UNIVERSITY OF NAIROBI

SCHOOL OF COMPUTING & INFORMATICS

ICT INFRASTRUCTURE SHARING FRAMEWORK FOR MOBILE OPERATORS IN KENYA

By

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A project report submitted in partial fulfillment of the requirement for the award of Masters of Science in Information Technology Management of the University of Nairobi.

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DECLARATION

This project is my original work and to the best of my knowledge this research work has not been submitted for any other award in any University

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This project report has been submitted in partial fulfillment of the requirement of the Master of Science Degree in Information Technology Management of the University of Nairobi with my approval as the University supervisor

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DEDICATION

This study is dedicated to my uncle Symon and my late aunt Awinja for sacrificing their resources to educate and raise me despite the financial challenges. Their support and encouragement influenced my decision to further education.

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ANATEL	National Telecommunications Agency	**KPC**	Kenya Power Company
ARPU	Average revenue per user	**KPMG**	Klynveld Peat Marwick Goerdeler
ATC	American Tower Corporation	**LION**	Lower Indian Ocean Network submarine cable
BICMA	Bhutan Information Communication and Media Authority	**MPICT**	Mid-Pacific Information and Communication Technologies
BSC	Base Station Controller	**MPLS**	Multi Protocol Label Switching
BTA	Botswana Telecommunication Authority	**MSC**	Mobile Switching Centre
BTRC	Bangladesh Telecommunication Regulatory Commission	**MVNO**	Mobile Virtual operator
BTS	Base Transceiver Station	**NCC**	Nigerian Communications Commission
CAK	Communication Authority of Kenya	**NEMA**	National Environmental Management Authority
CBC	Commonwealth Business Council	**NITA-U**	National Information Technology Authority Uganda
CIDA	Canadian International development agency	**NOFBI**	National Optic Fiber Backbone Infrastructure
EASSy	East Africa Submarine Cable System	**NTA**	Nepal Telecommunication Authority
GoJ	Government of Jordan	**PANAFTEL**	Pan African Telecommunications Network
GoK	Government of Kenya	**PTA**	Pakistan Telecommunication Authority
GSM	Global System Mobile Communications	**PR**	Pyramid Research
GSMA	Global System Mobile Association	**PWC**	PricewaterhouseCoopers
ICTA	Information Communications Technology Authority	**RAN**	Radio Access Network
INMMASAT	International Maritime Satellite Organization	**RASCOM**	Regional African Satellite Communications System
INTELSAT	International Telecommunications Satellite	**RNC**	Radio Network Controller
ITU	International Telecommunications Union	**SGSN**	Serving GPRS Support Node
JTL	Jamii Telecommunication Limited	**TEAMS**	The East African Marine System
KBA	Kenta Bankers Association	**TOE**	Technological, Organizational, Environment
KCAA	Kenya Civil Aviation Authority	**TRAI**	Telecom Regulatory Authority India.
KEBS	Kenya Bureau of Standards	**UCC**	Uganda Communication Commission
KIPPRA	Kenya Institute for Public Policy Research and Analysis	**WBG**	World Bank Group

DEFINITION OF IMPORTANT TERMS

Active infrastructure: The sharing of electronic infrastructure (the intelligence in the network) and facility and includes sharing of base transceiver station (BTS), spectrum, antenna, feeder cable, Radio Access Network (RAN), microwave radio equipment, billing platform, switching centers, router, base station controller (BSC), database, optical fiber, backbone transmission network

Average revenue per user (ARPU): Financial performance benchmark in the telecommunication industry that measures the average monthly revenue generated per customer

Base Transceiver Station (BTS): The BTS handles the radio interface to the mobile station. The BTS is the radio equipment (transceivers and antennas) needed to service each cell in the network. A group of BTSs are controlled by a BSC.

Base Station Controller (BSC): The BSC provides all the control functions and physical links between the MSC and BTS. It is a high-capacity switch that provides functions such as handover, cell configuration data, and control of radio frequency (RF) power levels in base transceiver stations.

Capital expenditure (capex): Money spent by a business or organization on acquiring or maintaining fixed assets, such as land, buildings and equipment.

Infrastructure sharing: Having two or more operators coming together to share various parts of their network infrastructure for the purposes of their service provisioning

Mobile Virtual Network Operator (MVNO): Concept allows operators to be hosted by other operators and offer services without holding a spectrum license and heavy infrastructure investment

Operational expenditure (opex): The money a company spends on an ongoing, day-to-day basis in order to run a business or system.

Passive infrastructure sharing: The sharing of non-electronic infrastructure and facility (physical sites, buildings, shelters, towers or masts, electric power supply and battery backup, grounding, air conditioning, security arrangement, poles, ducts, trenches, right of way).

Radio access network: part of a mobile telecommunication system that implements a radio access technology.

Towerco: Independent investors build ICT infrastructure specifically to lease out to operators. They can also manage operators infrastructure at a fee.

ABSTRACT

The economic development of a nation can be accelerated by improvements in the country's ICT infrastructure (PR, 2010). The lack of infrastructure in Africa especially South of the Sahara is widely recognized, one of the continent's greatest impediments to sustainable development (CBC, 2013). Even with this challenge, ICT operators in Kenya still prefer to invest in their own infrastructure despite the availability of underutilized ICT resources from other operators and other players such as utility companies. This has led to wastage of scarce resources, high cost of products and services due to high costs incurred by operators, poor quality services, environmental pollution and low investment in rural areas among others. The objective of the research was to propose an adoption framework for ICT infrastructure sharing after establishing the levels, drivers and challenges of infrastructure sharing among the four mobile operators in Kenya. The data was collected using a questionnaire with the target population being ICT staff and managers from the four mobile operators Safaricom, Airtel, Essar (YU mobile) and Telkom Kenya (Orange) across the country. To supplement and increase reliability, data was also collected from other ICT stakeholders such CAK, ICTA, submarine operators, ICT vendors, KBC and non ICT related firms Equity, Barclays and Kenya Power Company.

The research found out that ICT infrastructure sharing level in Kenya was low at 20.4%. The five key drivers of infrastructure sharing were identified as new market entrants, cost optimization, environmental conservation, operators focus on core business and network deployment to underserved and un served areas. The five main challenges were established as lack of regulatory & policy framework, high capital, complexity of the sharing process, high charges by infrastructure owners and operators unwillingness to share due to limited or lack of capacity. The study also established that the TOE framework could be adopted for ICT infrastructure sharing with organizational factors having a greater adoption influence than technology and external. Operator controlled infrastructure rollout had worked previously but due to changes in local and global market, there was need to change the way ICT resources were utilized to deliver value to stakeholders. To achieve quick wins, ICT operators had to partner with competitors in infrastructure development ventures. Infrastructure sharing was beneficial hence strategies to promote the same by use of incentives (license fee and tax concessions), having a legal framework, government investment in backbone infrastructure and attracting independent firms will ensure competitiveness of local businesses and a knowledge economy status.

CHAPTER ONE: INTRODUCTION

1.1. Background

Information and communication technologies are fundamental and essential infrastructure for to poverty reduction, high productivity, economic growth, improved accountability and governance. Kenya Vision 2030 stresses access to ICTs based on its potential to increase productivity and raise the competitiveness of local businesses in a knowledge-based economy. Investment in ICT infrastructure was a vital step to promote economic development and social integration. ICT infrastructure deployment comes with challenges such as high capital investment and operational costs, fast rate of obsoleteness and regulatory issues. ICT operators prefer to invest in own infrastructure despite the availability excess capacity and other resources from other operators, utility companies and municipalities. This leads to high cost of services, network duplication and waste of scarce ICT resources (Onakoya et al., 2012; Idachaba, 2010; MPICT, 2014; WBG, 2012; Kenya Vision 2030).

ICT infrastructure sharing is defined as having two or more operators coming together to share various parts of their network infrastructure for the purposes of their service provisioning. The definition can be extended to include the ability by independent third parties to buildup infrastructure with the purpose to lease to service providers (NTA, 2010; BTA, 2009). The main objective of infrastructure sharing is to optimize the scarce resources, maximize on economic returns on investments and development of business models that focus on affordable and accessible ICT services (Namisiko & Sakwa, 2013; Venmani et al., 2012; Allen & Overy, 2012)

ICT operators have been sharing infrastructure especially for international telecommunication traffic (satellite and submarine fiber cables). In Canada infrastructure sharing began in the 1950s, when cable operators began deploying cable television networks. In the USA, national infrastructure access was mandated in 1970s to fast track cable television industry growth. The emergence of the mobile virtual network operators (MVNO) a form of active sharing, began in 1999 by the establishment of the first MVNO, Virgin Mobile, in United Kingdom targeting companies with already established brand name and large retail market such as banks (Kimiloglu et al., 2011).

Mobile operators infrastructure sharing started materializing officially in 2001 following the 3G licensing in Europe. The high investments made to acquire 3G licenses forced operators to share infrastructure (Booz, 2007).

Earlier successful infrastructure sharing initiatives among African countries include the Pan African Telecommunications Network (PANAFTEL) interconnecting 28 African countries using shared bandwidth on microwave transmission spanning 20,000km and the Regional African Satellite Communications System (RASCOM) whose objective was to have a dedicated African satellite system that could lower communication costs by routing African traffic via Africa instead of routing the same via Europe. The RASCOM project was also supposed to foster the socioeconomic development of African countries and make the services accessible and affordable especially to the rural population. An initiative to launch shared African submarine under Africa one project failed to materialize (ITU, 2003; CIDA, 1999; Mukasa, 1992; Aloo, 1988).

Successive cases of ICT infrastructure sharing in Kenya include terrestrial and submarine cables (TEAMS, EASSy, SEACOM, LION 2, NOFBI and Kenya power,). NOFBI is a government funded open access fiber network shared by operators (Safaricom, Telkom Kenya, Jamii) among others. Kenya power fiber that runs over the power transmission lines is shared among KDN, JTL, Wananchi and Safaricom. Operators have also been sharing part of their networks (Namisiko & Sakwa, 2013). Kenyan operators also share the internet exchange point resources by keeping local internet traffic local via the Kenya Internet Exchange point. The country is also set to experience mobile virtual network operator (MVNO) services following the issuance of licenses in April 2014 to Finserve Africa Limited, Zioncell Kenya Limited and Mobile Pay Limited (Djamal, et al., 2010; CCK, 2014; Equity bank; 2014; Cartesian, 2013). The financial sector has Pesapoint and Kenswitch where participating financial institutions share payment infrastructure ATMs and Point of Sale terminals. There have also been initiatives to have towercos with no conclusive deals. They include initiatives by Safaricom and Telkom Kenya to form a joint tower management company to manage their infrastructure in 2011. Globally infrastructure sharing has been successfully implemented in USA Europe and India.

1.2. Statement of problem

The lack of infrastructure in Africa especially South of the Sahara is widely recognized as one of the continent's greatest impediments to sustainable development (CBC, 2013; PR, 2010). As a result, ICT operators have been investing heavily in own infrastructure even where there is availability of excess capacity from other operators, utility companies and municipalities. They have also focused mostly in urban areas because underserved or un-served areas are considered as economically unviable due to lack of basic infrastructure such as electricity and road network. This has led to network duplications, underutilization of scarce resources, inaccessible of ICT services to a section of the population, incidences of network vandalism and sabotage as operators compete to attract more customers, environmental pollution (power generators, trenches, radiation, health hazard, proximity of towers close to each other) and unaffordable services due to high cost of network deployment and long payback periods (10-15 years). Another challenge has been the poor quality of services offered to customers due to poor network coverage, network outages, frequent power failures and traffic congestion (Idachaba, 2010; Shruti 2011; Djamal et al., 2010; GSMA, 2013; PWC, 2013; TRAI, 2013)

1.3. Research objectives

1. Find out the extend of infrastructure sharing among mobile operators in Kenya;
2. Determine drivers of infrastructure sharing among mobile operators in Kenya;
3. Establish the main challenges of infrastructure sharing among mobile operators in Kenya;
4. Assess if the TOE framework can be adopted for ICT infrastructure sharing.

1.4. Research questions

The research sought to answer the following four questions:

1. To what extend are Kenyan mobile operators sharing ICT infrastructure?
2. What drives Kenya mobile operators to share ICT infrastructure?
3. What is hindering the Kenya mobile operators from sharing ICT infrastructure?
4. Can the TOE framework be adopted for ICT infrastructure sharing in Kenya?

1.5. Significance of the study

Infrastructure sharing benefits cut across the telecoms service providers, policy makers, regulators, and end users. The findings of the study would be of importance to various stakeholders such as ICT operators (telecommunication companies, ISPs and broadcasting firms), customers, special groups (rural and marginalized population), Kenya Government and citizens (economy, environment), regulators (regulatory compliance) and ICT research field (applications and body of knowledge). Benefits to operators include revenue from selling excess capacity, extending network coverage and reduction on capital and operational expenditure. New market entrants are able to deploy their network and market their products fast due to reduced network deployment cost and time. Sharing also improves relationship and trust between operators due to commercial dependence and knowledge sharing (Bogere et al., 2011; Djamal et al., 2010; Mokgware et al., 2009). Customers were likely to benefits from affordable products, service innovations and access to ICT services hence addressing the digital divide (Venmani et al., 2012; Yekin et al., 2011). The government of Kenya funded NOFBI and submarine cables can benefit from bandwidth uptake hence driving Kenya's economy. The findings can assist regulators in decision making in relation to reviewing or drafting specific policies, laws and frameworks that govern and promote ICT infrastructure sharing (Namisiko and Sakwa, 2013). Researchers were to benefit from body of knowledge and as reference material for further research.

Most of the researches on infrastructure sharing reviewed focused towards passive and active infrastructure sharing in mature and developed countries such as Europe and USA. In Kenya, a few studies had been done despite infrastructure sharing existence as acknowledged by Namisiko and Sakwa, 2013. They also acknowledged the need for further studies since they were unable to find Kenya literature on the same. While their research focused on towers, power and air conditioning challenges, it did not indicate the level of sharing among the mobile operators in Kenya. The scope was limited to three issues, asset valuation and management, cost pressure and cultural alignment. Their research lacked infrastructure sharing reference framework and the important role of neutral infrastructure owners like the government (e.g. NOFBI in Kenya), and other utility entities such as Kenya power were not acknowledged.

CHAPTER TWO: LITERATURE REVIEW

2.1. The evolution of mobile communications in Kenya

Both telegraphy and telephony were available in Kenya in the 1950's under the British colony and were managed by East African Common Services organization (EACSO) and other services such as postal, telecommunications, railways, harbors and income tax. In 1966 the three independent states, Kenya, Uganda and Tanzania formed the East African Community (EAC). East African Post & Telecommunications (EAP&T) was formed by the three states to manage postal and telecommunication services. In 1966, EAC broke up forcing each state to set up national organizations to provide services previously run by EAC bodies. The Kenyan government established Kenya posts & telecommunication corporation (KPTC) (Omwansa, 2009; Smith, 1971)

Mobile telephone services were first introduced in Kenya by KPTC in 1993 with the initial capacity of 2000 lines using analogue ETACS technology. At that time, mobile cellular services were under KPTC's Mobile Services department. The analogue system was later upgraded to GSM technology in 1997. Safaricom was incorporated as a private limited company in April 1997 under the company's act as a fully owned subsidiary of Telkom Kenya. In 1998, Kenya's parliament enacted the Kenya communications act to dismantle the monopoly enjoyed by KPTC and to regulate the communications sector with a view of making the sector more competitive. At that time, KPTC was a regulator and a service provider at the same time. Based on the KCA, five entities were created from the KPTC; Postal Corporation of Kenya, Telkom Kenya Ltd, Communications Commission of Kenya (CCK) as an independent regulator of the sector, National Communications Secretariat (NCS) as an advisory body and Appeals Tribunal to resolve sector disputes.

Following the liberalization of the ICT sector in Kenya, Safaricom was the first mobile company to be awarded a mobile license in 1999. In May 2000, Vodafone Group PLC acquired a 40 percent stake in Safaricom and took over the management of the company. The remaining 60% was held by Telkom Kenya. This explains why Telkom Kenya launched its GSM services late in the market (the law restricted the company from offering the service to prevent monopoly). Kencell Communications (changed to Celtel in 2004, then Zain in 2008 and Airtel in 2010) in

partnership with Vivendi of France was awarded a GSM license in February 2000, becoming the 2nd GSM operator and the first private firm to be awarded the license. In December 2007, France Telecom acquired 51% of Telkom Kenya and proceeded to launch GSM services under the Orange brand in September 2008 following TKL surrendering of its shareholding in Safaricom to the government and 25% shares offer to the public in March 2008. Before then, TKL had been using CDMA technology to provide limited mobile services to customers. Essar Telecom was the forth mobile operator to launch mobile services using yuMobile brand in December 2008. In April 2014 CAK licensed three mobile virtual network operators (Finserve Africa Limited, Zioncell Kenya Limited and Mobile Pay Limited) to compete in the Kenyan ICT market. (Safaricom, 2008; CAK, 2014; Equity, 2014)

Over the years there had been deployment of communications infrastructure and services in the country making Kenya among the Africa's fastest growing ICT markets. Operators were competing on infrastructure rollout so as to serve existing and attract new customers. Infrastructure development is critical to Africa's economic growth and poverty reduction. The mobile industry in Africa contributes US$56 billion to the regional economy, equivalent to 3.5 per cent of total GDP. To bridge the gap of lack of infrastructure in Africa, the private sector had invested close to US$50 billion in the last decade, with more focus on mobile, related applications and international submarine cables. To deal with impediment to economic growth requires more investments and optimization of available and future ICT infrastructure. Sharing reduces the risks such associated with long payback periods for passive infrastructure (15 years with 70-80% of network costs and 5 -7 years for active infrastructure with 20-30% of network costs) (CBC, 2013).

2.2. ICT infrastructure sharing

ICT infrastructure sharing is having two or more operators coming together to share various parts of their network infrastructure for the purposes of their service provisioning. ICT Infrastructure includes tangibles (lines, cables, fiber optic, routers, servers, equipment, apparatus, towers, masts, tunnels, ducts, risers, pits, poles, landing stations, lands, facilities) and intangibles (agreements, arrangements, licenses, franchises, rights of way, easements and other such interests) (Tanzania legal notice No 429, 2011). The main objective of resource sharing is to

optimize the scarce resources, maximize on investments returns and development of business models that focus on affordable customer services.

ICT resource sharing has evolved in line with technological changes. Examples include cloud computing, enterprise resource planning (ERP), mobile virtual network operator (MVNO), digital TV and multiplexing in telecommunications. In digital broadcasting, multi-channeling and data-casting conserves bandwidth by allowing simultaneous multiple channels and other information transmission hence reducing the number of frequencies required (digital dividend) and freeing bandwidth for 4G-LTE technology deployment (ITU, 2013, GSMA, 2013; NTA, 2010)

Mobile infrastructure sharing started materializing officially in 2001 following high capital requirements to deploy the 3G technology (Booz, 2007). Passive infrastructure sharing was driven by savings on capital expenditure for network rollouts (Allen & Overy, 2012). ITU ICT statistics for 2013 show universal growth in ICT uptake and the world moving closer to mobile saturations (6.8 billion out of 7.1 billion) representing 96% global mobile penetration. There is still a wide gap when it comes to fixed-broadband penetration rates, with 6.1% in developing countries compared with 27.2% in developed countries. In Africa, less than 10% of fixed broadband subscriptions offer speeds of at least 2 Mbit/s (ITU, 2013). The statistics show a trend of insufficient ICT infrastructure in Africa but rising demand for ICT services. Infrastructure sharing initiatives by African countries could help address this disadvantaged position and enable Africa to compete effectively globally.

The Kenya ICT 2nd quarter for 2013 /14sector statistics show mobile subscription growth with 31.3 million subscribers and a mobile penetration of 76.9%. The total international bandwidth utilization was low at 51% of the total available bandwidth. On market share, Safaricom Ltd maintained the highest market share (66.5%), Airtel (17.6%), Telkom Kenya Orange (7.1%) and Essar Telecom (8.8%) during the period (CCK, 2013/14). Due to stiff competition on voice services there has been a decline in revenues hence forcing operators to seek other revenues streams such as data centres, cloud computing and mobile banking services (KBA, 2012). For developing countries like Kenya to achieve knowledge economy status, they have to implement strategies that can narrow the ICT gap with their developed countries. One of the strategies was

to continuously invest in infrastructure including enacting attractive legal and regulatory framework that promotes infrastructure sharing among operators and other market players.

2.3. Network challenges faced by some operators in Kenya

Operators in Kenya had been losing revenue due to various challenges associated with network coverage, security threats and network vandalism. Telkom Kenya estimates to be losing Ksh. 2 billion annually in copper and optic fiber cable vandalism with the company spending close to Sh400 million on repairs alone. In July, 2013 Liquid Telecom (former Kenya Data Network) incurred losses estimated to be Sh300 million - Sh500 million during the construction of Thika highway. TEAMs spent $6 million (Sh500 million) in repairs and lease of alternative carriers when its submarine cable was damaged. Kenya power company loses about Sh1 billion every year through vandalized systems and equipment (Muriithi, 2013). As a result, operators lobbied parliament to enact anti vandalism statute law (miscellaneous amendment) act of 2012 to safeguard their infrastructure. Another challenge was the poor quality of services offered to customers due to poor network coverage, network outages, frequent power failures and traffic congestion. According to the quality of service report released by CCK in 2014, no operator met the quality of service targets and the overall performance shows a declining trend for the last three years. Non compliant with CCK quality requirements attracts penalties hence loss of revenue.

Similar quality issues have been replicated in Uganda according to UCC report released in 2013. Globally, the mobile market was near mobile saturation and the falling average revenue per user had negatively affected operator revenues. Due to high cost of infrastructure deployment, broadband penetration in developing countries was very low and concentrated in urban areas (KPMG, 2010). There is need for countries such Kenya to invest in broadband so as to stimulate fresh innovations and inspire a new generation of digital entrepreneurs to create new applications, services, and content (Twaakyondo, 2011; WBG, 2011).

A research done by Kenya Institute for Public Policy Research and Analysis (KIPPRA) in Kenya in 2012 found out that there was slow return on investment, high operation costs resulting from lack of electricity, access roads and security for the infrastructure (vandalism); low population and high licenses and spectrum fees, and lack of definition of spectrum policy for underserved

areas. Investment had been identified as the main obstacles for poor coverage in un-served areas (CCK, 2011). To address these challenges, operators had to put strategies in place to reduce business expenses with priority being infrastructure costs.

KPMG estimates that capital expenditure savings resulting from tower sharing in the Middle East and Africa region amounted to USD 8 billion. Operators need to address costs issues arising from capex and opex by sharing infrastructure, promoting joint ventures especially where there was lack of infrastructure, having agreements to allow each operator to invest in certain areas and lease and allowing a third parties to build and lease or acquire existing infrastructure (third parties can be independent or owned by operators) (Idachaba, 2010; Shruti 2011; Djamal et al., 2010; TRAI, 2013; KPMG, 2010)

2.4. Infrastructure sharing classification

Infrastructure sharing may be classified as types (GSMA, 2013; ITU, 2013; BICMA, 2009), models (BTA, 2009) forms (Analysys, 2010; Booz, 2007) and kinds (Shruti, 2013). From the literature review there was no standard classification of ICT infrastructure sharing. Most authors use classification, categories, types, levels, schemes, forms or models. Majority of the authors are in agreement that active and passive infrastructure sharing are the two main types of sharing. Active infrastructure sharing involves the sharing of electronic infrastructure (the intelligence in the network) and facility including BTS, spectrum, antenna, feeder cable, RAN, microwave radio equipment, billing platform, switching centers, router, BSC, radio network controller, database, optical fiber, backbone transmission network etc. Passive infrastructure sharing is the sharing of non-electronic infrastructure and facility (physical sites, buildings, shelters, towers or masts, electric power supply and battery backup, grounding, air conditioning, security arrangement, poles, ducts, trenches, right of way). Passive sharing was the most preferred as compared to active infrastructure. Active infrastructure sharing was unpopular across the globe due the complexity and increased inter dependency between service providers. The interdependence could reduce competitive edge of the infrastructure owner. It could also lead to collusion on prices or service between the sharing operators and hence the elimination of consumer choice (Bogere et al., 2011; Chanab etal., 2007; PTA, 2013; GSMA 2008/13; KPMG, 2010; NTA, 2010; BTRC, 2008; ITU, 2008)

There were six levels of mobile infrastructure sharing; Level 1 sharing of sites and passive elements, Level 2 sharing of network includes sharing of BTS, Level 3 Spectrum sharing or trading (operator leases the underutilized spectrum in certain areas), Level 5 radio access network and Level 6 sharing of backhaul (BICMA, 2009; BTA, 2009).

Mast sharing includes sharing the tower, antenna frame using different antennas, cabinets and backhaul at a site. The compound can also be shared with each operator having own mast, shelter and power or sharing the resources. Radio access network sharing was the most comprehensive form of mobile access network sharing but comes with challenges such as reduced coverage area due to the reduction in signal strength resulting from antennas combination. Broadcasting infrastructure sharing has been implemented in many countries. It allows a single multiplexer to carry multiple channels from various broadcasting stations hence reducing infrastructure rollout for broadcasting firms. Sharing of fiber cores and bandwidth for backbone is most applicable to where it is uneconomical to deploy own fiber or ducts cannot be accessed. In Africa Cameroon-Chad oil pipeline was a working example where 12 out of the 18 fiber cores are available for use by telecommunication operators. Sharing with non-telecom companies (utility companies, municipalities) applies where such entities rollout fiber networks to manage their operations such as oil pipe-lines, power transmission and railways. The Kenya power company; and Tanzanias Electricity Supply Company (TANESCO) are successful examples where this type of sharing was found. (Idachaba, 2010; GSMA, 2009; BTA, 2009). Backhaul sharing using IP/multi protocol label switching (MPLS) can be implemented between operators to improve resiliency among the operators since MPLS mechanism provides faster service recovery and better blocking probability as compared to conventional rerouting mechanism of Internet Engineering Task Force (IETF) standards (Venmani et al., 2012).

Other advanced forms of sharing were spectrum sharing, roaming and MVNO networks. Spectrum sharing was common in high density markets where there are more than four operators and the spectrum was limited and fragmented. Spectrum sharing model is developed for mature and regulated environments. A mobile virtual network operator (MVNO) is an operator providing mainly value added and mobile services without owning mobile frequencies or mobile access network and is prevalent in mature markets with well known brands. Most MVNOs have their own core network and only require access to radio access network (Djamalet al., 2010;

CCK, 2014). The Middle East and Africa region was underserved by MVNOs due to some regulations and heavy government involvement. MVNO analysis shows that the demand in the mobile market is shifting value-added services preferred by the youth (Kimiloglu et al., 2011; Singh, 2010; Virgin Mobile, 2013).

Mobile roaming is a form of sharing where operator's traffic is routed via competitor's network especially in areas where the competitor has no network. Roaming allows new entrants to share infrastructure with incumbent operators in some geographic areas at the initial stages of network deployment. International roaming enables accessing of mobile services while in foreign countries (Bogere et al., 2011; GSMA, 2009/2013). Site sharing is suitable for densely populated areas with limited land such as underground subway tunnels; and rural areas with high transmission costs (Shruti, 201; Booz, 2007). Analysis of active network sharing partnerships worldwide shows that operators employ active infrastructure sharing in cases such as network coverage expansion of 3G or LTE, efficient utilization of network resources, increased revenue from selling excess capacity, greater spectrum bandwidth pooling as a result of joint bidding (Analysys, 2014; Virgin Mobile, 2013).

Infrastructure sharing was implemented using various business models (operator, inter operator or joint ventures and independent firms). Operator controlled tower companies are created by hiving off operator tower portfolios and transferring to subsidiaries. Examples are Indus Towers Limited owned by Bharti Airtel Limited, the Vodafone group, and the Idea Cellular group in India. The inter-operator business model uses bilateral arrangements between operators on commercial or no payments (barter trade or swap). The third party independent business or towercos model involves companies assuming responsibility for tower deployment and maintenance, entering agreements with operators (Shruti, 2011; PTA 2013; Allen & Overy, 2012).

2.5. Drivers of ICT infrastructure sharing

Infrastructure sharing presented a number of advantages that cut across the telecoms service providers, policy makers and regulators, and end users of the services. ICT Operators benefited more in savings if the extend of sharing was also high. They included extra source of revenue which could exceed 10 percent of the total annual revenue raised by providers, reduction of

infrastructure costs by 40-60%, better use of scarce spectrum resource, easy market entry by new players hence increasing competition in the industry, improved innovation and better customer service, addressing a decline in ARPU), achieving universal service goals by expanding network to underserved or rural areas to meet policy and regulator targets, less negative environmental impact due to reduced network build up, higher uptime due to diversity routes, cost and energy efficiencies due to reduced emissions and diesel consumption hence improved green concept (Bogere et al., 2011; Shruti, 2013; PTA, 2013; GSMA, 2013). New operators were able to launch and market services rapidly across the country due to elimination of massive investments in infrastructure. Sharing could be used to bridge the digital divide, meet regulatory requirements and help governments to achieve universal access goals (NTA, 2010). Infrastructure deployment comes with multiple risks and by sharing infrastructure the risks were also shared among cooperating operators. Sharing ensures operators optimize the use of scarce national resources like rights of way/spectrum hence availing the freed resources for strategic use (ITU, 2013).

The main drivers of infrastructure sharing were cost optimization (capital and operational expenditure), the rise in demand for mobile broadband services offered on technologies such as 3G/4G -LTE and their licensing constraints, the need for new entrants to quickly increase coverage and to lower the cost of deploying ICT so as to achieve widespread affordable access to broadband services (ITU, 2009; BICMA, 2009). Globally there was a decline of average revenue per user (ARPU) hence operators had been forced to seek other revenue streams. Growth of ICT had seen capacity demand rising especially in congested urban areas with challenges in acquiring new sites and frequencies. Firms had also been seeking additional revenue source and ways of lowering costs and increase profit margins (GSMA, 2013). Low market penetration and decreasing profit margins in the emerging markets had also made infrastructure sharing an attractive. Infrastructure cost for operators were estimated to decline by 16% to 20% (KPMG, 2010). The rationale for infrastructure sharing differed between new entrant and incumbent operators and mature/developing markets. For mature markets, sharing provided an additional source of revenue, minimized operating costs, added capacity in congested areas where space for sites and towers was limited. For developing markets, infrastructure sharing expanded network coverage and fast tracked on marketing strategies. ICT Operators sharing infrastructure from the start of the build-out especially 3G/4G had an opportunity to reduce capital and operational

expenditure while for new entrants, national roaming could be used for a limited fixed period, usually the first few years of network deployment and expanded coverage (Kimiloglu et al., 2011; Singh, 2010; BICMA, 2009).

Capital and operational expenditure (capex and opex) analysis showed a difference in capex between developed and emerging markets. In some emerging markets, fuel was a key cost component since sites were either not connected to a power grid or the power grid was unreliable, requiring diesel generators. The valuation of each tower varied significantly across markets (Africa, India and Europe) with average cost of USD 139, 000 per site. This could explain why the developed countries shared the site to reduce opex (Djamal et al., 2010; Analysys, 2012). For more penetrated and mature markets, passive sharing was mainly driven by opex reduction. For new entrants where new technologies were required capex reduction was the main driver (Allen & Overy, 2012). Passive sharing savings were estimated to be between 15-30% overall and 60% savings on yearly capex depending on the geographical or quantitative extent of sharing (ITU, 2013). It was estimated passive infrastructure for rural areas accounted for 70% of the total (Ericsson, 2010). Others estimated that sharing achieved 43% saving in capex and 49% on opex (Venmani et al., 2012). Consultants estimated 15% of total revenue, savings of 30 to 40% and USD 8 billion as the amount of capex savings achieved from tower sharing in the Middle East and Africa regions (KPGM , 2010; Booz, 2007).

Table 2.1. Capex & Opex costs analysis for developed and emerging markets

CAPEX/OPEX infrastructure costs per site		
1. CAPEX markets analysis		
Description	**Developed markets (%)**	**Emerging markets (%)**
Router pricing	2	2
Spares	3	3
Backhaul	6	6
Power	10	31
Site acquisition & design	10	4
Network testing	12	2
BTS node	15	15
Building rigging & materials	42	37
2. OPEX markets analysis		
Description	**Developed market (%)**	**Emerging market (%)**
Insurance	0	5
Spares	3	4
Backhaul	12	14
Power maintenance	8	20
Electricity	10	0
Site acquisition & design	10	4
HW & SW support	16	20
Land rent	42	15
RF engineering support	5	7

Source: Analysys, 2010

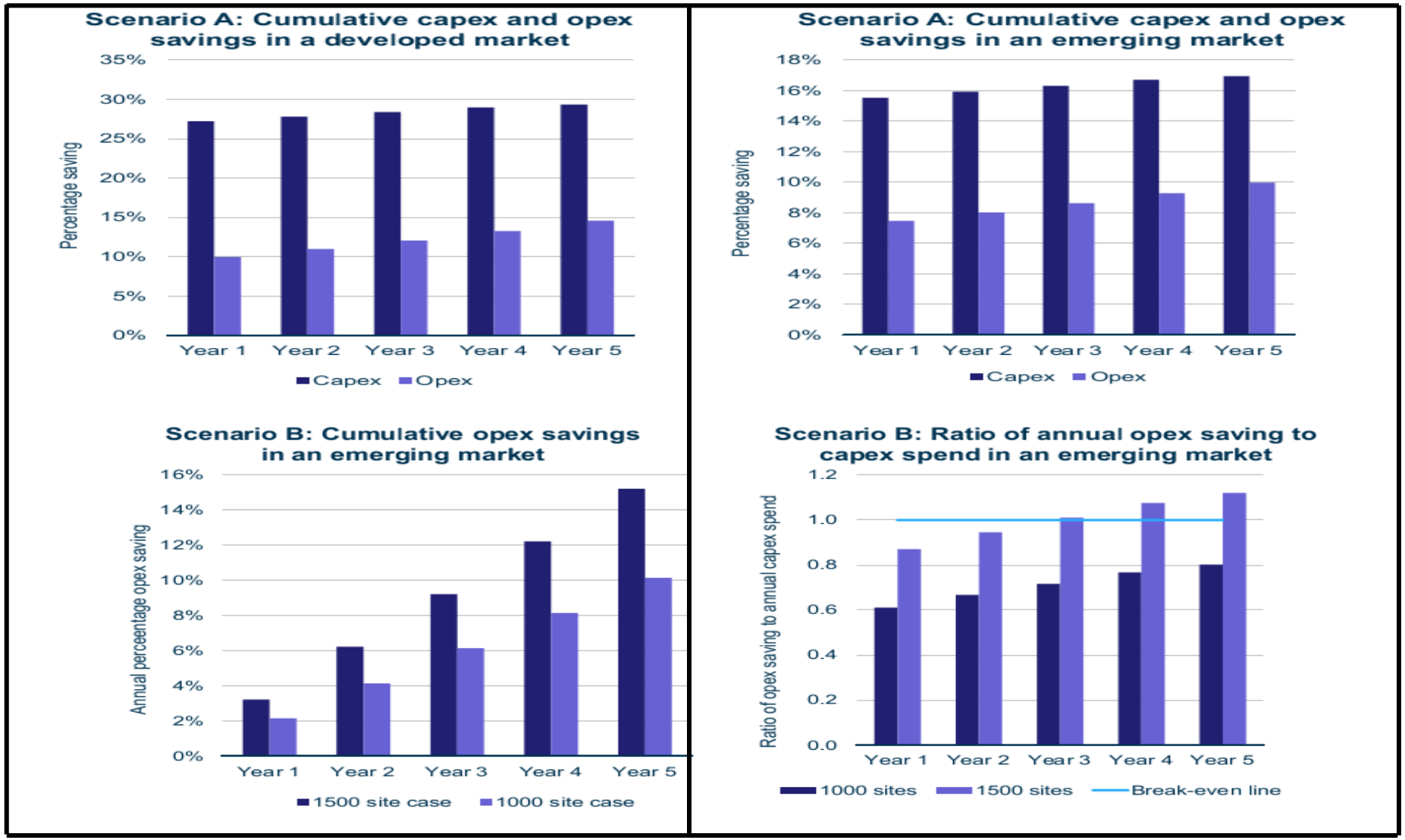

Figure 2.1: Savings on capex/opex for emerging and developed markets **Source:** Analysys, 2012

2.6. Levels of ICT infrastructure sharing

Infrastructure sharing levels differ globally with high levels more evident in Europe, USA and India. Asia Pacific accounted for only 25% of sharing while Europe accounts for 61% of the 36 active network sharing arrangements signed in APAC, Europe and North America. In Austria about 50% of sites had been shared by the end of 2009; Sweden 70% in 2011. In India it was estimated out of the total 300, 000 sites, 60% had been shared with an average tenancy of 1.5 with operators such as Indus having a tenancy ratio of 1.71x, Bharti Infratel 1.62x and WTTIL Quippo 1.84x. The USA had a tenancy ratio of 2.5x (Analysys, 2014; TRAI 2013). Amongst mobile operators in Pakistan, Waridi had the highest tenancy ratio of 1.44 followed by Ufone 1.3 (PTA, 2013). Independent towercos in Africa own and manage 25% of Africa's estimated 165,000 sites with major players being IHS Africa with 20,000, American towers (5136), Helios TA (over 7800), Eaton (over 5070) and Swap technologies (1459). Five of the tower companies in Africa were concentrated in Ghana (ATC, Helios, Eaton, IHS Africa, and SWAP Technologies). Europe, Australia and North America had seen growth in the MVNOs, with more than 760 MVNOs active globally. However the growth for the MVNO model in the Middle East and Africa (MEA) region was still low and at infancy stage. In 2013 the two regions had 8 and 4 active MVNO respectively as compared to Europe which had 496 MVNOs (Virgin, 2013)

2.7. Challenges of infrastructure sharing

ICT operators were faced with various challenges that stopped them from fully exploiting infrastructure sharing opportunities. The challenges experienced in Europe could be different from those witnessed in developing countries due to maturity of the communication sector in developed countries. Among infrastructure challenges identified by mobile service operators in Kenya were asset valuation and management, shareholder and cost pressure, cultural alignment, stakeholder management and sponsorship (Namisiko & Sakwa, 2013). The key challenge faced by operators seeking sharing agreements, were the incumbent operators unwilling to approve or delay sharing with their competitors. Infrastructure owners deliberately used tactical delays to prevent competitors from rolling out fast (ITU, 2013; Idachaba, 2010; Booz, 2007). Infrastructure sharing was a challenge in highly populated areas due to a lack of network capacity and the use of different vendors leading to incompatibility issues and hence the poor quality of service. For national roaming, the incumbent were protecting their investments and

retained monopoly in certain areas (Bogere et al., 2011; Onuzuruike, 2008; PWC, 2013). Network sharing was a complex process that required managerial resources, extensive information gathering and due diligence (ITU, 2008). Although tower sharing enabled new market entrants to scale-up faster, it exposed established players to the risks of market share loss. Increased inter dependency especially for active sharing could limit the competition due to increased interdependence. In emerging markets there were hurdles of obtaining clearance from multitude of governmental bodies (KPMG, 2010). For example in Kenya operators have to go to CCK, Counties governments, NEMA, KCAA, KEBS among others.

In some countries, foreign ownership was restricted to encourage local investments. For example in Ghana and India, a foreign direct investment was limited to 74%. Third party rights or agreements could also affect the transfer of assets and completion of deals. Valuation methodologies were more developed in mature markets than in emerging markets hence it was easier to fast track deals in developed markets. Local tax laws especially in emerging markets affected disposing of network infrastructure due to local tax laws. Accounting challenge was also witnessed during infrastructure transfer. Network sharing had many risks (projects implementation, third-party, and confidentiality risks) which required to be managed to achieve success (Naisiko and Sakwa, 2013; Allen & Overy, 2012).

Lack of regulatory framework was also another barrier to infrastructure sharing. It created a friendly competitive environment investment. The Kenya Information and Communications law of 2009 (CAP. 411A section 85A) recognizes infrastructure sharing but was not specific on the implementation guidelines. Tanzania has a comprehensive infrastructure sharing law under the legal notice No 429, 2011. Active sharing required close commercial cooperation between operators which could impede competition. According to GSMA, imposing mandatory shared access tended to increase competition for a short while but decreased long-term incentives for network rollout. Infrastructure sharing should be based on commercial negotiations between operators and not mandated or subject to regulatory constraints. Regulators mandate was continuously monitor compliance and standards. Mobile virtual network operator concept was still at infancy stage in Africa due to regulatory issues, low ARPU/price volatility and high interconnection charges by incumbent operators (Idachaba, 2010; Deloitte, 2014; BTA, 2011; Ericsson, 2010; Booz, 2007).

2.8. Global infrastructure sharing trends

ICT infrastructure sharing had been implemented successfully across the world especially in America, Europe and Asia. Africa market had not matured but was beginning to embrace infrastructure sharing change. Globally, American Tower corporation (ATC) has presence in 5 continents and 13 countries with over 62,000 sites under their management. In Brazil, National Telecommunications Agency (ANATEL) has issued the rules on infrastructure sharing (Shruti, 2013; ATC, 2014; NTA, 2010). European Commission permitted a 3G site-sharing agreement to T-Mobile and mmO2 in the United Kingdom and approved a plan by mmO2 and T-Mobile to share 3G infrastructures in Germany (BICMA 2009). In New Zealand, mobile site sharing was mandatory upon request (NTA, 2010). In Sweden and Norway network infrastructure sharing is allowed as long as each service provider has 30% of the population covered with its own infrastructure. In France sharing of 3G infrastructure is permitted as long as frequencies were not shared. In Netherlands 3G service providers can collaborate on network deployment as long as competition between service providers was maintained but the joint use of frequencies and core network is restricted RAN-sharing had been approved in Spain between France Telecom and Vodafone and in the UK between Vodafone and Orange (BICMA, 2009).

In Asia and Middle East the major passive infrastructure sharing tower companies were found in India with Indus Towers (a joint venture among Bharti Airtel, Vodafone Essar and Idea Cellular) as the market leader with about 110,000 towers and tenancy ratio of 1.7. Others were Reliance with 48000 towers and tenancy ratio of 1.7, BSL/MTNL 45000 sites and tenancy ratio of 1.07, and GTL 32650 sites and tenancy ratio of 1.2. The tenancy ratio in India is 1.2 – 2.4 with an average of 1.8x implying infrastructure sharing was more developed (Shruti, 2013). In India, sharing of information on available resources is transparent and operators are required to avail the information on their website with details of existing as well as future infrastructure installations available for sharing by the other service providers. In Singapore the regulator IDA has classified critical support infrastructure for sharing to protect public interest. In Hong Kong the regulator may direct the licensees to share infrastructure to protect public interest. In China, the Ministry of Industry and Information Technology (MIIT) encourages joint construction and use of telecom infrastructure. In Jordan, Telecommunications Regulatory Commission (TRC) had issued infrastructure sharing guidelines with restrictions on spectrum sharing (NTA 2010).

In Africa, the co-location, site management and joint ventures were being embraced by ICT operators. Major tower companies include; IHS Africa with 5610 sites owned and managed, American (4540), Helios TA over (3800), SWAP technologies (1211) and Eaton (1500) sites operating in Nigeria, Ghana, South Africa, Uganda, DRC, Tanzania, Cote d'Ivoire and Cameroon (TXC, 2014). In Uganda, MTN entered into an agreement to sell and lease back their towers to TowerCo Uganda Limited, a joint venture between MTN and American Tower Corporation. Eaton Towers Uganda Limited had taken over the site portfolio of Orange Uganda Limited while Warid Telecom reached an agreement in March 2012 to transfer their passive infrastructure to Eaton Towers Ltd (UCC, 2011/2012). In Ghana, ATC acquired a stake in 1876 of MTN Ghana's transmission towers. Electronic and Postal Communications (access, co-location and infrastructure sharing) regulations, 2011 of Tanzania mandates infrastructure provider to share communication facilities with other operators on first-come first served basis.

African Union (AU) ICT initiative had also seen the establishment of internet exchange points (IXPs) in 30 AU member states as part of Phase I of the African Internet Exchange System (AXIS) project. The AXIS project aims to cut communication costs by keeping Africa's internet traffic local to the continent instead of routing the same via Europe (CBC, 2013). The Kenya power (a utility company) has a fibre optic cable running over power transmission lines from Mombasa, Nairobi to Malaba on the Kenya Uganda border and up to Tororo Uganda (1700km). It had leased fiber cores to Kenya ICT operators (KDN, JTL, Wananchi and Safaricom). The firm was targeting to roll out about 25,000 km of fiber optic network to reach households connected to power across the country at a cost of 156bn and projected monthly revenue of Ksh. 50 billion per. In Cameroon, Chad oil pipeline had availed 12 cores out of the 18 fiber pairs for use by operators while Tanzania Electricity Supply Company (TANESCO) had also modeled on Cameroon/Kenya business model (Daniel, 2013; BTA 20O9). Uganda Communication Commission (UCC) had promoted infrastructure sharing in the past, by setting up co-location and sharing of infrastructure policy guideline (Bogere et al., 2011; UCC, 2010).

2.9. Sampled strategy plans and policies that promote infrastructure sharing

Kenya had recognized the importance of infrastructure and infrastructure sharing through ICT Master plan 2013/14 – 2017/18, national broadband strategy 2013-2017, CAK strategic plan 2013 – 2018 and Vision 2030 Second Medium Term Plan 2013-2017. Others include the World bank group ICT strategy 2012-2015, Uganda ICT policy 2012, Nigeria ICT draft policy 2012 and Jordan National ICT Strategy (2013-2017). The CAK strategic plan 2013 - 2018 stresses the importance of promoting environmental sustainability through development of guidelines for infrastructure sharing, co-location, green ICT and mainstream environmental sustainability within the ICT sector. Under enabling environment pillar, the strategy deals with legal and regulatory framework and the development of guidelines for open access. The strategy also acknowledges that as the growth in the telecom sub-sector stabilizes and matures, there was a clear shift in the ICT growth focus from infrastructure-centric to a service-centric growth. The Kenya national broadband strategy 2013-2017 aims to transform Kenya to a knowledge-based society driven by a high capacity nationwide broadband network at estimated cost of Ksh.70 Billion. Two of the five Strategy thematic areas are Infrastructure, Connectivity/devices and policy, Legal and regulatory environment. The strategy recognizes the need to optimize the ICT infrastructure through sharing and development of policy framework for open access by all to the national backbone networks. There are plans to extend the existing national fiber optic cable (NOFBI) from 5,000 km to 30,000km to cover more areas. The NOFBI fiber complements the undersea cables (TEAMS, SEACOM, EASsy and LION 2) and aims to facilitate universal access to ICTs.

The Kenya ICT Master plan 2013/14 – 2017/18 recognizes that for Kenya to become Africa's most globally respected knowledge economy. There was need to implement integrated ICT Infrastructure and information structure that minimizes duplication and creates true integration that enables application of shared services, national data infrastructure, open data, and policy framework. Foundation 2 of the strategy highlights the importance of sharing and seeks to provide backbone infrastructure required for cost effective delivery of ICT products and services to Kenyans. Kenya Vision 2030 Second Medium Term Plan 2013-2017 highlights emerging issues and challenges in implementing the vision as; digital divide between the rural and urban areas which limits public awareness of the advantages and opportunities of ICT, vandalism of

ICT infrastructure, roll out of 4 G networks to provide faster internet and increase bandwidth capacity and expansion of fiber optic networks (to cover hospitals, schools, police stations and other public service institutions). World bank group ICT strategy 2012-2015 innovate pillar (one of the three pillars) focuses on developing competitive IT-based service industries and fostering ICT innovation across the economy. The connect pillar focuses on scaling up affordable access to broadband. The WBG commits to support investment in shared infrastructure such as independent tower companies, expansion of high-capacity international and domestic broadband connectivity through submarine cables, satellites, and fiber optic backbone networks. One of the policy guiding principles of Uganda ICT policy 2012 which aims to make Uganda a knowledge society is to ensure universal access to basic ICT infrastructure, expanding ICT infrastructure throughout the country through national backbone infrastructure and integrated communication, broadcasting, information infrastructure and systems. Nigeria ICT draft policy 2012 acknowledges challenges of ICT in national development as regulatory deficiencies and an absence of coordination in fiber deployment leading to degradation of roads and public infrastructure, lack of a comprehensive and harmonized ICT policy, inadequate infrastructure, legal and regulatory framework, universal access /service, security and local content among others. These challenges must be addressed for a country to meaningfully participate in the information economy. The Jordan National ICT Strategy (2013-2017) acknowledges the important role of modern telecommunications infrastructure as essential to economic growth and the need to update ICT infrastructure to be an enabler for continuous innovation in technology trends (NGN, LTE and cloud computing) and the enforcement of infrastructure sharing between operators and public utilities such as electricity providers at reasonable prices and in order to reduce the costs of providing and extending Internet service (GoJ, 2013).

The strategic plans and policies reviewed above highlighted the important role of ICT role and prioritized infrastructure sharing as one of the primary growth drivers of the information economy not only in Kenya but other countries also. Developing countries such as Kenya aspire to become a knowledge-based economy to be achieved by continuously investing in ICT infrastructure and human resource and formulating friendly ICT policies that promote competition in the industry. One strategy of achieving knowledge-based economy was by the implementation of open access to ICT resource through infrastructure sharing framework.

2.10. Conceptual frameworks

The SAS resource optimization model deals with how available resources can be optimized depending on the nature of the resources, decision variables, the constraints at hand and the organization's strategy. The objective of the SAS framework is to maximize or minimize, as appropriate, the performance metric in the objective by assigning values to the decision variables that satisfy the constraints. The model acknowledges that changing market and technologies warrants corresponding changes in the way the scarce resources are utilized (SAS, 2008). Business model innovation (BMI) by BCG relates to game theory strategy (when the game gets tough, the team is supposed to change the tactics so as to win) and aims to offer renewing competitive advantage and reigniting growth in challenging environment. The model is concerned with how organizations innovate to configure their resources to deliver value proposition and profitability. BMI is a proactive tool for new revenue growth especially where there is stiff competition, regulatory issues and technical challenges (BCG, 2009). The limitation of SAS, and BMI models is their generic nature and its application in various business environments.

Namisiko and Sakwa study investigated the challenges of site sharing in the context of open ICT infrastructure sharing by mobile service providers in Kenya. They noted that the mushrooming of towers across the country had changed urban and rural landscape hence there was need to promote infrastructure sharing. Despite operators interest in open ICT infrastructure sharing, little attention was being paid to conclusion of deals that could lead to infrastructure sharing. Due to challenges such as asset valuation and management, stakeholder cost pressures and cultural alignment, there was need to formulate a proper legislative framework that governs how the mobile operators can share the infrastructure in a manner that does not create suspicions. They recommended CCK to formulate rules to guide the providers in promotion of site sharing. Their research did not have a reference conceptual framework and focused on challenges of passive sharing with more concentration on power. Their scope was also limited to three issues, asset valuation and management, cost pressure and cultural alignment while our research focused on wide scope including general information, drivers, levels, challenges and a framework. The important role of neutral infrastructure owners like the government (e.g. NOFBI in Kenya), and other utility entities such as Kenya power were not acknowledged in their research. Their study

lacked a conclusive framework that could guide ICT infrastructure sharing decisions by operators, regulators and county governments. There was no reference framework that could be adopted for our research. Given the challenges they faced in getting Kenya literature on the same, their study laid a foundation towards infrastructure sharing research in Kenya. Both questionnaires and interviews were used as data collection instruments while descriptive and inferential statistics was used for data analysis (Namisiko & Sakwa, 2013).

Lule at el., 2012 used Technology Acceptance Model (TAM) in M-Banking adoption in Kenya using M-Kesho. The study focused on the factors that hinder or promote such technology acceptance using questionnaires. Technology Acceptance Model (Davis, 1989) key factors are: Perceived usefulness (PU) defined as the degree to which a person believes that using a particular system would enhance his or her job performance. Perceived ease-of-use (PEoU defined as the degree to which a person believes that using a particular system would be free from effort. The research integrated TAM with four additional variables to investigate adoption of M-banking. The constructs of perceived ease of use, perceived usefulness, attitude to use, and adoption were retained according to TAM. Additional constructs (perceived credibility, transaction cost and perceived self efficacy and perceived normative pressure) were added making eight generic constructs that were found to significantly influence the adoption of M-banking services. The model focuses more on understanding of individual behavior as opposed to adoption behavior of the entire organization hence it has limited application in ICT infrastructure sharing where decision to innovate is not individual based.

Borgman et al., 2013 used TOE Framework to focus on factors influencing cloud computing adoption and how IT governance processes and structures moderate those factors. The study found out that cloud computing was a convenient means to address capital and operating expenditures with technology and organization context factors influencing organizations decision to adopt cloud computing. A high perceived relative advantage of cloud computing, a high level of top management support and a high competition intensity (measured as a short lifecycle of products/services in the industry) were the three factors positively linked to the decision to adopt cloud computing. Data was obtained via structured interviews. The study of cloud computing adoption is one example of infrastructure sharing that has recorded a gradual growth in Kenya and relates well to our study.

Institutional theory emphasizes that environments are crucial in shaping organizational structure and actions (Scott and Christensen 1995, Scott 2001). Firms in the same field tend to become homologous over time, as external pressures from competitors, trading partners, customers, and government motivate them to copy industry leaders. Technology, Organization, and Environment (TOE) framework (Tornatzky and Fleischer 1990) identifies three aspects that describe the organizational components that affect the firm's adoption decisions: Technological context, Organizational context and Environmental context. Technological context describes both the internal and external technologies relevant to the firm (the existing technologies in use and new technologies available to the organization). Organizational context refers to descriptive measures about the organization such as scope, size, and managerial structure while the environmental context is the arena in which a firm conducts its business and its industry, competitors, and dealings with the government (Oliveira and Martins, 2011). This compares well with Kenya where the four mobile operators have been forced to offer 3G services and mobile money transfer services based on market leader, Safaricom's Mpesa business model. They have also been seeking infrastructure sharing approval including Mpesa money transfer infrastructure in order to leverage.

The above models and framework relates well to ICT industry in Kenya. ICT Infrastructure is a scarce resource that requires to be optimized by operators in order to deliver value. The mobile service providers operates in a dynamic environment (technology changes e.g. 3G/4G-LTE, high obsoleteness, market saturation, regulatory issues, stiff competition) and as such, they have to innovate to remain competitive (lower cost of service to attract more customers, increase coverage/capacity by utilizing excess bandwidth from competitors). The research will adopt the TOE framework given its organizational, environment and technology wide scope focus and flexibility to adapt to various environments. The framework can be adjusted to suit the technology and capex/opex driven infrastructure sharing. The three contexts present both constraints and opportunities for innovation decision making hence they influence the way firms see the need for, searches for, and adopts new innovations such sharing infrastructure. The same framework has been used in ERP and cloud computing studies. Cloud computing and ERP operate on the principle of shared resource and cost optimization (same concept is applicable to ICT infrastructure sharing among mobile operators). The TOE framework has a solid theoretical (Diffusion of innovations (Rogers 1995), basis and specific constructs within the three contexts

that may vary or can be modified across different studies such as open systems, internet, e-commerce, ERP and e-business (Oliveira & Martins, 2011). The same was confirmed by Wanjiku, 2013 who adopted the same framework for ERP in banks studies in Kenya while Lippert & Chittibabu, 2006, adopted the same for web services. Borgman et al., 2013 and Ramagoffy, 2012 used the same framework for cloud computing and governance studies respectively. ICT industry is technology driven hence the technology context of the framework is in alignment with ICT infrastructure sharing.

2.11. TOE framework (Tornatzky and Fleischer 1990)

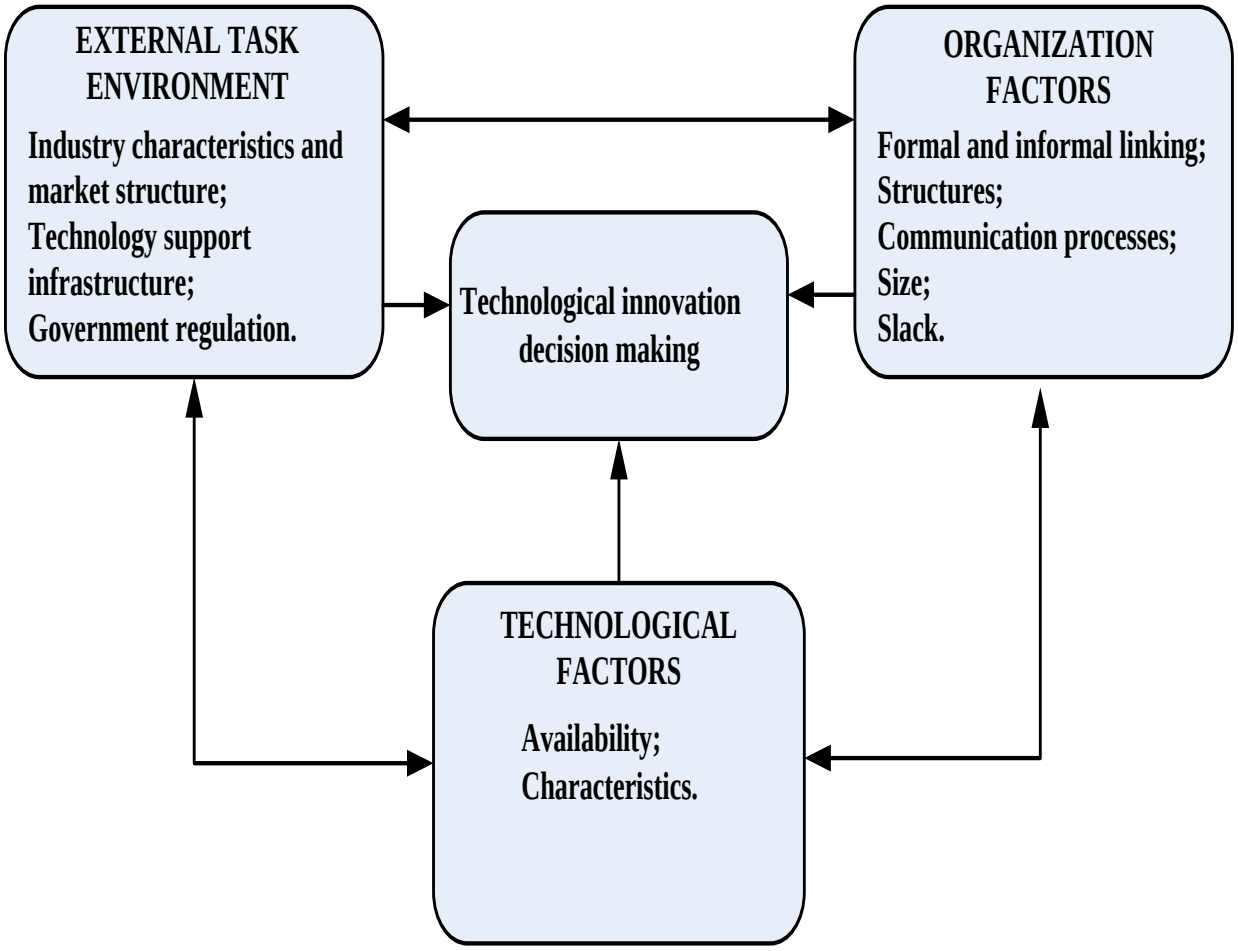

Figure 2.2. TOE framework (Tornatzky and Fleischer 1990)

2.12. ICT sharing framework adapted from the TOE framework

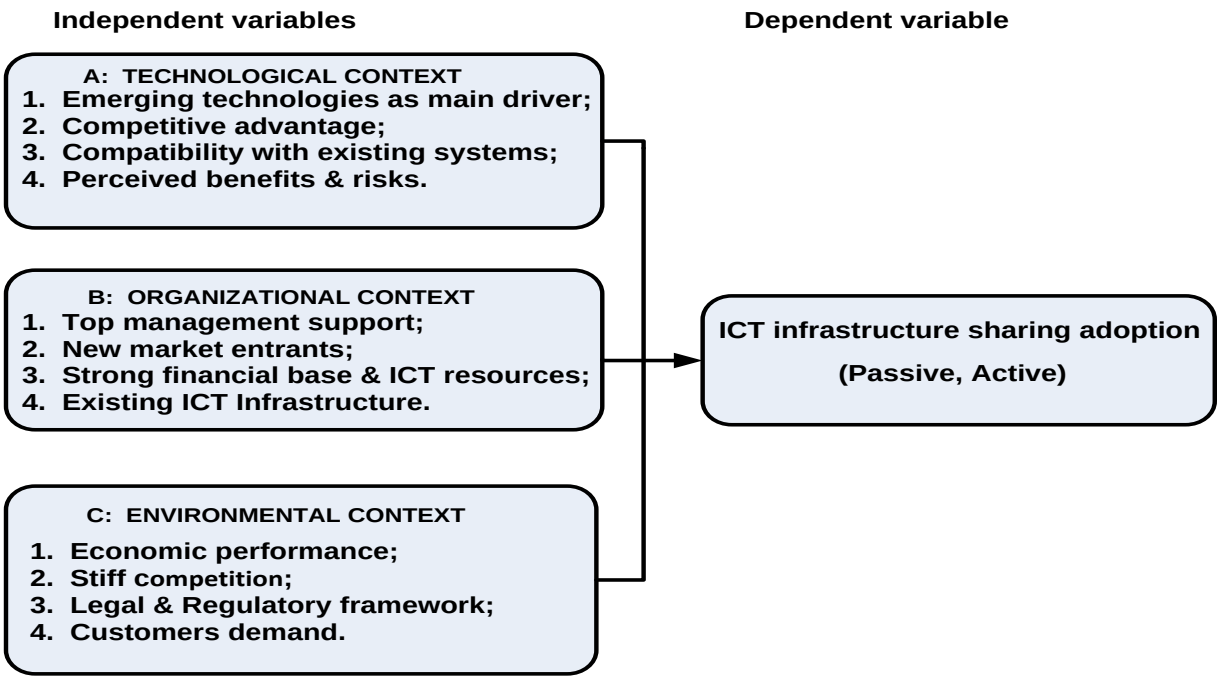

Figure 2.3. ICT Infrastructure sharing framework adapted from TOE framework

2.13. TOE framework constructs description

The framework has three contexts, technology, organization and environment with constructs that can be adopted depending on circumstances. Our research adopted 12 constructs (four for each context).The technological context considered the available internal and external technologies important to the firm. Decisions to adopt technology innovations were mainly driven by what was existing**.** When operators costs of deploying and operating new technologies through resource sharing were low, prices were likely to fall while profit margins were likely to grow. The savings made could be invested in core areas. ICT infrastructure is a limited resource hence operators who had invested more had an edge over those who had not. By not sharing the limited resource it becomes a competitive advantage. ICT infrastructure sharing comes with challenges such inability to integrate systems, technologies and policies. The higher compatibility of existing technologies led to higher adoption of ICT infrastructure sharing. When the risks of integration were high, operators were likely to shun infrastructure sharing adoption.

If operator's perception was positive about technology (high chances of economic and social gains), the chances of adoption of infrastructure sharing so as to deploy the technology at a lower cost was high and vice versa (Borgman et al., 2013; Oliveira & Martins, 2011; Lippert & Chittibabu, 2006)

The organizational context is defined in terms of resources available to support innovations. Through long term strategic vision and budget commitments, the top level management could influence organization's infrastructure sharing adoption. New operators were more likely to adopt sharing to rollout their network and market their services fast hence saving on capital and operational expenses. Higher organizational level of technical & financial resources led to less intent to adopt ICT infrastructure sharing. When an organization was in a strong financial position and had more ICT resources it was easy to deploy new technologies and offer maintenance support. Such firms may want to retain their higher market share hence they were less likely to adopt infrastructure sharing. If the firm's current ICT infrastructure could not support corporate strategy then the firm was forced to explore other options such as upgrading or renting the infrastructure from other operators so as to remain competitive

The environmental context represents the setting in which the firm conducts business and is influenced by the industry, competition, the firm's access to resources supplied by others, and interactions with the government. A decline in economic performance affected the profit margins of operators hence reduced capital investment. As a result there was reduced consumption of ICT services due to weak purchasing power of the customers. This could force operators to explore cost cutting options such as adoption of infrastructure sharing. High intensity of competition forced ICT operators to adopt infrastructure sharing. The stiff competition gave customers power to choose from multiple options to. To maintain and attract more customers, operators had to differentiate themselves by focusing more on product innovations and explore new revenue streams such as infrastructure sharing. Having a legal framework in place created an attractive environment for infrastructure sharing adoption and vice versa. The rise in demand for ICT services by customers led to high consumption of ICT services hence putting pressure on operators to explore the optimal way of meeting the customers' needs such as leasing excess capacity from other operators and utility companies to provide service (Borgman et al., 2013; Oliveira & Martins, 2011; Lippert & Chittibabu, 2006).

CHAPTER THREE: RESEARCH METHODOLOGY

3.1. Research design

The main objective of the study was to propose ICT infrastructure sharing a framework for mobile operators in Kenya after determining the drivers, levels and challenges of sharing among the mobile operators in Kenya. The study employed quantitative (pure research) using questionnaires to collect information from the sample population. The research design enabled the generalization of the findings in Kenya to other developing countries especially in Africa. From the literature review most studies had adopted the same method (Mugenda & Mugenda, 2003; Namisiko & Sakwa, 2013).

3.2. Data collection

The study targeted ICT staff and managers in respective organizations. A total of 19 organizations with a sample size of 170 were targeted but only 17 organizations responded representing 89% and 125 respondents completed the questionnaire representing a 74% success rate. The main data (76%) was collected from the four mobile operators Safaricom, Airtel, Essar (YU mobile) and Telkom across the country. The sample population was grouped into five regions with more focus on Nairobi and Coast regions. Main target towns were Nairobi, Mombasa, Nakuru, Kisumu, Eldoret, and Nyeri towns. The grouping was arrived at after considering how the four mobile operators had divided their administrative units, the concentration of ICT infrastructure and consumption of ICT services. To supplement and increase on data reliability, 24% of data was collected from other ICT stakeholders such as regulators CAK and ICTA, ISPs (Wananchi, Access Kenya and Jamii Telcom), submarine operators (SEACOM, TEAMS, EASSY & LIONE 2), ICT vendors (Ericsson and Huawei Kenya), broadcasting firm (KBC) and non ICT related firms in banking (Equity and Barclays) and a utility company (Kenya Power Company). The CAK is responsible for facilitating the development of the information and communications sectors (including broadcasting, multimedia, telecommunications and postal services) and electronic commerce hence they were a reliable source for research. The ICTA was important source as they are responsible for the design, implementation and use of ICTs in the public service in Kenya including NOFBI shared optic fiber network and e-government services. The non ICT organizations were considered because they had successfully implemented ICT infrastructure sharing in their organizations. The

Kenya power has an fiber optic cable running over power transmission lines from Mombasa, Nairobi to Malaba on the Kenya Uganda border and up to Tororo Uganda (1700km). It has leased to Kenya ICT operators (KDN, JTL, Wananchi and Safaricom). Some data was also obtained from reports of some ICT operators and other organizations (ITU, CBK, WBG, GSMA) and management consultants (KPMG, PWC & Analysys Mason) among others.

The sample size

According to Mugenda & Mugenda, 2003, where the sample is not known:

$n = \mathrm{p}(1-\mathrm{p})(\mathrm{Z}/d)\text{^}2$ where n = sample size;

Z = the table value for the level of confidence, for instance 95% level of confidence = 1.96, 90% = 1.645

d = margin of error

p = proportion to be estimated

Mugenda & Mugenda, 2003 recommends that if you don't know the value of ***p*** then you should assume ***p*** = 0.5

Therefore the sample size of this study is estimated (assuming level of confidence of 95% = 1.96) as follows

$n = 0.5(1-0.5)(1.96/0.075)\text{^}2 = 170$

Table 3.1. The sample size

Sample population		
Organization	**Market share**	**Sample size**
Safaricom	66.5	45
Airtel	17.6	30
Essar	8.8	25
Telkom Orange	7.1	25
Other stakeholders	NA	45
Total		**170**

Source: Researcher & CAK, 2014

Note: The sample size estimation assumed that although Safaricom had the highest market share of 66.5%, it may not necessarily imply that their ICT infrastructure market share was 66.5%. There was also some form of infrastructure sharing among the mobile operators.

3.3. Data reliability and analysis

The research data was gathered exclusively through questionnaires designed in line with the research objectives. The questionnaire had 3 sections with 23 questions; Section A - focusing on demographics; Section B - on the awareness, general information, drivers and challenges of infrastructure sharing and Section C - using the TOE framework to assess ICT infrastructure sharing adoption among operators.

Since the target population was technical staff mostly in the field, a questionnaire was preferred due to logistical challenges of reaching the respondents. The main advantage of using questionnaires was the low cost geographical distribution and free from interviewer bias.The questionnaire was refined by the supervisor, seven colleagues and three of MSC classmates to test the understanding of questions and to remove ambiguities so as to enable self administration, increase reliability and completion success rate. Pretesting employed purposeful sampling technique where 7 out of the targeted 10 Telkom Kenya ICT staff responded (achieving a success rate of 70%).The main purpose of performing a pre- test was to assist our research in ensuring that the questionnaire was reliable and fit for the intended study. Though care was taken to minimize errors, the research might still contain some errors beyond researcher's control. Final refinement of the questionnaire was done, key contact persons identified from participating organizations and consent sought through networks, phone and email. They were then briefed on the objective of the study prior to delivery of the physical copies or softcopies of the questionnaire through email depending on their preference. There was a follow up with key contact persons and individual respondents through visits, phone calls, short messages and email reminders to encourage higher completion rates. A five level likert scale with weights ranging from 1-5 was used by respondents to evaluate the level of agreement or disagreement (strongly agree -5, agree-4, not sure-3, disagree-2 and strongly disagree -1). Percentages were used to find the level of agreement (sum of respondents for strongly agree and agree), disagreement (sum of respondents for strongly disagree and disagree) and not sure. In cases where the lead was not clear, a higher weighted mean prevailed. The collected data was checked for completeness, coded and captured into MS access database before being analyzed using SAS statistical software and presented in-form of MS Excel. Descriptive statistics used included tables, frequencies, weighted mean, standard deviations and percentages.

3.4. Ethical issues

The research was done objectively and free of personal bias or negative effect on participants. The trust of participants was not abused since confidentiality and privacy was maintained through anonymity by using numbers, third parties and pseudo names. The respondents were contacted in advance and briefed about the purpose of the research and their consent sought before engaging them. The letter of introduction from the university and our cover letter was be sent or delivered along site the questionnaires.

CHAPTER FOUR: RESULTS AND DISCUSSIONS

4.1. Response Rate

The research achieved a 74% completion success rate with 125 out of the targeted 170 respondents completing the questionnaire from 17 organizations out the targeted 19. The sample size was based on the market share of the four mobile operators as per CAK sector statistics report released in the July 2014.

Table 4.1. Respondents geographical distribution and demographics

A: Geographical distribution			
Region	**Target**	**Response**	**%**
Western (Western & Nyanza areas)	17	10	59%
Nairobi	84	72	86%
Rift valley	22	15	68%
Coast	30	19	63%
Central & Eastern (central, Eastern & North Eastern areas)	17	9	53%
Total	**170**	**125**	**74%**

B: Demographics of respondents			
Variables	**Classification**	**Frequency**	**%**
Gender	Male	109	87%
	Female	16	13%
Age bracket	19 - 30 yrs	30	24%
	31- 40 yrs	58	46%
	41- 50 yrs	33	26%
	Over 50 yrs	4	3%
Highest level of education	Post Graduate	19	15%
	Degree	52	42%
	Cert/ Diploma	54	43%
Years worked in the ICT Industry	Less 5 yrs	17	14%
	5 to 10 yrs	46	37%
	10 to 20 yrs	38	30%
	over 20 yrs	24	19%
Position	Technical support	104	83%
	Manager	21	17%

Source: Researcher, Survey data

4.2. Objective 1: The Level of sharing among the Kenyan mobile operators

The research established that operators were sharing passive infrastructure (sites and fiber). Fiber lead capacity and dark fiber were used to provide services and in some cases to improve network reliability through redundancy routes. The common shared infrastructure included compounds, equipment rooms, security, towers, power (commercial, generator, batteries), air conditioners, ducts, trenches, fiber (cores and wavelengths) and RAN (at very low levels). Below is the summary table.

Table 4.2. Level of sites sharing in Kenya in comparison to sampled global levels

A: Sites sharing levels in Kenya among mobile operators					
Mobile operator	**Market share**	**Total sites**	**Sites market share**	**Shared sites**	**Shared sites %**
Safaricom	66.5%	3140	51%	344	11
Airtel	17.6%	1220	20%	448	37
Essar (YU mobile)	8.8%	739	12%	123	17
Telkom (Orange)	7.1%	1050	17%	341	32
Grant total	**100%**	**6149**	**100%**	**1256**	**20.4**
B: Sampled global levels					
Country	**Operator**	**Tenancy ratio**	**Average tenancy ratio**	**Average operators per site**	
Pakistan	Waridi	1.4	1.24	≥ 1	
	Ufone	1.3			
India	ATC	1.8	1.8	≥ 1	
	BSL/MTNL	1.07			
	Viom Networks	2.4			
	GTL	1.2			
USA			2.5	≥ 2	

Source: Researcher, CAK, Mobile operators, PTA, 2013; TRAI, 2013

The research findings showed that mobile infrastructure in Kenya is 100% operator controlled with 20.4 % level of ICT infrastructure sharing among the mobile operators. Airtel Kenya and Telkom Kenya were leading at 37% and 32% respectively. When compared globally with USA, Europe and India the levels were low. USA had tenancy ratios of 2.5 with over 60% of the sites owned by independent companies such as American Towers, Crown Castle International and SBA communications (ITU, 2010). This implies that sites in USA had more than two tenants

unlike Kenya where less than 20% of the sites had at least one tenant. In India the tenancy ratio was 1.8 with joint ventures controlled through operator subsidiaries and independent firms. Some of the reasons given by respondents for the low levels in Kenya could be attributed to lack of a legal framework to mandate or encourage sharing, having operators investing and controlling own infrastructure as a competitive advantage, lack incentives to promote sharing among operators especially those who had invested heavily and lack of information on available excess capacity. The market had also attracted only one independent tower company (Eaton towers) with no ownership or sites management in Kenya.

The late market entrants Essar and Telkom had opted for sharing and had leased 41% and 32% of their sites mainly from Airtel and Safaricom respectively. The findings confirms previous findings where it was found that new market entrants preferred to lease capacity from existing operators so as to save on capex, opex and to launch their products faster in the market (Venmani et al., 2012; Allen & Overy, 2012 & ITU, 2009). There could also be a relationship of Essar's high leasing levels at 41% and Airtels higher sharing levels at 37% due to the fact that their ownership was affiliated to Bharti and Essar group whose origin was India where sharing had been implemented successfully. When compared with Safaricom's infrastructure market share of 51%, there could be a relationship to its higher market share in terms of subscribers and annual turnover. Safaricom's financial report released in March 2014 (**Note:** Other operator's financial reports are not publicly available), total revenue was Kshs 144.67 billion for 2013/14 financial year and a customer base of over 21 million. The company had strategically been competing on infrastructure and services (e.g. BTS rollout, cloud computing and Mpesa). In 2014 the company had invested Kshs 27.78 billion in infrastructure and had piloted and launched 4G services in Nairobi and Mombasa. The company was undertaking due diligence to takeover Essar infrastructure (739) sites. If the 302 shared sites are excluded, Safaricom will have estimated 437 additional sites hence increasing its infrastructure market share close to 60%. The number will likely reduce following consolidation as some sites are proximity to each other. The implication is a higher market share in infrastructure, mobile data, money transfer, customer base, cloud computing and turnover. With such potential resources at their disposal, it implies that if Airtel, Telkom Kenya and new entrants were to adopt infrastructure sharing strategy to expand their network coverage, they will have to partner with Safaricom due to its extensive

network coverage. This implies that for infrastructure sharing to be more successful in Kenya, operators and CAK have to encourage Safaricom to share more including offering incentives to safeguard against their investments. Essar's exit from Kenyan market will shift Airtel's customer base from 17.6% to 26.4% (assuming all Essar customers migrate to Airtel following customer takeover) but will also lose on infrastructure sharing revenue. Airtel had been contracted by the three VMNOs to host them (a form of active sharing). When compared with Essar infrastructure market share of 12% and mobile customer base of 8.8%, Telkom had a higher sites infrastructure market share of 17% but a lower mobile customer base of 7.1%. With such market structure change in favour of Safaricom and Airtel, Telkom Kenya has to implement winning strategies such as infrastructure sharing and optimizing its ICT resources including its shareholding in the three submarine cables (TEAMS, EASsy and LION 2)/terrestrial fiber and exploring market consolidation in order to deliver value to shareholders and to remain competitive.

Operators seem to have strategically selected business partners with whom to share. A part from few isolated cases each operator had identified a sharing partner. Airtel had identified Essar with the later leasing 300 sites from the former on commercial basis and the sharing in favour of Airtel. The relationship could be explained by the shareholders of the two firms having their origin in India where sharing was most successful. Safaricom had identified Telkom Kenya as a business partner by leasing 259 sites from Telkom while the later had leased 257 sites from Safaricom. With this fair sharing the business model implemented was barter (swap) with the two firms mutually benefiting. Their partnering and business model could be attributed to the fact that Safaricom was a mobile department and a subsidiary of Telkom before privatization. Essar anticipated exit from the Kenyan market and Safaricom takeover of Essar's infrastructure implies Airtel will have lost a key business partner and revenue. It has to change strategy and to partner with other operators especially Telkom and Safaricom.

4.3. ICT Infrastructure sharing awareness and general information

Table 4.3. Infrastructure sharing awareness levels and general information

A: Infrastructure sharing awareness			
ICT infrastructure sharing types	**Frequency**	**%**	**Ranking**
Cloud computing /data centres	81	65	5
Digital broadcasting	67	54	8
Banking industry	71	57	7
Fiber	105	84	2
Satellite communications	76	61	6
Mobile roaming	84	67	4
Enterprise resource planning	35	28	9
Sites sharing	107	86	1
Radio Access Network	96	77	3
B: ICT infrastructure sharing general information			
Question	**Classification**	**Frequency**	**%**
8. Do you encourage ICT infrastructure sharing among ICT stakeholders?	YES	122	98
	NO	3	2
9. Preferred infrastructure sharing type	Active	26	21
	Passive	99	79
10. Should CCK make ICT infrastructure sharing voluntary and mandatory?	Voluntary	61	49
	Mandatory	64	51
11. Should operators sharing their infrastructure be given incentives	YES	110	88
	NO	15	12
12. Should mobile money transfer infrastructure be shared?	YES	79	63
	NO	46	37
13. Should operators with excess capacity share the information?	YES	95	76
	NO	30	24
14. Which infrastructure sharing business model would you prefer?	Operator controlled	29	23
	Inter operator	32	26
	Independent	64	51
15. Emerging technologies MPLS, 3G/4G- have been putting pressure on mobile firms	YES	111	89
	NO	14	11
16. ICT infrastructure sharing decision is mainly driven by capex & opex	YES	113	90
	NO	12	10

Source: Researcher, Survey data

64% of respondents were aware of infrastructure sharing with site sharing being the most popular followed by fiber sharing, radio access network, mobile roaming and cloud computing. The findings were in line with Ericssons, 2010 finding where passive investment for rural site was estimated to be 70% of total cost hence operators could share to minimize the cost. In Nigeria sharing had reduced average cost per site by more than 50% with savings of up to 30% (Idachaba, 2010). Level of awareness for site sharing had risen from 72% in 2013 to 86% in 2014 (Namisiko & Sakwa, 2013).

Cloud computing awareness was lower as compared to sites and fiber. Its adoption was fairly new in Kenya, with most organizations having adopted it either in 2010 or 2011 (Omwansa et al., 2014). Fiber optics was also more popular due to sharing of cores, bandwidth and using the same to provide redundancy to improve network reliability. Digital broadcasting was less popular since the concept was in its early stages in Kenya. ERP had the least awareness at 28%. The lower acceptance level could be explained by in their research findings where developing countries had low ERP implementations ERP systems as compared to developed ones (Abdelghaffar & Azim, 2010).

The findings showed that 98% of respondents encouraged infrastructure sharing. This compared well with Europe, USA and India where sharing had matured with high tenancy ratios (India with 1.8x and USA with 2.5x) (Analysys, 2012). The main reasons given by respondents for encouraged sharing were factors such as capex reduction, faster rollout especially for new market entrants, efficient resource utilization, reduced vandalism cases, solve network coverage and congestion challenges, improved Kenya's economic development and network reliability, access to ICT services in rural/marginalized areas, promote fair competition (reduced monopolies and barriers to entry), make ICT services affordable, lower environmental degradation, generate revenue, enable operators to focus on core business and promote competition in ICT industry. Those who discouraged sharing (2%) believed that sharing reduced operator's competitive advantage. The study outcome showed that as the sharing market in Kenyan grows and with stiff completion, the level of infrastructure sharing is more likely to increase in future due to operator's cost optimization strategies and low profit margins.

Passive sharing at 79% was more preferred form of sharing as compared to active at 21%. Passive infrastructure sharing began with mobile phone towers so as to lower capital expenditure for network rollouts (Allen & Overy, 2012). Africa infrastructure investment report for 2013 by Commonwealth Business Council showed that the payback period for passive infrastructure was long (estimated at 15 years). Passive sharing allowed significant savings of 15-30% overall and with savings up to 60% yearly on capex depending on the geographical and the extent of sharing (ITU, 2013). It was estimated that passive sharing constituted 70% of the total cost for rural areas (Ericsson, 2010). Estimated savings was between 30 -49 % on capex and opex with 15% savings in total revenue (Venmani et al., 2012; Booz, 2007). KPGM estimated USD 8 billion as the amount of capex savings resulting from tower sharing in the Middle East and Africa regions. The economic gains from passive sharing could explain why it was more popular globally and in Kenya. Active infrastructure sharing was unpopular across the globe due the complexity and increased inter dependency that required close commercial cooperation between operators. This could impede competition and lead to collusion on prices or service between the sharing operators and hence the elimination of consumer choice (Bogere et al., 2011).

Mandatory sharing was preferred by 51% of respondents as compared to voluntary at 49%. Those who preferred mandatory believed mandated sharing could reduce network vandalism/mistrust among operators, stop unhealthy competition, lead to fair distribution of infrastructure, preserve environment, lead to some standardization, fast track the sharing process and provide a legal framework. Reasons given for voluntary sharing were allowed market forces to dictate, mandatory requirements infringed on business interests and could lead to increased malpractices in the sector, operators will be reluctant to invest or wait for other players to invest, there was no framework, systems incompatibility challenges, different operators business strategies, gave operators flexibility and freedom to identify willing business partner. Successful cases where mandated sharing had been implemented successfully included New Zealand, China, Ecuador and Jordan. The European Union encouraged site-sharing through the EU framework agreement. India and Bangladesh had guidelines promoting infrastructure sharing to encourage more operators (Analysys, 2012). Tanzania had mandated infrastructure provider to share with other operators on first-come first served basis. The margin between respondents who preferred voluntary and mandatory was not large enough to provide a clear lead. This could be

attributed to lack of a comprehensive regulatory and legal framework in place to guide respondents. However, even with lack of a comprehensive legal framework in place, operators had been sharing their infrastructure through negotiated SLAs on both commercial and barter trade (swap) basis. The reason for voluntary sharing with a legal framework in place was informed by the findings that operators in Kenya were sharing even in the absence of a legal framework. The issue that could arise for mandated sharing will be, 'If operators had been sharing their network voluntarily through negotiated SLAs, why would they be forced to share?'.

88% of respondents agreed that the government should give tax and license fee concessions as incentives to operators so as to promote sharing in Kenya. The reasons given were to promote competition especially for new entrants and reluctant operators, increased access and lower service cost, encouraged cooperation among operators, economic growth contribution (saved on foreign exchange from imported ICTs and generator fuel). Those who disagreed (12%) believed incentives mostly benefited operators as they are profit oriented.

63% of respondents were in agreement that mobile money transfer platforms should be shared to lower operation costs, to ffer affordable financial services to customers hence spurring Kenya's economic growth. It was also convenient for agents to operate business and for customers to access services hence promoting competitiveness. Agents were to benefit from commissions arising from anticipated increased financial transactions. Some respondents preferred agent network sharing only but not IT platforms so that competition could be on platforms and service delivery. In the Kenya banking sector, ATM infrastructure sharing was one of the success cases where commercial banks, Co-operative societies and independent ATMs operator Pesapoint had shared resources. Those in disagreement (37%) believed that the market leader Safaricom had invested heavily in both the infrastructure and mpesa brand name over time while other operators were reluctant hence more time was needed for Safaricom to recoup their investment. System security was not guaranteed hence high risks to fraud. Sharing could also infringe on operators innovation as late market entrants would benefit unfairly.

76% of respondents were in agreement that it was important for operators to share information on excess capacity amongst themselves and CAK. In India and Bangladesh operators were required to publish on their website the details of existing as well as future infrastructure development to other service providers. In Bangladesh, all operators were required to publish on

their websites detailed infrastructure information (BTRC, 2008). In Kenya such information was only available to infrastructure owner. This could lead to network duplication and underutilization of ICT resources since operators could not make informed decision. By availing the information, ICT stakeholders would be able to optimize the scarce resource and deliver value to their organizations. From the findings it would be prudent for CAK to have access to ICT resource inventory in Kenya to be able to make informed decisions as concerns ICT resource optimization.

The independent business model was more preferred by 51% of respondents followed by inter-operator 26% and operator controlled at 23%. The reasons given for independent business model were, to promote fair competition, better management of shared resources, operator focus on core business, increased access to ICT services, impartiality (no partisan interest), strict adherence to KPIs and SLAs to deliver better QOS, easy maintenance of standards and streamline charges. The findings compare well with the USA where more than 60% of the sites are owned by independent companies such as American Towers, Crown Castle International and SBA communications (ITU, 2010). Nigeria and Ghana are successful cases in Africa with Ghana having five of the major towercos with each having over 16000 and 3900 sites owned and managed by independent firms. Tanzania had 2169 sites while Uganda had 1700 sites owned and managed by independent companies. Kenya was likely to follow suit if the Airtel deal of selling its towers estimated to be over 15000 in Africa is successful. Analysis of independent towercos in Africa shows increasing trends with a market share shift from 18% in August 2014 to 25% in October out of the estimated 165, 000 sites. The market share was also projected to rise to 38.8% by end of 2014 and 47% by end of 2015 (TXC, 2014).

The inter-operator was preferred by 26% of respondents. The reasons for their choice included fosters relations and minimizes network sabotage and vandalism incidences, improved network reliability and gave operators a sense of ownership and responsibility. This model had successfully worked well in India where Indus Towers, a joint venture among Bharti Airtel, Vodafone Essar and Idea Cellular, were the market leaders with about 110,000 towers (Shruti, 2013). In Europe successful cases include United Kingdom and Spain between Orange and Vodafone and United Kingdom and Germany between BT and Deutsche Telekom (Booz, 2007).

The operator controlled model was the least preferred with 23% of respondents in agreement. The reasons given included full control, was easy to enhance quality of services, operators had invested a lot in existing infrastructure and operators had different business strategies. In India operators have control of their infrastructure through subsidiaries. The findings were in tandem with global trends where infrastructure ownership had evolved from operator controlled, to inter-operator/joint ventures/subsidiaries and finally to independent firms. In Europe and USA, the market had matured with independent firms controlling over 60% of infrastructure while in India the market was dominated by both joint ventures and independent firms (ITU, 2010). In Africa operators were still in control of their infrastructure but when compared with success of tower companies in Ghana, Nigeria, Uganda Tanzania and the anticipated sell of over 15,000 Airtel towers across the continent, there were indications that joint ventures and independent firms would increase their market share in the near future as operators face stiff completion, global falling average revenue per user and the need to have clean balance sheets (TXC, 2014).

Although the majority of the surveyed respondents preferred independent business model, the Kenya market had operator controlled model. To implement the independent model would require mobile operators' willingness to sell their existing infrastructure to independent companies through sell and leaseback agreements. Airtel Africa was pursuing this model and if successful, Africa was more likely to witness other operators following suit in future as they seek to raise more capital to fund their activities, clean their balance sheets and attract investments. Alternatively, the market could attract independent firms to invest in infrastructure and lease the same to operators. This requires guaranteed ROI and the support of operators. With lack of a comprehensive infrastructure sharing regulatory framework and no independent towerco infrastructure, the success of this model is not guaranteed. Given that most operators in African and in Kenya prefer full control of their infrastructure, inter-operator model would be the most appropriate for a start but given the dynamics of the market, operators could still shift from operator controlled to independent firms.

The communication industry requires strategies such as infrastructure sharing to help Kenyan operators mitigate risks and generate more revenue. Where the cost of implementing new technologies could be high, willing operators could negotiate to jointly implement the same and share the costs. The challenge would be varying business strategies and suspicions among cooperating competitors. To succeed, Kenya could learn from India, Ghana and USA.

4.4. Infrastructure sharing initiatives by ICT stakeholders

Table 4.4. Initiatives to promote ICT Infrastructure sharing in Kenya

A: Infrastructure sharing initiatives by ICT stakeholders (government, operators, utility firms and towercos)								
Statements	**Strongly agree**	**Agree**	**Not sure**	**Disagree**	**strongly disagree**	**Mean**	**Standard deviation**	**Agree %**
1. CAK should draft infrastructure sharing guidelines to regulate the industry	77	41	3	3	1	4.5565	0.7371	94.4
2. The GOK should continue investing in ICT backbone and core infrastructure	71	37	7	7	3	4.3629	0.9825	86.4
3. ICT Infrastructure development planning should be coordinated among ICT stakeholders	76	39	5	4	1	4.5161	0.7899	92
4. The GOK should pursue public-private partnerships for funding	86	35	3	0	1	4.6774	0.6155	96.8
5. Kenyan firms should be sensitized and given incentives to invest in sharing ventures	70	47	6	1	1	4.5081	0.7032	93.6
6. Infrastructure sharing agreements to increase in future	73	44	5	2	1	4.5242	0.7262	93.6
B: Stakeholders who stand to benefit more from infrastructure sharing								
Statements	**Strongly agree**	**Agree**	**Not sure**	**Disagree**	**strongly disagree**	**Mean**	**Standard deviation**	**Agree %**
1. ICT operators	74	44	3	3	1	4.5323	0.7373	94.4
2. Regulators (CAK, ICT A, NEMA)	60	47	6	12	0	4.2742	0.9287	85.6
3. Customers	81	37	3	4	0	4.5968	0.7012	94.4
4. Government	64	50	8	3	0	4.4355	0.7193	91.2
5. Rural/marginalized population	66	49	4	5	1	4.4274	0.803	92

Source: Researcher, Survey data (2014)

Priority ranking of the six initiatives to promote sharing in Kenya were the public-private partnerships funding especially in rural and marginalized areas, drafting guidelines, increasing infrastructure sharing agreements, sensitization and incentives to Kenyan firms, coordinated ICT infrastructure development planning and government to continued investment in ICT backbone infrastructure to supplement private investors. The important role of ICTs in promoting economic growth in Kenya had been acknowledged through various strategies and policies. The CAK strategic plan 2013 - 2018 stresses the importance of promoting sharing through development of guidelines. The Kenya national broadband strategy 2013-2017which aims to transform Kenya to a knowledge-based society recognizes the need to optimize the ICT infrastructure through sharing and development of policy framework for open access by all to the national backbone networks. The Kenya Vision 2030 Second Medium Term Plan 2013-2017 highlights emerging issues and challenges in implementing the vision as; digital divide, vandalism of ICT infrastructure and increase bandwidth capacity and expansion of fiber optic networks across Kenya. Nigeria ICT draft policy 2012 acknowledges the challenges of ICT in national development as regulatory deficiencies and an absence of coordination in fiber deployment leading to degradation of roads and public infrastructure.

By formulating friendly ICT policies that promote competition in the industry, countries such as Kenya stand to benefit and leap frog their economies through the implementation of open access to ICT resource. 93.6% of respondents were in agreement that Kenyan firms should be sensitized and given incentives to invest in ICT infrastructure sharing ventures. The funding of backbone and core ICT infrastructure is highly capitalized hence operator investment decisions were commercially driven. This had led to unequal distribution of infrastructure with operators focusing on urban areas and hence the digital divide for marginalized and rural areas. To address the challenge implies that the role of the private sector was to be supported by the government through public – private partnerships. Kenya had one towerco (Eaton towers) hence there was need for the government to put strategies in place such as tax concession incentives and a legal framework to attract more towercos. Since infrastructure development was capital intensive, the independent towercos could only invest where they were assured of returns on investment. The government should also supplement operators' initiatives by investing in backbone and core infrastructure and leasing the same to operators. Successful cases were the NOFBI project in Kenya, National Data Transmission Backbone Infrastructure in Uganda and Multimedia Super

Corridor (MSC) in Malaysia. The government of Kenya had recognized the importance of investing in key infrastructure and was currently implementing NOFBI 2 to make the network more resilience and to increase the coverage to all the 47 counties.

On stakeholders to benefit from sharing, the research findings were strongly in favour of all the five stakeholders with scores of 86% - 94% for those in agreement. The outcome was a confirmation that infrastructure sharing benefits applied across all five ICT stakeholders. The greatest beneficiaries were found to be customers and operators. Previous studies had shown that customers benefited through low cost products and services and increased access to ICT services. Infrastructure sharing enabled operators to generate new revenue from leasing capacity, extend network coverage especially in areas perceived to be commercially unviable, providing redundancy routes to improve network reliability, reduction on capital and operational expenditure, more focus on customer service innovation and strategic investments. New market entrants were able to deploy their network and market their products fast due to reduced network deployment cost and time. Sharing also improved relationship and trust between operators due to commercial dependence and knowledge sharing (Bogere et al., 2011; Djamal et al., 2010; Mokgware et al., 2009; Allen & Overy, 2012; KPMG, 2010; BICMA, 2009).

The case of Equity bank in Kenya is one of the success cases where new market entrants are able to launch services faster in the market with minimal network deployment. The company was licensed in April 2014 to offer mobiles service and within six months it is piloting its services using Airtel network (Equity, 2014 & CAK, 2014).The government will benefit through vision 2030 objectives such as digital economy, increased bandwidth uptake on NOFBI, universal access goal and general economic gain. Rural/marginalized population will have access to ICT services hence contribution to Kenya's economic growth and reducing the digital divide. The government of Kenya through the ICT master plan 2013/14 – 2017/18 intends to position Kenya as an ICT hub and make the country a digital economy. It is impossible to achieve the vision with insufficient ICT infrastructure and having more concentration of the same in urban areas. Sharing was one strategy of achieving Kenya vision 2030. CAK strategic plan 2013 - 2018 stresses the importance of promoting environmental sustainability through development of guidelines for infrastructure sharing, resource optimization and a legal framework.

4.5. Objective 2: Drivers of infrastructure sharing among mobile operators in Kenya

Table 4.5. Infrastructure sharing drivers

Statements	Strongly agree	Agree	Not sure	Disagree	strongly disagree	Mean	Standard deviation	Agree %
1. Sharing resources lowers costs and generates extra revenue for operators	85	36	3	1	0	4.6774	0.5748	97
2. Enables new entrants firms to launch and market their services more rapidly.	79	43	2	1	0	4.6371	0.5692	98
3. Efficient utilization of scarce ICT resources	70	36	7	12	0	4.3468	0.9545	85
4. Enables operators to focus on core business & innovations	63	51	6	5	0	4.4113	0.7593	91
5. Improves our environment due to reduced electronic waste	80	39	5	1	0	4.6210	0.6126	95
6. Increases coverage and access to ICT services	60	54	7	4	0	4.3952	0.7348	91
7. Improves network reliability (redundancy routes)	65	48	6	3	3	4.3871	0.8737	90
8. Promotes cooperation among competitors	73	38	9	3	2	4.4516	0.8544	89
9. Operators are able to comply with policy and regulatory requirements.	50	51	12	11	1	4.1371	0.9579	81
10. Hurdles in obtaining clearance from multiple government agencies	55	44	20	5	1	4.2097	0.8992	79

Source: Researcher, Survey data (2014)

Generally, the 10 drivers received overwhelming support with sores of 79% – 98% for respondents in agreement. The top 5 drivers were, enabled new entrants to launch and market their services faster, capital and operational expenditure, environmental conservation, operators focused on core business, increased network coverage and access of ICT services to underserved or un-served areas. Our findings relate to previous studies where the main drivers of infrastructure sharing were found to be cost optimization, the rise in demand for mobile broadband services, the need for new entrants to quickly increase coverage and to lower the cost of deploying ICT so as to achieve widespread affordable access to broadband services (Allen & Overy, 2012; ITU, 2009; BICMA, 2009). The global decline in ARPU had influenced operators to seek other revenue streams to increase profit margins. By sharing, infrastructure, costs were estimated to decline by 16% - 20% (KPMG, 2010. Other researchers estimated that sharing achieved 43% saving in capex and 49% on opex (Venmani et al., 2012). Backhaul sharing using IP/multi protocol label switching (MPLS) could also be implemented between operators to improve resiliency through redundancy ring networks among the operators hence improving on service availability.

Given that ICT infrastructure deployment required high capital investment and the long payback periods of over 10 years coupled with obsoleteness and market saturation, new operators were focused more on sharing to leverage. The financial sector in Kenya had witnessed the success of ICT infrastructure sharing among commercial banks (ATMS and funds transfer) through Pesapoint and Kenswitch (Pesapoint, 2014; Kenswitch, 2014). Kenyan operators had been sharing the internet exchange point resources to keep local internet traffic local via the Kenya Internet Exchange Point (KIXP) instead of routing the same via Europe. The research outcomes and sampled success cases are indications that more infrastructure sharing adoption and independent infrastructure investors will emerge in future as operators shun intensive capital investments and focus on core business and product innovations. Already the Kenyan market may witness the exit of Essar (YU mobile) brand due to stiff competition. Airtel Africa has made its intention to sell its sites in Africa including Kenya based on sell and lease back agreement (TXC, 2014). As the ICT market continues evolving, capital expenditure reduction so as to be remain competitive will remain a key cost optimization strategy among ICT operator especially in Africa and Kenya at large.

4.6. Objective 3: Challenges of infrastructure sharing among mobile operators in Kenya

Table 4.6. Infrastructure sharing challenges

Statements	Strongly agree	Agree	Not sure	Disagree	strongly disagree	Mean	Standard deviation	Agree %
1. May hinder competition due to reduced control and increased interdependence	20	34	8	57	6	3.0645	1.2536	43
2. Operators are exposed to risks (e.g. market share loss, security threats)	29	41	8	42	5	3.4032	1.2745	56
3. Complexities (requires stakeholders support, due diligence and extensive information)	34	56	10	16	9	3.75	1.2025	72
4. Unwillingness to share due to limited or lack of capacity to meet new demands	30	46	16	25	8	3.5484	1.2356	61
5. Incompatibility of different technology platforms	30	42	10	36	7	3.4435	1.2841	58
6. High charges by infrastructure owners	38	44	24	17	2	3.8226	1.0728	66
7. Lack of regulatory & policy framework to guide operators	52	42	8	16	7	3.9597	1.2263	75
8. High capital requirement for network upgrades and deployment	38	53	15	15	4	3.879	1.086	73
9. High contractual exit costs arising from breach	28	46	21	22	8	3.5403	1.2026	59
10. Fear of losing market share by operators with larger market share	26	47	37	13	2	3.6855	0.9768	58

Source: Researcher, Survey data (2014)

Out of the 10 infrastructure sharing challenges studied the top 5 were, lack of regulatory framework, high capital requirement for network upgrades and deployments, complexity of the sharing process (requires stakeholders support, due diligence and extensive information gathering), high charges by infrastructure owners and unwillingness to share due to limited or lack of capacity. When compared with previous findings, the incumbent operators were unwilling to share with their competitors and they deliberately used tactical delays (ITU, 2013; Idachaba, 2010; Booz, 2007). For highly populated areas lack of network capacity and incompatibility issues were the main challenges (Bogere et al., 2011; Onuzuruike, 2008; PWC, 2013). Having a regulatory framework was important in promoting infrastructure sharing. The Kenya ICT law of 2009 (CAP. 411A section 85A) recognizes infrastructure sharing but the law was not specific on the implementation guidelines. Tanzania has infrastructure sharing law under the legal notice No 429, 2011. Examples where sharing regulation had worked well include Europe, Ghana, Jordan, Nigeria and India. More respondents (57%) were in disagreement that reduced control and increased interdependence between operators affected competition. This contracted some previous findings as it mainly happened in active RAN sharing which was not implemented in Kenya. Since the operators had been sharing parts of their network even in the absence of a legal framework, it was likely that they had benefited from sharing and their market share had not been affected.

The findings showed that that even though challenges existed, they were outweighed by benefits. This was an indication that with close cooperation between operators the challenges could be overcome. Operators had control over the 4 of the 5 main challenges with the exception of a legal framework which was beyond the control of operators. Operators could implement risk management strategies such as joint ventures for upgrades and network deployment, review sharing process to make it more efficient and lower the cost leasing infrastructure. Regulators such as CAK should have infrastructure sharing enforcement mechanisms to guard against unfair practices and promote sharing. If the current infrastructure was sufficient, the operators were reluctant to fund network upgrades just to accommodate competitors. The reason for reluctance was the different priorities and corporate business strategies. Considering the opportunity cost, most operators would prefer to fund network expansions that add more value to them. To address the upgrade issue, operators could explore allowing others to fund the upgrades if they were willing.

4.7. Objective 4: Using the TOE framework for infrastructure sharing adoption

Table 4.7. Technological, Organizational and Environmental factors influence on sharing

A: Technological factors that influence infrastructure sharing adoption								
Statements	**Strongly agree**	**Agree**	**Not sure**	**Disagree**	**strongly disagree**	**Mean**	**Standard deviation**	**Agree %**
1. New technologies reduces capital and operational expenses	35	52	18	17	3	3.8226	1.0728	69.6
2. Invest in new technologies to gain a competitive advantage	62	48	5	10	0	4.3306	0.8808	88
3. The higher the compatibility the higher the adoption	57	53	9	6	0	4.3226	0.8021	88
4. Perceived benefits and risks from new technologies sharing adoption	34	56	21	12	2	3.8952	0.9788	72
B: Organizational factors that influence infrastructure sharing adoption (are factors the firm control)								
1. Top level management support leads to higher adopt ion	61	53	4	6	1	4.3710	0.8233	91.2
2. New operators are more likely to adopt infrastructure sharing	87	33	3	2	0	4.6774	0.6155	96
3. A strong financial base & ICT resources are less likely to adopt sharing.	51	39	10	21	4	3.9274	1.2041	72
4. Current ICT infrastructure influences sharing .	47	53	14	7	4	4.0887	1.0030	80
C: External environmental factors that influence infrastructure sharing adoption (are factors the firm cannot control)								
1. A decline in economic increases infrastructure sharing adoption.	55	55	6	8	1	4.2742	0.8750	88
2. Stiff competition forces operators to adopt infrastructure sharing	45	52	9	17	2	4.0000	1.0626	77.6
3. Having a legal framework & policy leads to higher infrastructure adoption	48	55	17	4	1	4.1935	0.8373	82.4
4. Customers demand for new ICT product influences sharing adoption	34	43	14	28	6	3.5968	1.2404	61.6

Source: Researcher, Survey data (2014)

4.7.1. Technological context

The study findings showed that technology changes influenced ICT infrastructure sharing adoption among operators with 70% - 88% of respondent in agreement. Operators preferred to invest in new technologies and ICT infrastructure so as to gain a competitive advantage scored the highest followed by the higher the compatibility of existing systems, then perceived benefits and risks from new technologies and deployment of new technologies as a key driver of infrastructure sharing. Compared with previous findings, mobile operators infrastructure sharing began officially in 2001 following the launch 3G technology in Europe. The high investments made to acquire 3G licenses forced operators to share infrastructure so as to recoup their investment fast (Booz, 2007). Infrastructure sharing was a challenge in highly populated areas due to a lack of capacity and incompatibility of systems which could lead to poor quality of service. For national roaming, the incumbent wanted to protect their investments and retain monopoly in certain areas (Bogere et al., 2011; Onuzuruike, 2008). Some of the technologies promoting resource sharing include cloud computing, digital broadcasting and fiber technologies. Cloud computing enables enterprises to deploy and maintain enterprise applications allowing for greater flexibility to shared resources. The case of global digital broadcasting allows sharing infrastructure and conserving bandwidth for 4G-LTE technology rollout (at least eight new channels can be provided using same frequency). In fiber transmission systems, DWDM allows bandwidth sharing based on wavelengths and cores as applies to submarines cables (SEACOM, TEAMS, EASsy and LION 2), Kenya power fiber and NOFBI network in Kenya. ICT operators in Kenya had also been investing heavily in infrastructure as a competitive advantage. For example Safaricom took the risk among the Kenyan mobile operators by investing their capital in 3G/4G rollout and mobile money transfer (Mpesa) infrastructure. The perceived benefits from these innovations worked to their advantage forcing other operators to also implement the same but by that time Safaricom had already taken up the larger market share in terms customer base and agent network. When compared globally with developed economies like the USA and Europe the future is such that competing on own infrastructure deployment is not economically viable given the high cost, long payback periods and falling revenue per user. The only option wasto leverage through the adoption of sharing.

4.7.2. Organizational context

Organizational factors had a strong influence on infrastructure sharing adoption with 72% - 96% of respondents in agreement**.** The strong influence could be attributed to the firm having more control over internal factors. New market entrants were disadvantaged especially in mature and saturated markets hence sharing was a strategy to remain competitive. National roaming was used by new entrants for a limited fixed period to quickly expand coverage in the initial stages (GSMA, 2008/09). The most recent example in Kenya was Equity bank MVNO hosted by Airtel Kenya. They were licensed in April and within six months, they were piloting their services (CCK, 2014; Equity, 2014). The infrastructure owner could generate extra revenue from selling excess capacity to other operators (ITU, 2013; GSMA, 2012/13). Top level management construct with higher levels (91%) of agreement could be attributed to the fact that managers were the ones directing organizations through business strategies. They were charged with the responsibility of influencing key decisions in their respective firms through the power bestowed to them by shareholders.

4.7.3. Environmental context

External environmental factors that influenced infrastructure sharing adoption in based on priority ranking were a decline in economic performance, having infrastructure a legal framework and policy, stiff competition and customers demand for new ICT product. The findings compared with Namisiko and Sakwa, 2013 study that investigated the challenges of site sharing in the context of open ICT infrastructure sharing by mobile operators in Kenya. They recommended the need for CAK to formulate a legal framework to govern how operators could share infrastructure without suspicions. The regulators (CAK and ICT Authority) through their strategies had also acknowledged the importance of sharing and the need to have infrastructure guidelines. Following global mobile near saturation at 96% and Kenya at 80%, stiff competition especially on voice and the decline in average revenue per user has seen a decline in profits operators been forced to embark on alternate service provision including data centres, cloud computing and also mobile banking services (CAK, 2014; ITU, 2013; GSMA 2013, KBA, 2012)**.** The firm has no control over external environmental factors such as the economic performance of a country which has a direct impact on the consumer as it reduces the purchasing power and operators revenue. As a result, operators may be forced to implement cost optimization strategies such as infrastructure sharing to save on capex in order to remain

competitive. They could expand into other areas without necessarily investing heavily in infrastructure. Analysis of Porter's 5 (suppliers, customers, new entrants, substitute products, competitors) of the forces show that it is strategic to have a competitive edge and ensure the profitability of the firm is sustainable through innovations and strategic investments. The bargaining power of customers increased as they were able to influence the profitability of the market by indirectly imposing their requirements in terms of price, service and quality. They had the option of switching between the operators as they wish based on preferences.

The overall findings of the TOE framework showed that organizational context with a greater influence on ICT infrastructure sharing adoption as compared to technology and external factors. Out of the 12 constructs tested the ones with higher influence were found to be new market entrants, top level management support technology competitive advantage, systems compatibility, economic performance and legal framework. The high acceptance level for organizational context could be attributed to the extent to which individual organization had full control over the internal factors hence it could easily manipulate the factors depending on circumstances to drive its business strategy. Organizations had no influence on technology and external factors. Operators have to pursue winning strategies to mitigate the risks of high capital requirements for infrastructure deployment in order to minimize the negative effects associated with factors which the firms have no control over. The changing ICT market warrants corresponding changes in the way the scarce ICT resources were utilized to deliver value to stakeholders

4.8. Results comparison with other TOE framework research findings

Comparing to other adoption studies that had used the same TOE framework, Borgman et al., 2013 study indicate the general influence of TOE factors on cloud computing. A high perceived relative advantage of cloud computing, a high level of top management support and a high competition intensity were the three factors positively linked to the decision to adopt cloud computing. In our finding the two constructs were second and third in ranking. Lippert & Chittibabu, 2006 on web services adoption by linking technological, organizational, and environmental determinant compared well to our findings in relation to increased return-on-investment (ROI).The adoption behaviour was a significant component of organizational effectiveness, a better understanding of its determinants that improved overall organizational

performance. By adopting infrastructure sharing operators could get returns on their investment in time due to reduced payback time and revenue gained from leased resources. Boon & Zo, 2007 studied factors affecting e-government assimilation in developing countries and suggested that regulatory environment, competition, organization compatibility, top management support and ICT expertise were important prerequisites for e-government assimilation. In our research a strong financial base and more ICT resources was a contributing factor but with a lower in ranking (bottom 3 of the 12 constructs). Kevin et al., 2013 on exploring the factors influencing the adoption of open source software in western Cape schools in South Africa showed that the organization context of the TOE framework was the most influential. Although the factors were not directly linked to those of the TOE framework, and compares well findings of our study where organizational factors had the highest average acceptance level of 85% for respondents in agreement. The average acceptance level of the entire TOE framework (12 constructs tested) was 81%. The three contexts presented both opportunities and challenges made organizations to adopt new innovations such as sharing infrastructure so as to remain competitive in the dynamic ICT industry. This implies that the TOE framework could be adopted for ICT infrastructure sharing among the ICT operators especially the mobile operators in Kenya. The same can be replicated elsewhere especially in the emerging markets such as Africa (has the highest demand for ICT service but with lack of infrastructure to meet the demand).

4.9. Discussion of Findings

ICT infrastructure sharing is a resource optimization strategy that deals with how available scarce resources are used to deliver value to the ICT stakeholders. Changing ICT market and technologies warrants corresponding changes in the way operators utilize the resources. Stiff competition, along with high capital and operational expenses in the ever changing ICT environment, had been putting pressure on operators to seek new ways of optimizing the costs and maintaining the profit margins so as to remain competitive. From the research findings infrastructure sharing was one strategy of achieving such quick wins by allowing competition by cooperation among ICT operators. There is insufficient ICT infrastructure in Africa including Kenya while the demand for ICT services is high and there is a notable gap in terms of ICT infrastructure availability between major urban centres and rural communities hence widening the digital divide (CAK, 2014; Mtega & Ronald, 2013; CBC, 2013). Adoption of infrastructure

sharing and increased investments by both government and private sector in ICT infrastructure can address the problems and contribute to economic growth.

The findings showed low levels of sharing among mobile operators as compared to other countries such as India and USA. High levels of sharing could be achieved if operators engaged each other as business partners aiming to benefit more from sharing their infrastructure. Safaricom had the highest infrastructure and market share following continuous heavy capital investment. When compared with global trends, more operators had opted to share through joint ventures or subsidiaries. The Kenyan market is not an exception hence mobile operators and other ICT operators will be forced to embrace more sharing especially with Safaricom given their extensive network coverage. With Essar's anticipated exit from the Kenyan market and their infrastructure takeover by Safaricom (due diligence process ongoing) Safaricom's infrastructure market share will increase close to 60%. This implies that for Kenya to increase sharing levels, the other operators and government will have to engage Safaricom to open up more while at the same time protect their business interests. The research showed overwhelming support for sharing adoption based on the TOE framework. ICT infrastructure sharing decision was mainly driven by operator's desire to reduce capex and opex so as to remain competitive. Emerging technologies such as cloud computing, digital broadcasting, MPLS, 3G/4G-LTE had also been putting pressure on ICT operators to share infrastructure. Sharing was advantageous to all ICT stakeholders with some limited shortcomings that could be mitigated by stakeholders with the support of CAK. Developed economies such as USA and Europe had successfully implemented sharing, hence it was important for Kenya through CAK to adopt the same so as to increase access to ICT services and achieve a knowledge economy as stated in Kenya vision 2030 and ICT master plan 2013/14 – 2017/18. Infrastructure deployment could not be left to private investors alone because they tended to focus more in urban areas leaving underserved and un-served areas. The Kenya government continued investment in key infrastructure such as NOFBI and data centres was critical to having such areas access to ICT services and lowering the cost of ICT services. To enable a good sharing environment there is need to have an enabling regulatory framework spearheaded by CAK and supported by ICT stakeholders. Since gains have already been made without the infrastructure sharing guidelines in place, CAK should initiate consultations on legal framework with stakeholders. Strategies such as incentives to

operators, coordinated network rollout including mandated sharing could then be explored to promote sharing. The current Kenyan status where infrastructure development is left to individual operators and with lack of information on available excess capacity held by operators (to CAK and other operators) resulted to continuous network duplication and underutilization of scarce resources. When compared to Ghana with 5 towercos, Kenyan had one towerco (Eaton towers) without own infrastructure or management contracts locally, hence there was need to attract more independent tower companies through incentives since it had been shown that countries that had embraced independent companies like USA and India had shown more high levels of sharing.

Operators' decision to adopt passive or active infrastructure sharing is driven by the environment (external/internal) in which they operate. Once infrastructure sharing is adopted, operators are faced with some challenges that must be overcome for the stakeholders to fully exploit opportunities and benefit from sharing. The figure below gives a summary of the research.

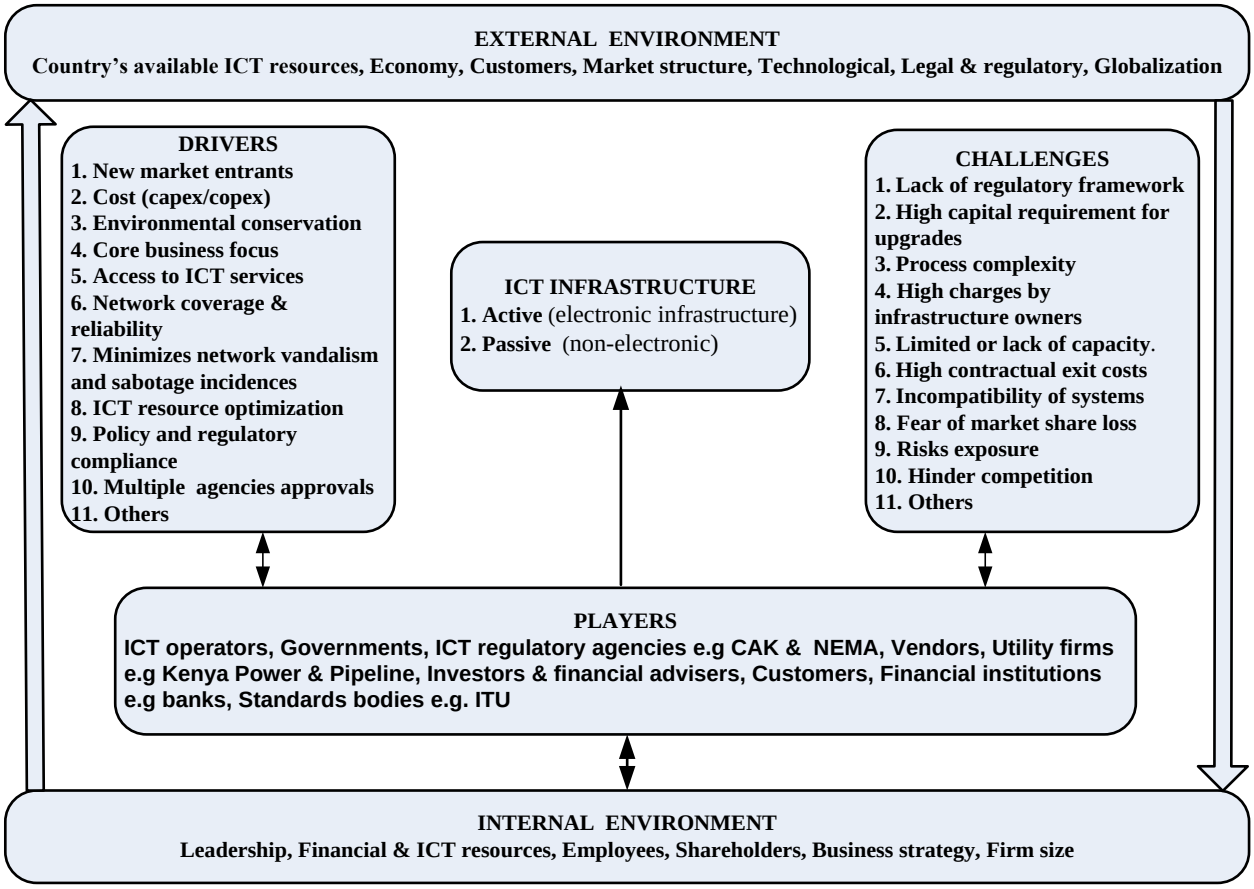

Figure 4.1. ICT infrastructure sharing factors **Source:** Researcher

4.10. Proposed ICT infrastructure sharing framework

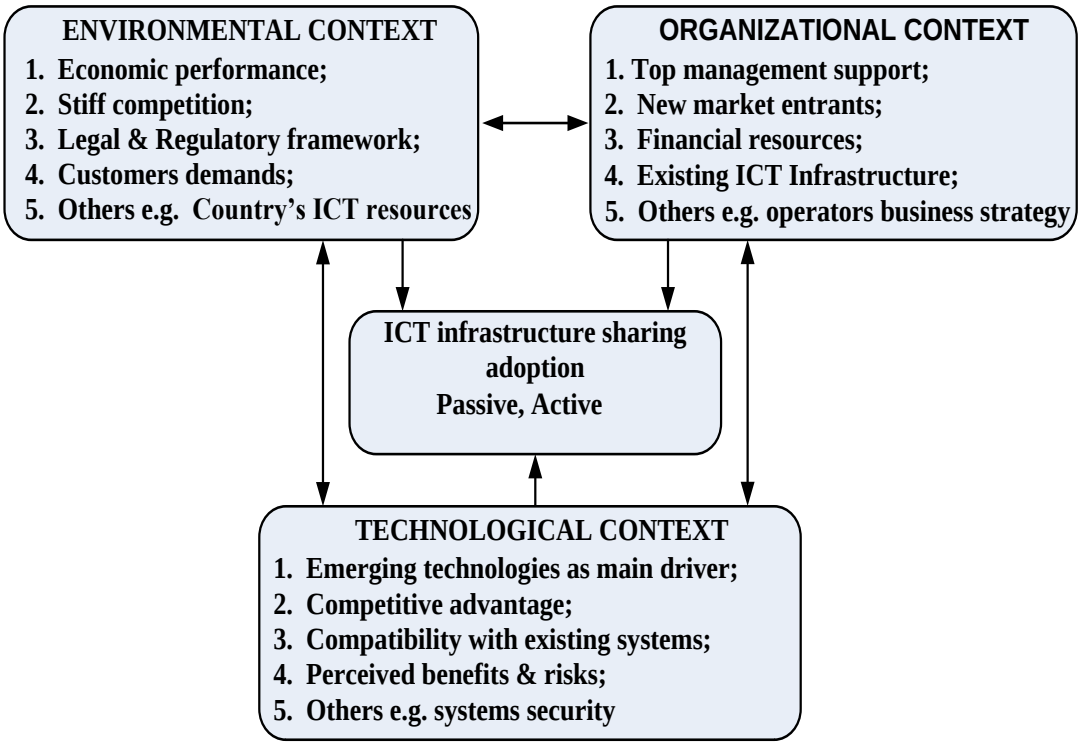

Figure 4.2. Proposed ICT infrastructure sharing framework

Note:

The study focused only on the 12 constructs (the first 4 in each context). The scope and flexibility of the TOE framework allows constructs to be expanded depending on circumstances in order to deliver results.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

The research sought to propose an adoption framework for ICT infrastructure sharing for mobile operators in Kenya after establishing the levels, drivers and challenges of infrastructure sharing among the four mobile operators.

5.1. Achievements

The research established that the level of infrastructures sharing in Kenyan among the 4 mobile operators was low (1256 sites out of the 6147 sites had been shared) representing 20.4% with Airtel Kenya and Telkom Kenya leading at 37% and 32% respectively. The five key drivers of infrastructure sharing in Kenya were determined as new entrants wanting to launch and market their services faster, cost optimization (capex/opex and revenue generation), environmental conservation, operators intention to focus on core business /innovations and increase coverage of ICT services to underserved or un-served areas. The five main challenges of infrastructure sharing in Kenya were established as lack of regulatory & policy framework to guide operators, high capital requirement for network upgrades to meet other operators demands, complexity of the sharing process, high charges by infrastructure owners, and unwillingness to share due to limited or lack of capacity to meet other operators demands. The research established that the TOE framework could be adopted for ICT infrastructure sharing with organizational context having a greater influence than technology and external factors. Out of the 12 constructs of the framework tested the ones with higher influence were found to be new market entrants and top level management support. The research also determined that passive sharing type was the most preferred while the most preferred business model was independent towercos with capex and emerging technology having more influence on operator's decision to share. On initiatives it was established that the government of Kenya should continue to invest in backbone infrastructure, pursue public-private partnerships funding and enact a legal framework to guide stakeholders. Among the five stakeholders (operators', regulators, customers, government and rural/marginalized population) it was found that customers and operators were the main beneficiaries from infrastructure sharing.

The findings of our study can be used by CAK and ICT Authority as reference material while drafting or reviewing infrastructure sharing guidelines so as to promote sharing in Kenya. For

operators the findings could encourage them cooperate rather than investing in own infrastructure and view competitors as business partners (utilize available extra bandwidth and generate extra revenue). Customers could benefit through access to ICT services and affordable products if sharing is implemented on a large scale. The Universal Service Fund management could also use the findings to make informed decisions while investing (the 0.5% levy based on operators annual revenue) in ICT infrastructure to un-served and underserved areas by involving existing operators to promote sharing/joint ventures in such areas so that the disparity in availability and access to telecommunications services between rural and urban is addressed to reduce digital divide. The government of Kenya funded NOFBI and submarine firms could benefit through increased bandwidth uptake. By optimizing the country will save on the foreign exchange and environmental preservation (ICT infrastructure and fuel are imported). Other researchers can use the findings as a reference to extend research on infrastructure and fill the gap as acknowledged by Namisiko and Sakwa, 2013 that a few studies had been done despite infrastructure sharing existence and the lack of Kenyan literature on the same.

5.2. Limitations

The results of the study were limited to mobile operators with more focus on passive site sharing. The wide scope of the TOE framework implies that the constructs could be expanded or reduced depending on circumstances. The study was limited to the 12 constructs tested but the same could be varied to deliver different results.

5.3. Conclusion

Infrastructure sharing levels in Kenya were low hence strategies to promote the same and increase the levels should be explored by the ICT stakeholders especially by CAK and ICT Authority. One strategy would be giving incentives such as concessions on tax and license fee to independent firms and operators so as to encourage sharing especially Safaricom. Operator controlled infrastructure deployment as a competitive advantage had worked previously for Kenya but as Africa's ICT industry evolves with increasing number independent firms investing in infrastructure and operators faced with stiff competition, demand for infrastructure and services rising, high capital requirements and long payback periods, bank loans, emerging technologies, shareholders pressure and market saturation, infrastructure sharing adoption was key to helping operators mitigate the risks and to remain competitive. To contribute to the

growth of the ICT sector in Kenya requires an appropriate regulatory framework with strategies such as protecting existing investments to deliver value to owners, coordinated planning and network rollout among ICT stakeholders, fair commercial pricing that benefits the buyer and seller, right incentives for investments in infrastructure to guarantee reasonable return on investments, transparency and information sharing on ICT resources and allowing sharing with other market players such as Kenya power, governments and Kenya pipeline. The sharing of infrastructure was beneficial to all the stakeholders as witnessed with the success of ATMs sharing among banks, microfinance institutions and cooperative societies hence it should be embraced to enable opportunity exploitation. Even though sharing had some challenges, strategies can be implemented to mitigate the risks and promote resource optimization. Given the findings in relation to the nature of TOE framework (wide scope of contexts and flexibility to adapt to multiple environments), the framework was found to be appropriate for adoption for ICT infrastructure sharing among mobile operators in Kenya. The same can be replicated to other ICT operators in emerging markets especially in Africa where there is insufficient and high demand/growth of ICT services.

5.4. Recommendations

To promote infrastructure sharing in Kenya, there was need to have regulatory framework owned and supported by ICT stakeholders and the one that compares to Pakistan Telecommunication Authority vision (create a fair regulatory regime that promotes investment, encourages competition, protects consumer interest and ensure high quality ICT services). Since gains had already been achieved without a comprehensive infrastructure sharing guidelines in place, CAK should initiate consultations on same with stakeholders. For a start, Kenya could explore voluntary sharing with clear guidelines applicable to India. CAK should design a model site standardized to accommodate at least three operators with a view of implementing the same for future mobile network deployments. The Kenya government should continue investing and at the same time pursue public-private partnerships funding in backbone infrastructure to increase access and to lower the cost of ICT services especially in underserved or un-served areas. Strategies such as incentives to operators and independent towercos, coordinated network rollout among ICT stakeholders in Kenya and sensitizing Kenyan firms to invest in ICT infrastructure sharing ventures should be explored to increase sharing levels. To benefit all ICT stakeholders,

operators with excess capacity should share the information with CAK and other operators to prevent network duplication and underutilization of scarce resources. The same should be extended to any future network rollout plans. This requires CAK to have a comprehensive ICT infrastructure database for the entire country including any sharing information agreements in force.

5.5. Further Work

Our research targeted mobile operators hence to gain a holistic understanding, a further research should be extended to other ICT operators such as broadcasting firms, ISPs, utility firms, governments (central & county) to determine the level of sharing in Kenya among ICT operators**.** The dynamic nature of ICT market calls for a longitudinal study to be conducted to access whether the factors will still hold as there are anticipated changes (rising adoption of cloud computing, completion of digital migration, Essar takeover by Safaricom and Airtel, initiatives by CAK to have infrastructure sharing framework, Airtel Africa tower sell and leaseback, progress of joint national 4G network rollout venture and Safaricom 4G-LTE network rollout in partnership with the government among other factors). Since the government had invested heavily in shared resources (NOFBI and data centres), a study on the same to determine if the objectives had been met with a view of improving and having a framework, increase bandwidth uptake and efficient utilization of the resources could guide future investments. Given that the mobile money transfer had been adopted in most sectors of our economy, further research on sharing of IT platforms & agent network can be done with a view of coming up with successful business model and framework that could benefit all the stakeholders (Kenya's economy, operators, agents, financial institutions and customers).

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APPENDICES

Appendix 1: Questionnaire

The objective of this study is to determine the **drivers, levels and challenges** of ICT infrastructure sharing among ICT operators in Kenya. The information given will be treated with high degree of confidentiality. Please provide the correct information. If you encounter any challenges in filling the questionnaire please **contact Charles** on 0772 259 069 or 0720 259 069.

SECTION A : Demographics

1. Name of organization……City/town…….
2. What is your gender? ☐ Male ☐ Female
3. Your age bracket: ☐ 19 - 30 Years ☐ 31 - 40 Years ☐ 41 - 50 Years ☐ Over 50 years
4. What is your highest level of education? ☐ College certificate /diploma ☐ University degree
   ☐ Post graduate ☐ others (specify) …….
5. How long have you been working in the ICT Industry?
   ☐ Less than 5 Years ☐ 5- 10 Years ☐ 10- 20 Years ☐ Over 20 yrs
6. What is your position?
   ☐ Technical support (e.g. engineer, technician, supervisory role, system admin/analyst /security)
   ☐ Manager
   ☐ Others (specify) ……

SECTION B: General information, drivers & challenges of infrastructure sharing among ICT operators

7. Please tick the appropriate examples of ICT infrastructure sharing you are aware of from the list below:
   ☐ Cloud computing /data centres
   ☐ Digital broadcasting (e.g. Signet & Pan African Networks Group signal distributors in Kenya)
   ☐ Banking industry e.g. using ATMs of other banks or Pesapoint ATMs
   ☐ Fiber (e.g. terrestrial such as NOFBI, KPLC & submarine fiber optics such as SEACOM, TEAMS,)
   ☐ Satellite telecommunications such as INTELSAT, IMMARSAT
   ☐ Mobile roaming (national & international)
   ☐ Enterprise resource planning (ERP)
   ☐ Sites (e.g. equipment rooms/shelters, compounds, power, tower, air conditioning)
   ☐ Radio Access Network (e.g. transmitters/receivers, antenna systems)
8. Do you encourage ICT infrastructure sharing among the Government, ICT operators, independent tower companies and utility firms such as Kenya Power? ☐ **YES** ☐ **NO**
   Give reasons ……..
9. What form of infrastructure sharing (active or passive) would you prefer most?
   ☐ Active (e.g. switches/routers, servers, spectrum, microwave, BTS/BSC/RNC)
   ☐ Passive ((e.g. towers, power, air conditioners, ducts, security, equipment rooms, trenches)

10. Should CCK (CAK) make ICT infrastructure sharing: ☐ Voluntary or ☐ Mandatory?

    Give reasons ……
11. Should ICT operators sharing their infrastructure be given incentives such as tax and license fee concessions by the government? ☐ **YES** ☐ **NO**

    Give reasons ……..
12. Operators should share mobile money transfer infrastructure (IT platforms, agent network). Do you agree?

    ☐ **YES** ☐ **NO**

    Give reasons ……
13. Operators with excess capacity should share the information with other ICT operators and CCK (CAK) to enable them to make infrastructure sharing decisions. ☐ **YES** ☐ **NO**
14. Which infrastructure sharing business model would you prefer most?

    ☐ Operator controlled

    ☐ Inter-operator or operator joint ventures

    ☐ Independent companies

    Give reasons ……
15. Do you agree that emerging technologies such as cloud computing, digital broadcasting, MPLS, 3G/4G-LTE have been putting pressure on ICT operators to share infrastructure so as to lower deployment costs and generate extra revenue? ☐ **YES** ☐ **NO**
16. ICT infrastructure sharing decision is mainly driven by operator's desire to reduce capital and operational expenses so as to maximize on profit margins and remain competitive. Do you agree? ☐ **YES** ☐ **NO**
17. There should be initiatives by ICT stakeholders such as the government, operators, utility firms and independent investors to promote infrastructure sharing in Kenya.

Statements	**Please tick the most appropriate answer**				
	Strongly Agree	Agree	Not sure	Disagree	Strongly disagree
1. CCK (CAK) should draft infrastructure sharing guidelines to regulate infrastructure sharing in Kenya					
2. The government should continue investing in ICT backbone and core infrastructure to supplement private investors					
3. ICT Infrastructure development planning should be coordinated by ICT promote efficient resource utilization					
4. The government should pursue public-private partnerships to provide ICT services in underserved or un-served areas					
5. Kenyan firms should be sensitized and given incentives to invest in ICT infrastructure sharing ventures					
6. ICT Infrastructure sharing agreements are more likely to increase in future as more operators focus on core business and value added services to meet customer needs					

18. ICT infrastructure sharing is **more beneficial to the stakeholders** listed in the table below? Please indicate the extent to which you agree by ticking the most appropriate answer.

Stakeholders	**Please tick the most appropriate answer**				
	Strongly Agree	Agree	Not sure	Disagree	Strongly disagree
1. ICT operators (e.g. mobile, submarine ,ISPs & broadcasting)					
2. Regulators (CAK, ICTA, NEMA KCAA)					
3. Customers (low cost products & services, increased access to ICT services)					
4. Government (vision 2030 objectives such as digital economy, bandwidth uptake on NOFBI, universal access goal)					
5. Rural/marginalized population (access to ICT services hence contribution to Kenya's economic growth, solve digital divide)					

19. ICT infrastructure sharing is mostly **driven** by the factors listed in the table below? Please indicate the extent to which you agree (**single response per statement**)

Statements	**Please tick the most appropriate answer**				
	Strongly Agree	Agree	Not sure	Disagree	strongly disagree
1. Sharing resources lowers costs (capital and operational) and generates extra revenue for operators					
2. Infrastructure sharing enables new entrants /small ICT firms to launch and market their services more rapidly.					
3. Infrastructure sharing leads to efficient utilization of scarce resources e.g. servers, frequency, bandwidth & space					
4. Infrastructure sharing enables operators to focus on core business and innovations					
5. Improves our environment due to reduced electronic waste and network deployment e.g. towers, trenches					
6. Increases coverage and availability of ICT services. Helps to achieve universal service goals to underserved or rural areas.					
7. Sharing improves network reliability since operators can lease excess capacity from other operators to provide redundancy/protection routes					
8. Promotes cooperation (fosters good relationships) among competitors hence reducing network vandalism and sabotage incidences					
9. Infrastructure sharing enables operators to comply with policy and regulatory requirements e.g. provide services in rural areas.					
10. Hurdles in obtaining clearance/licenses from a multiple government agencies such as CCK, NEMA, County governments					

20. ICT operators are faced with various **challenges** that hinder them from fully exploiting infrastructure sharing opportunities. Please indicate the extent to which you agree.

Statements	strongly agree	Agree	Not sure	Disagree	Strongly disagree
1. Infrastructure sharing may hinder competition due to reduced control and increased interdependence between operators.					
2. Sharing exposes operator to risks (e.g security threats, interference and services quality issues)					
3. Sharing is a complex process that requires stakeholders support, due diligence and extensive information gathering					
4. Operator's unwillingness to share due to limited or lack of capacity to meet the demands of other operators					
5. Incompatibility of different technology platforms (e.g. MPLS, CDMA, 2G/3G/LTE, SDH, DWDM)					
6. High charges by infrastructure owners					
7. Lack of regulatory & policy framework to guide operators					
8. High capital requirement for network upgrades and deployment to meet new demands from other operators					
9. High contractual exit costs arising from breach of infrastructure sharing contract especially for long term agreements					
10. Fear of losing market share by dominant players (operators with larger market share)					

SECTION C: Factors influencing infrastructure sharing adoption among ICT operators

Technological factors that influence infrastructure sharing adoption

21. Technology changes influences ICT infrastructure sharing adoption among operators. Please indicate the extent to which you agree with the following statements (**single response per statement**)

Statements	**Please tick the most appropriate answer**				
	Strongly Agree	Agree	Not sure	Disagree	Strongly disagree
1. Deployment of new technologies is the main driver of infrastructure sharing adoption					
2. Operators prefer to invest in new technologies and own ICT infrastructure so as to gain a competitive advantage					
3. The higher the compatibility of existing technologies or systems, the high the adoption of ICT infrastructure sharing					
4. Perceived benefits and risks from new technologies influences infrastructure sharing adoption					

External environmental factors that influence infrastructure sharing adoption

22. External environment (factors the firm **cannot** control) influences ICT infrastructure sharing adoption among operators. Please indicate the extent to which you agree with the following statements.

Statements	**Please tick the most appropriate answer**				
	Strongly Agree	Agree	Not sure	Disagree	Strongly disagree
1. A decline in economic performance forces operators to implement cost saving strategies such infrastructure sharing adoption.					
2. Stiff competition in the ICT industry forces operators to adopt infrastructure sharing so as to reduce costs and remain competitive					
3. Having infrastructure sharing legal framework & policy in place leads to higher adoption of infrastructure sharing					
4. Customers demand for new ICT product/service (e.g. 3G/4G, money transfer) affects infrastructure sharing adoption					

Organizational factors that influence infrastructure sharing adoption

23. Operator's organizational factors (factors the firm **can** control) influences ICT infrastructure sharing adoption. Please indicate the extent to which you agree with the following statements.

Statements	**Please tick the most appropriate answer**				
	Strongly Agree	Agree	Not sure	Disagree	Strongly disagree
1. Top level management support leads to greater intent to adopt ICT infrastructure sharing					
2. New operators are more likely to adopt infrastructure sharing so as to market their services fast and save on network rollout and operational expenses.					
3. Operators with a strong financial base & more ICT resources are less likely to adopt infrastructure sharing.					
4. If operator's current ICT infrastructure cannot support its objectives, chances of adopting infrastructure sharing to meet the shortfall are high.					

Respondents are also invited to give their opinion they consider important to the study but was not covered by the questionnaire ……
…….....

We thank you for completing the questionnaire.

Appendix 2: List of participating organizations

List of organizations that responded per domain	
Organization/classification	**Market segment description**
1. Mobile operators	
Safaricom	Market leader as per CAK 3rd quarter report (published in July 2014) with market share of 67.8% (21,567,388 of the total 31.8 million mobile subscribers in Kenya), Mobile data/internet subscription market share of 72.1%, ranked 7th at 7.1% in fixed/terrestrial wireless data/Internet subscriptions and mobile money transfer (Mpesa) agents market share at 78% (81,025 out of 103,660 total agents). Annual financial report released in March 2014 shows turnover of Ksh.144.67 billion. **Source:** CAK & Safaricom
Airtel	Mobile market share of 16.5% (5, 251, 087 of 31.8 million subscribers) and 13.7% for mobile data/internet subscription market share. **Source:** CAK
Essar (YU mobile)	Mobile market share of 8% (2,557,630 of 31.8 million subscribers) and mobile data/internet subscription market share of 3.9%. **Source:** CAK
Telkom Kenya (Orange)	Mobile market share of 7.7% (2,453,898 of 31.8 million mobile subscribers) and mobile data/internet subscription market share of 10.3%. The company also has 205,856 fixed lines and 148,823 fixed wireless on CDMA technology. In addition the company also manages three submarine cables (TEAMS, EASSY & LION 2). **Source:** CAK & Telkom
2. Fixed/terrestrial wireless data/Internet subscriptions (The market shares for the top 10 operators)	
Wananchi	Market leader in Fixed/terrestrial wireless data/Internet subscriptions market segment as per CAK 3rd quarter report for Jan 2014 - March 2014 with market share of 44.7 % (44, 254 subscriptions) **Source:** CAK
Access Kenya (Internet solution)	Ranked 3rd in Kenya market share at 11.5% (11, 360 subscriptions) in fixed/terrestrial wireless data/Internet subscriptions **Source:** CAK
JTL	Ranked 7th in Kenya n fixed/terrestrial wireless data/Internet subscriptions market share at 2.6% (2, 574 subscriptions) **Source:** CAK
3. Submarine cable operators (International Internet Available Bandwidth (Mbps)	
SEACOM	Market leader in available international internet bandwidth (Mbps) as per CAK 3rd quarter report (published in July 2014) with market share of 67.4 % (583,680 Mbps). **Source:** CAK
TEAMS (The East African Marine System)	Market share of 13.9% (119, 970 Mbps) based on available international internet bandwidth of 865,714 Mbps . **Source:** CAK
EASSy (Eastern Africa Submarine Cable System	Market share of 14% (120, 880 Mbps) based on available international internet bandwidth 865,714 Mbps
LION 2 (Lower Indian Ocean Network)	Market share of 5% (40, 960 Mbps) based on available international internet bandwidth 865,714 Mbps. **Source:** CAK
4. Broadcasting	
KBC (Kenya Broadcasting Corporation)	The Kenya national state owned broadcaster (TV & RADIO). Its subsidiary Signet is a digital signal distributor (form of infrastructure sharing). KBC shares ICT infrastructure with other broadcasting companies such as Nation media and KTN and all the four mobile operators. **Source:** KBC

Organization/classification	Market segment description
5. Regulators	
Communications Authority of Kenya	Regulatory authority for Information and Communications sectors in Kenya including; broadcasting, multimedia, telecommunications, electronic commerce, postal and courier services. **Source:** CAK
ICT Authority	The Authority is tasked with rationalizing and streamlining the management of all Government of Kenya ICT functions. Its broad mandate entails enforcing ICT standards in Government and enhancing the supervision of its electronic communication. The Authority is in charge of NOFBI network (infrastructure is shared among ICT operators such as Telkom, Safaricom, Jamii), County connectivity project and is implementing NOFBI 2 project. **Source:** ICTA
6. Banking industry (have implemented sharing of ATMs & Kenswitch)	
Equity bank	According to CBK annual supervisory report released in December 2013, Equity is the largest bank in the region in terms of customer base with over 7.4 million bank accounts (market share of 33.92 % of all bank accounts in Kenya) with a net asset base of Ksh. 238.194 billion (market share of 8.8%) and a branch network of 153. The bank was also licensed in April as a mobile virtual network operator through its subsidiary Finserve Africa using thin SIM technology. It is currently piloting the mobile services. **Source:** Equity, CAK & CBK.
Barclays bank	Has net asset base of Ksh.207.01 billion (market share of 7.7 %), 1.24 million bank accounts (market share of 5.69%) and a branch network of 107 as of Dec 2013. **Source:** Barclays & CBK
7. Telecommunication equipment vendors	
Huawei	Is a chinese base multinational networking and telecommunications equipment and services company ranked the second in terms of sales globally. It is also the 2nd largest router and switch vendors globally after CISCO. Its current customers in Kenya include Safaricom, GOK, Telkom Kenya, JTL, MTN and SEACOM. It is contracted for NOFBI 2 project to make the network more resilience. NOFBI is government funded and is shared among some ICT operators. **Source:** Huawei, ICTA & operators
Ericsson	Globally Ericsson international is the main supplier of communication equipments globally and is ranked first terms of sales globally. Its current customers in Kenya include Safcom, Telkom Kenya, Essar (YU) and Airtel among others. **Source:** Ericsson and operators
Nokia Siemens Networks	Nokia is ranked the 4th largest communication equipment vendor globally in terms of sales. In Kenya the company has been contracted by Airtel Kenya to provide GSM operations & maintenance services. **Source:** NSN & Airtel
8. Utility company	
Kenya power	The utility company is responsible for electricity distribution across Kenya and has a fibre optic cable running from Mombasa, Nairobi to Malaba on the Kenya Uganda border and up to Tororo Uganda (1700km) using the power lines hence making it more reliable due to minimal sabotage incidences. It has leased to Kenya ICT operators (KDN, JTL, Wananchi and Safaricom). The firm is targeting to roll out about 25,000 km of fiber optic network to reach households connected to power across the country at a cost of 156bn and projected revenue of Ksh. 50 billion per month. **Source:** KPC

Appendix 3: Sample distribution & response by organization

Sample distribution & response by organization							
#	Organization	Target	Response	Response technique			Response %
				Hardcopy	Online	Phone	
1	Safaricom	45	36	20	13	0	80
2	Airtel/Nokia	30	21	6	15	0	70
3	Essar (YU mobile)	25	15	7	9	1	60
4	TKL	25	21	12	9	0	84
5	Wananchi	5	3	0	3	0	60
6	Access	2	2	0	2	0	100
7	JTL	2	1	0	1	0	50
8	SEACOM	5	4	0	4	0	80
9	TEAMS,EASSY & LION2	5	4	0	4	0	80
10	CAK (former CCK)	3	4	0	4	0	133
11	ICT Authority	2	1	0	2	0	50
12	Huawei	3	3	2	1	0	100
13	Ericsson	3	3	0	3	0	100
14	Royal media	2	0	0	0	0	0
15	KBC	2	3	3	0	0	150
16	Equity	3	1	0	0	0	33
17	KCB	2	0	0	0	0	0
18	Barclays	2	1	2	0	0	50
19	Kenya Power company	4	2	0	2	0	50
Total		**170**	**125**	**52**	**72**	**1**	**74**

Source: Researcher, Survey data