driver could be the new, younger generation of urban dwellers, according to Informant T (Interview, March 14, 2017). These are people who have been born and raised in the City and have a vision for its development and sustainability. The majority of this age group are highly educated and have the power to demand for change within the County (Informant T, Interview, March 14, 2017).

4.4.2 To Innovators and Mobile Tech Developers

All the key informants agreed that mobile technology has the potential to contribute to urban climate resilience and reduce vulnerability. According to Informant Q, “...we are barely scratching the surface...” when it comes to applying mobile tech in the environmental sector (Interview, February 12, 2017). Despite this positive perception towards the role mobile tech plays, innovators and developers face various challenges.

Informant Q notes that financing is a major hindrance, especially for apps aimed at social development (Interview, February 12, 2017), this is also echoed by Mr Edward Mungai while discussing challenges that innovators face (KCIC, 2013). App development is a time-consuming process and the developer requires resources (Informant Q, Interview, February 12, 2017) to not only support themselves during the development process but also invest in the process. Informant Q’s motivation for development of apps, such as the Climate Change in Kenya App (Section 4.3.1), is purely personal, as environmental issues are of personal concern. However, he acknowledged it would be difficult to profit from it, thus he only develops in his spare time, and holds a full-time job working as a developer for a telecommunications company. He further stressed that marketing is very expensive, for individual developers trying to attract users and build an audience. Thus, he relies on free platforms such as social media to market his apps (Informant Q, Interview, February 12, 2017).

Another challenge faced is access to facilities and the need for business development skills (KCIC, 2013). Developers may require specialised equipment to test their innovations before they can be rolled-out to the users, or just dedicated space to work on their ideas. Innovation labs and hubs such as iHub, Climate Innovation Centre and RAN are a few examples of spaces innovators could have access to (as discussed in previous sections),

however, many more developers may still not have access to such facilities. Capacity building for improvement in business development is a necessary component (KCIC, 2013; RAN interview, February 21, 2017) to ensure that developers can maximise on the resources available to them. Further, it helps them deliver scalable innovations that are optimised for the market, thus increasing the chances of bringing in returns.

The enabling environment also drives the development of apps and tech that can facilitate resilience building and reduce vulnerability. In Kenya, the policies are fully in favour of support for the use of ICTs as analysed above, however, there still needs to be a conducive environment for developers to tap into the opportunities presented by the emerging urban climate resilience discourse in the city. A key factor is the drive both politically (from the county) and from the users demands. Additionally, it should be easier for innovators to patent their innovations, thus the government's regulating body should make the process shorter and less bureaucratic, which is a major challenge according to a RAN interview informant (RAN interview, February 21, 2017). This will encourage more innovation and promote the growth and development of start-ups.

Market forces are another major challenge for developers (Informant Q, Interview, February 12, 2017; RAN interview, February 21, 2017). Two key themes appeared regarding this: competition from large telecommunication companies (RAN interview, February 21, 2017) and competition to attract user-attention (Informant Q, Interview, February 12, 2017). With regards to the first, the challenges which individual developers face such as securing financing, marketing and attracting users, are not issues that are experienced by large telecommunication companies. This means that in some cases, small start-ups may not be able to keep up with the pressure and discontinue their innovation process, leading to a shortfall. With regards to user-attention, Informant Q points out that there is stiff competition in attracting users who will keep using the app or technology and respond to it as is required, developers therefore should come up with innovative ways to market their apps or tech (Interview, February 12, 2017).

4.4.3 To Tech Users and Vulnerable Groups

A major challenge with the use of mobile technology is the access to the tech due to factors such as the cost of mobile devices, SMS and internet data especially by economically poor users. While cheaper phones may be available on the market they may have limited functionality, hindering the inclusiveness of targeted users (Koskinen, 2017). Additionally, Koskinen (2017) also points out that technical literacy may also be a hindrance for some user groups. Innovators must therefore come up with solutions to overcome some of these challenges to meet the needs of their target users, including the poor. This is also brought up by Informant T concerning users living in more vulnerable areas such as the unplanned settlements of Nairobi. These areas face even more pressures, which so far are not adequately addressed (Interview, March 14, 2017). Tech aimed at supporting resilience and reducing vulnerabilities in Nairobi's unplanned areas will have to be specifically tailored to various users, particularly for the women living in these areas, as they are even more vulnerable to shocks as detailed by Beyer et al. (2016) who also stress that a 'one size fits all' approach must be avoided.

Another challenge, is creating awareness amongst residents of the city on climate change resilience. While mobile tech can act as a channel to raise awareness, users still need to have some interest to seek apps or technology that would satisfy their demands, a level of awareness is necessary to facilitate this. These sentiments are brought up by both Informant Q and Informant T. It would also be important to overcome the issue of trust in the use of mobiles as a legitimate information channel (Koskinen, 2017). It is therefore necessary that a spotlight is put on UCCR to generate the necessary hype that will not only promote the creation of more tech to address Nairobi's issues, but also drive users to influence the system- and drive the development.

DISCUSSION

Upon analysis of these results, it seems Nairobi still has significant room for growth in the use of mobile technology to facilitate urban climate change resilience. The Seven Entry Points Framework has proved to be a good tool to assess Nairobi's present status with regards to mobile tech and has highlighted some key areas where mobile tech could be of potentially greater effect than others.

High potential areas include the use of mobile tech to collect climate and urban development data and information and disseminate it to various users, at the various levels. As data collection can be carried out by various groups and individuals for various purposes, the ease of use and versatility of mobile phones greatly facilitates the process. Additionally, mobile technology has shown great potential in the development and delivery of urban infrastructure and services. Various sectors are already benefitting from the implementation of numerous technologies to address gaps in service delivery and meeting the needs of the users and of more vulnerable members of the community, such as the poor. Indeed, as aptly phrased by Informant Q, “we are barely scratching the surface” when it comes to the application of mobile technology in the service delivery sector. Mobile tech can be tailored to meet the various city challenges addressed in Section 4.1.1. It is flexible and tech can be inclusive and integrated into already existing community structures, these factors are in line with the qualities of a resilient city outlined by Bahadur et al. (2016) and Arup (2014).

A key concern would be to ensure that the technologies are synergised and do not lead to counter-active effects, over-lapping and silos. This can be controlled by developing a clear vision for Nairobi’s urban resilience and climate change strategies with the collaboration of all key stakeholders. Taking advantage of Nairobi’s membership into the 100 Resilient Cities Initiative could be the best way to bring all the stakeholders together and create more mobile tech based channels to address some of the city’s vulnerabilities. This will be a more integrated approach to climate change resilience and urban vulnerability, preferably under the leadership and guidance of the County’s authorities, who are elected and employed to represent the people and their needs. Needless to say, Nairobi is not an island, and doesn’t exist in isolation from its neighbours. It would therefore be imperative that the broader metropolitan area’s objectives are incorporated into the planning, this includes neighbouring counties and the broader National agenda. As exemplified by the failure of curbing urban challenges by trying to decrease rural-urban migration (Abdullah et al.,2011), the underlying societal challenges must be addressed to achieve an overall successful result.

CBOs generally seem to be acting as a good channel between the higher administrative levels and the community, the clear vision will provide a better platform to advocate for

improved services and will lead to increased resilience. Looking at the private sector, there appears to be pockets of interest in addressing urban resilience challenges and climate change vulnerability, however other societal pressures seem to take precedence, thus are addressed first. Climate change however, in some cases, may be a secondary or tertiary consideration. To some extent, therefore, Nairobi's will have some levels of increased resilience (perhaps better healthcare, water & energy access) but on the climate change front, more measures need to be taken.

There needs to be increased buy-in from all levels, which may be difficult, especially for lower income residents and those living in unplanned settlements, who according to studies are considerably more vulnerable. It is therefore difficult to envision presently how CC could be 'sold' to them. Perhaps, it could be prudent then to build climate change resilience by approaching it from other avenues, such as addressing the challenges faced by low income households such security, stable income sources, and education to lower their vulnerability, as recommended by Beyer et al (2016). A considerable improvement in financial stability has been observed with the opportunity for people to save money using mobile money applications. While the additional loan services and PAYG platforms from the service providers has facilitated better access to services such as water, energy and healthcare.

The challenges in funding and financing for tech developers is a great deterrent to individual developers and channels need to be set-up as incentives for tech to address climate change vulnerability and support efforts to enhance UCCR. This of course again would require a conscious effort by the administration to incorporate mobile tech into its strategies and plans, thus create an initial platform for further development. Though the County has prioritised ICTs broadly as 'tools' to increase the County's effectiveness in service delivery, more succinct plans and strategies as to how they will be used to tackle urban challenges and address vulnerability need to be outlined.

Perhaps a shift by developers towards embracing emerging trends such as the use mobile phones for gaming as a channel for communication and awareness raising is a good way to target users. It could also provide the economical returns necessary to motivate more

innovation in this field, thus reducing the reluctance to develop purely society resilience based apps and tech.

A key aim of this research was to identify scalable technologies that could be used to enhance urban climate change resilience. While most of the technologies and apps discussed will, in various ways, contribute to this, it is important to understand how this enhanced resilience can be measured. For some technologies such as M-Kopa Solar, the company can quantify the savings users make (in terms of money spent on buying alternative fuel for lighting), the carbon reductions made by the adopting the system and several other indicators. However, this is not the case in all the scenarios. Perhaps by creating better platforms to share data amongst developers and researchers, better conclusions can be drawn into the cumulative impacts of the various tech in the market that aims to increase resilience or lower vulnerability. Further, it would be important to sell to the user base that there's value in them feeding back data through their phones and the apps they use. This may perhaps raise concerns in security and user privacy: data tracking and target advertising are becoming major issues of concern. One way to approach this, perhaps, is to create more user-interactive apps and technology, where the user is aware that they are contributing to a pool of data. This could allow general trends and user submitted information to be used to analyse change in behaviour, just as described by Informant Q.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

In answering the research question, “how can mobile technology facilitate urban climate change resilience in Nairobi? ”, the Swahili proverb ‘*haba na haba, hujaza kibaba*’ comes to mind. Translating to ‘little by little fills the measure’, it gives a clear picture of the various, innovative ways mobile technology is working at different levels in the city and country to facilitate resilience. Reflectively, this is perhaps Nairobi’s best strategy to achieving climate change resilience; breaking down this broad, seemingly complex notion into smaller community focussed and driven resilience goals. However, these smaller goals need to feed into the city’s broader resilience picture. Therefore, it is imperative that the NCC’s authorities and residents have similar development and resilience objectives. Therefore, while the innovations in place are addressing several of the city’s challenges, a more unified vision could drive a more focussed, scalable resilience County-wide initiative.

Mobile technology clearly has great potential in enhancing urban climate change resilience especially in its application for climate and urban development data and knowledge collection and dissemination through innovative mobile based apps and games that reach various target users. Further, while it is evident that the private sector is a strong driver of the development and launch of tech to address various gaps in service delivery, more can still be done, especially in partnership with the NCC.

The major driving force will be ensuring that UCCR is higher on the agenda, the push can be bottom-to-top, driven by private individuals, CBOs, CSOs and even the private sector. Tapping into the tech sector by the county should not be viewed as an additional burden, but as a resilient and sustainable development strategy, where the County’s goals and visions can be facilitated and materialised through more inclusive and reflective technological application.

Finally, Nairobi, being the Country’s capital should be at the forefront in driving resilience planning and sustainable development. The successful implementation of inclusive, technology supported resilience strategies will play a key role in driving the city towards

fulfilling the Sustainable Development Goals which are crucial global development objectives that every country is working towards.

5.2 Recommendation for Further Research

Upon reflection of this process, it is evident that direct contribution from the county may have facilitated better understanding of its plans and perspective, particularly on the use of mobile technology. It is important that future studies can further drive the inclusion of County participation and contribution to research in this field.

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APPENDICES

APPENDIX A- INTERVIEW GUIDES

1) ResilientAfrica Network

Questions

Hack4Climate Competition

- 1) What were the lessons learnt by the organisation from the competition?
- 2) What were the organisation's key objectives you set out to meet while setting up the competition?
- 3) Do you think as an organisation you met them? What did you feel were the key take-aways by all the competitors from the whole process?
- 4) From my understanding, the winners will have the opportunity to develop their pitch further. What kind of support will you offer in this regard? (Mentoring, financial, marketing etc.)
- 5) Are there any requirements from the developers that will be need by the organisation- In terms of user data collection or monitoring?
- 6) In relation to question above, do you intend to collect user innovation to track changes such as in user behaviour upon use of the innovation, for long term planning and research for instance? Is it the prerogative of the developer? How would you achieve this if you do?

Organisation's Operations/ Role

- 7) What would the organisation's key focus points be? (health, agriculture, energy, urban development, WASH, poverty alleviation?)
- 8) What other plans or initiatives are in the pipeline to promote or support innovation?
- 9) How do you promote or facilitate better uptake of innovations within the various levels of society?
- 10) What is your opinion about the use of mobile technology in general to facilitate climate change adaptation and build resilience- with a focus on urban dwellers
- 11) What do you think can make such innovations be more easily adopted by the community?
- 12) How do you think sectors such as urban planning and infrastructure use mobile tech to make it easier to deliver better services to the community?
- 13) Do you receive government support? How/ what kind?
- 14) As part of a network, you may have greater access to resources and partnering with the private sector to facilitate a broader influence of your activities. How do you think you can further tap into these resources to make regular citizens more aware of climate change and their abilities to adapt to it and become more resilient?
- 15) Do you have any contacts whom you think would further assist to this study?
- 16) Is there anything else you would like to add about the competition, the network's activities or any other issues that have come to mind during this interview?

2) Individual developers

Developer 1 (Wainaina Mungai)

Questions

- 1) If you can begin by describing FixMyWard, its objectives and how you promote it to different community members; main platform is computer/mobile based?
- 2) Who are your primary user group or focus?
- 3) How do you create awareness about your innovations?
- 4) Who are your primary user group or focus?
- 5) How do you create awareness about your innovations?
- 6) Do you collect user data and usage statistics? To track changes that are intended by the app for example
- 7) What challenges do you face or have you observed as a developer- in the development and marketing of technology, are there any support systems?
- 8) Do you receive government or private sector support? How/ what kind?
- 9) In 2005 you authored a paper about the 'M-vironment Approach', do you think Kenya has been effectively able to use mobile based technology to address issues such as those you discussed in your paper- environmental sustainability, awareness raising and information exchange?
- 10) How do you think urban residents can be more specifically targeted and encouraged to take advantage of tech access- considering they may have unique challenges brought about by climate change, compared to their rural counterparts?
- 11) In relation to the question above, what do you think can make innovations more easily adopted by the community?
- 12) As a developer and advocate for social justice, what do you think needs to be done to encourage more social participation at different levels- community, administrative?
- 13) How do you think sectors such as urban planning and infrastructure use mobile tech to make it easier to deliver better services to the community?
- 14) How do you think you can further tap into the resources available to you to make regular citizens more aware of climate change and their abilities to adapt to it and become more resilient?
- 15) Is there anything else you would like to add that have come to mind during this interview?

Developer 2 (Simon Mutua)

Questions

- 1) If you could begin by giving me a bit of background about your app, your motivation for developing it, and your general process
- 2) How do you determine what types of apps to develop? (Driven by prevailing demands/ for pay/personal interests)
- 3) If for pay, is all the data given to you or do you conduct separate research?
- 4) Who are your primary user group or focus?

- 5) How do you create awareness about your innovations?
- 6) Do you collect user data and usage statistics? To track changes that are intended by the app for example
- 7) What challenges do you face- in development, marketing, support systems?
- 8) Do you receive government or private sector support? How/ what kind?
- 9) What is your opinion about the use of mobile technology in general to facilitate climate change adaptation and build resilience- with a focus on urban dwellers mainly?
- 10) Do you think more can be done at different levels- community, administrative?
- 11) What do you think can make such innovations more easily adopted by the community?
- 12) How do you think sectors such as urban planning and infrastructure use mobile tech to make it easier to deliver better services to the community?
- 13) How do you think you can further tap into the resources available to you to make regular citizens more aware of climate change and their abilities to adapt to it and become more resilient?
- 14) Do you know any other developers creating apps aimed at social resilience or social development?
- 15) Is there anything else you would like to add that have come to mind during this interview?

3) Urban Planner (Constant Cap)

Questions

- 1) What do you think are Nairobi's major vulnerabilities- to climate change and disasters?
- 2) How can urban planning address some of these vulnerabilities?
- 3) Currently, what are the supporting factors driving urban resilience in the county?
- 4) What would be the most important aspects, in your opinion, for Nairobi's Urban Resilience Strategy?
- 5) What roles do you see the various stakeholders playing in this- county officials, national government, public, civil society and donors?
- 6) How could mobile technology fit into this complex system?
- 7) How could tech play a bigger role in facilitating the County's objectives?
- 8) What challenges do you think the county would face in implementing some activities supported by mobile technology?
- 9) Do you think the public should be involved in this resilient planning? How?
- 10) Do you think more can be done at different levels- community, administrative?
- 11) Briefly describe how you would envision a climate resilient Nairobi, and its residents