



ICT Infrastructure Sharing Framework for Developing Countries: Case of Mobile Operators in Kenya

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ABSTRACT

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 [1]. Even with this challenge, ICT operators in Kenya prefer to invest in own infrastructure despite the availability of underutilized ICT resources from other operators and players. This has led to wastage of scarce resources, high cost of services, poor quality services, environmental degradation and low investment in rural areas among others. 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. Data was collected from ICT staff of the four mobile operators Safaricom, Airtel, Essar and Telkom Kenya Orange across the country using a questionnaire. To supplement and increase reliability, data was also collected from other ICT stakeholders such as CAK, ICTA, submarine operators, ICT vendors, KBC and non ICT related firms Equity, Barclays and Kenya Power Company. The research found out that the level of ICT infrastructure sharing among mobile operators was low at 20.4%. The five key drivers 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 lack of regulatory framework, high capital, complexity of the sharing process, high charges by infrastructure owners and operators unwillingness to share. The TOE framework can be adopted for ICT infrastructure sharing with organizational factors having a greater influence than technology and external factors. 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 achieve quick wins, operators had to partner with competitors by leasing and undertaking joint 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 and a knowledge economy status

General Terms

Mobile communications, ICT infrastructure

Keywords

ICT infrastructure sharing framework, Mobile operators cost optimization, TOE framework

1. INTRODUCTION

Information and communication technologies are fundamental and essential infrastructure for poverty reduction, high productivity, economic growth, improved accountability and governance [2]. The lack of infrastructure in Africa especially South of the Sahara is widely recognized, one of the continent's greatest impediments to sustainable development [1]. 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. 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 [3] [4] [5] [6]. The main objective of infrastructure sharing is to optimize the scarce resources, maximize on economic returns on investments and the development of business models that focus on affordable and accessible ICT services [3] [7] [8]. 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 open 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 established brand name [9]. Earlier successful infrastructure sharing initiatives among African countries include the Pan African Telecommunications Network PANAFTTEL 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 foster the socioeconomic development of African countries by having a dedicated African satellite system that could lower communication costs by routing African traffic via Africa instead of Europe. Another initiative to launch shared African submarine cable under Africa one project failed to materialize [10] [11] [12].

Kenya is set to experience active sharing based on VMNO concept following the licensing of three firms in April 2014 by CAK. One of the firms, a subsidiary of Equity bank had piloted the services using Airtel network [13]. The Kenya ICT Master plan 2013/14 – 2017/18 recognizes the need to implement integrated ICT Infrastructure and information structure that minimizes duplication and enables application of shared services. To achieve the objective, there was need to have a national data infrastructure, open data, and policy



framework. Communication Commission of Kenya strategic plan 2013 – 2018 is also committed to promoting environmental sustainability through development of guidelines for infrastructure sharing, co-location, green ICT and mainstream environmental sustainability within the ICT sector. The Kenya national broadband strategy 2013-2017 vision is to transform Kenya to a knowledge-based society and recognizes the need for optimization of ICT infrastructure through sharing and the development of policy framework for open access by all to the national backbone networks [14] [37] [38]. Successive infrastructure sharing examples in Kenya are Pesapoint and Kenswitch where participating financial institutions share payment infrastructure, a government funded fiber project NOFBI, Kenya power fiber network, Kenya internet exchange point. Globally infrastructure sharing has been successfully implemented in USA, Pakistan and India [16] [17].

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 [1]. As a result, ICT operators have been investing heavily in own infrastructure even where there was availability of resources from other operators, utility companies and municipalities. They have also focused mostly in urban areas. This had led to 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 degradation 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 of 10 to 15 years [18] [19] [25].

2.1 Research objectives

- i. Determine the extent of infrastructure sharing among mobile operators in Kenya.
- ii. Determine drivers of infrastructure sharing among mobile operators in Kenya.
- iii. Establish main challenges of infrastructure sharing among mobile operators in Kenya.
- iv. Assess if the TOE framework can be adopted for ICT infrastructure sharing.

3. RELATED WORK

3.1 Levels of infrastructure sharing

Mobile communication infrastructure sharing levels differ globally with high levels more evident in Europe, USA and India. In Austria about 50% of sites had been shared by the end of 2009 while in Sweden 70% of the sites had been shared by end of 2011. In India it was estimated that out of the total 300,000 sites, 60% had been shared with an average tenancy of 1.5. Operators such as Indus had a tenancy ratio of 1.71x, Bharti Infratel 1.62x and WTTIL Quippo 1.84x. The USA had an average tenancy ratio of 2.5x [17]. Amongst mobile operators in Pakistan, Waridi had the highest tenancy ratio of 1.44 followed by Ufone 1.3 [16]. Europe, Australia and North America had seen growth in the mobile virtual network operators MVNOs, with more than 760 MVNOs active globally. The growth for the MVNO model in the Middle East and Africa MEA region was still low and at infancy stage with the two regions having 8 and 4 active MVNO respectively in 2013 as compared to Europe which had 496 MVNOs [21]. Africa was estimated to have 165,000 sites in

2014 with major players being IHS Africa with 20,000 sites, American towers with 5136, Helios TA with over 7800, Eaton with over 5070 and Swap technologies with 1459 sites managed and owned. Ghana had the highest concentration of independent tower firms [22].

3.2 Drivers of infrastructure sharing

The main drivers of infrastructure sharing among mobile operators were capital cost capex and operational expenditure opex savings, the rise in demand for mobile broadband services offered on 3G/4G -LTE technologies and their licensing constraints, the need for new market entrants to quickly increase coverage and to lower the cost of deploying ICT so as to achieve widespread affordable access to broadband services [23]. Infrastructure sharing generated extra revenue estimated at 10% of the total annual revenue, reduced infrastructure costs by 40-60%, offered better use of scarce spectrum resource, enabled easy market entry by new players hence increasing competition in the industry, improved innovation and better customer service hence addressing a decline in ARPU, achieved universal service goals by expanding network to underserved or rural areas to meet policy and regulator targets, minimized environmental degradation due to reduced network build up, resulted in higher uptime due to diversity routes, led to cost and energy efficiencies due to reduced emissions and diesel consumption hence improved green concept [3] [19] [20] [24] [25]. Infrastructure sharing can also be used to bridge the digital divide, meet regulatory requirements and help governments to achieve ICT services universal access goals [4]. Infrastructure deployment came with multiple risks and by sharing infrastructure the risks were reduced among cooperating operators. Sharing encourages scarce national resources optimization such as rights of way and spectrum hence availing the freed resources for strategic use [5] [26]. The rationale for infrastructure sharing differed between markets. For mature markets, sharing provided an additional source of revenue, minimized operating costs, added capacity in congested areas with limited space and towers. For developing markets, infrastructure sharing expanded network coverage and fast tracked on marketing strategies. ICT operators sharing infrastructure from the start of network rollout especially 3G/4G had an opportunity to reduce capital and operational expenditure [9] [27]. Capital and operational expenditure capex and opex analysis show a difference 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 hence requiring diesel generators. The valuation of tower build up capex varied significantly across markets with costs ranging from 150,000 USD to 173,000 USD per tower. This could explain why the developed countries shared sites to reduce opex [20] [28]. Financial management consultants, KPGM and BOOZ & CO estimated revenue generated at 15% of total revenue, savings of 30 to 40%. The total amount of capex savings achieved from tower sharing in the Middle East and Africa regions was estimated to be USD 8 billion [29] [30].

3.3 Challenges of infrastructure sharing

The challenges experienced differed based on the maturity of the communication sector. Among infrastructure challenges identified by mobile service operators in Kenya were asset valuation and management, shareholder and cost pressure, cultural alignment and stakeholder management [30]. The others were the incumbent operators' unwillingness to approve sharing with their competitors so as to protect their



investments and retain monopoly in certain areas, lack of network capacity, use of different vendors and poor quality of service [18] [24] [26]. Increased inter dependency especially for active sharing could also limit competition. In emerging markets there were hurdles of obtaining clearance from multitude of governmental bodies [29].

Network sharing had some risks such as projects implementation, third-party interests, and confidentiality risks which required to be managed to achieve success [3] [8]. Active sharing required close commercial cooperation between operators which could impede competition. Mobile virtual network operator concept was still at infancy stage in Africa due to regulatory issues, low ARPU and high interconnection charges by incumbent operators [18] [30] [31] [35]. Lack of regulatory framework to guide operators and ensure fair competition was also another barrier. The Kenya Information and Communications law of 2009 CAP. 411A section 85A recognizes infrastructure sharing but was not specific on the implementation guidelines as compared to Tanzania and Botswana which had a comprehensive infrastructure sharing law.

3.4 TOE framework

Technology, Organization, and Environment TOE framework Tornatzky and Fleischer 1990 identifies three aspects contexts 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 [32]. Borgman et al., 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 [33]. 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 [32]. 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. 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 obsolescence, 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.

4. RESEARCH METHODOLOGY

The study employed quantitative study design using questionnaires to collect data from ICT staff of the four mobile operators and other stakeholders. A total of 19 organizations with a sample size of 170 were targeted with 125 17 organizations responding. Sample distribution was based on mobile operators' market share. 76% of the data was collected from the four mobile operators. Both hardcopy and soft copies were used. A five level likert scale with weights ranging from 1-5 was used to evaluate the level of agreement or disagreement. Percentages were used to find the level of agreement sum of respondents for strongly agree and agree. Data was analyzed using SAS and excel.

Table 1: Sample distribution

Organization	Market share	Sample size
Safaricom	66.5	45
Airtel	17.6	30
Essar	8.8	25
Telkom Kenya	7.1	25
Others stakeholders	NA	45
Total		170

Source: Researcher & CAK, 2014

5. FINDINGS

The research established that operators mostly shared passive infrastructure sites and optic fiber. Optic 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 was found to be compounds, equipment rooms, security, towers, power commercial, generator, batteries, air conditioners, ducts, trenches and fiber cores and wavelengths. The findings also indicate that ICT Infrastructure sharing awareness levels were high with site sharing being the most popular at 86%, followed by fiber sharing at 84%, radio access network at 77%, mobile roaming at 67% and cloud computing at 65%.

Table 2: Sharing levels 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	8.8	739	12%	123	17
Telkom Orange	7.1	1050	17%	341	32
Total	100%	6149	100%	1256	20.4

Source: Researcher, CAK, operators, 2014



Table 3: Drivers of infrastructure sharing

Statements	Weighted mean	Standard deviation	Agree %
1. Sharing resources lowers costs and generates revenue	4.6774	0.5748	97
2. Enables new entrants firms to launch and market their services faster	4.6371	0.5692	98
3. Efficient utilization of scarce resources	4.3468	0.9545	85
4. Enables operators to focus on core business / innovations	4.4113	0.7593	91
5. Preserves our environment due to reduced electronic waste	4.621	0.6126	95
6. Increases coverage and access to services	4.3952	0.7348	91
7. Improves network reliability by use of redundancy routes	4.3871	0.8737	90
8. Promotes cooperation among competitors	4.4516	0.8544	89
9. Enables policy and regulatory compliance requirements.	4.1371	0.9579	81
10. Hurdles in obtaining clearance from multiple government agencies	4.2097	0.8992	79

Source: Researcher, survey data, 2014

Table 4: Challenges of infrastructure sharing

Statements	Weighted Mean	Standard deviation	Agree %
1. May hinder competition due to reduced control and interdependence	3.0645	1.2536	43
2. Exposure to risks e.g. market share loss & security threats	3.4032	1.2745	56
3. Sharing process complexities	3.75	1.2025	72
4. Unwillingness to share due to limited or lack of capacity	3.5484	1.2356	61
5. Incompatibility of different technologies	3.4435	1.2841	58

6. High charges by infrastructure owners	3.8226	1.0728	66
7. Lack of regulatory & policy framework	3.9597	1.2263	75
8. High capital requirements	3.879	1.086	73
9. High contractual exit costs arising from breach of contract	3.5403	1.2026	59
10. Dominant operators fear of market share loss	3.6855	0.9768	58

Source: Researcher, survey data, 2014

Table 5: Using the TOE framework for infrastructure sharing adoption

Statements	Weighted Mean	Standard deviation	Agree %
A: Technological context			
1. New technologies reduces capital and operational expenses	3.8226	1.0728	69.6
2. Invest in new technologies as a competitive advantage	4.3306	0.8808	88
3. The higher the compatibility the higher the adoption	4.3226	0.8021	88
4. Perceived benefits and risks from new technologies	3.8952	0.9788	72
B: Organizational context			
1. Top level management support increases adoption	4.371	0.8233	91.2
2. New market entrants are more likely to adopt sharing	4.6774	0.6155	96
3. A strong financial base & ICT resources influences sharing.	3.9274	1.2041	72
4. Current ICT infrastructure influences sharing	4.0887	1.003	80
C: Environmental context			
1. A decline in economic performance increases sharing adoption	4.2742	0.875	88
2. Stiff competition forces operators to adopt infrastructure sharing	4	1.0626	77.6
3. Having a legal framework & policy leads to higher infrastructure adoption	4.1935	0.8373	82.4



4. Customers demand for new ICT products influences sharing adoption	3.5968	1.2404	61.6
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Source: Researcher, survey data, 2014

6. DISCUSSIONS

ICT infrastructure sharing is a resource optimization strategy that deals with how available scarce resources are used to deliver value to the stakeholders. Changing ICT market warrants corresponding changes in the way operators utilize available ICT 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. Infrastructure sharing allows competing entities to cooperate and shift focus to service innovations.

On awareness, a study carried out in Kenya in 2013 found that 72% of the respondents had a clear understanding of site sharing [3] while in our study, 86% of respondents had a clear understanding of awareness indicating increased awareness. Cloud computing awareness was lower as compared to sites and fiber. Studies carried out Kenya on the same found out that cloud computing adoption was fairly new, with most organizations having adopted it either in 2010 or 2011 hence its impact was limited [34].

The research findings showed that mobile infrastructure in Kenya was 100% operator controlled. This could explain why the level of sharing was low at 20.4 %. When compared globally with USA where a site had at least 2 operators, India and Pakistan with more than one operator per site, the levels in Kenya were low [16] [17]. This could be attributed to lack of a regulatory framework, lack incentives to promote sharing among operators especially those who had invested heavily, lack of information on available excess capacity and only one independent firm Eaton Towers in the market without owned or managed infrastructure. 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 [7] [8]. 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 groups whose origin was India where sharing had been implemented successfully [19]. The findings imply that if Airtel, Telkom Kenya and other new market entrants were to adopt infrastructure sharing strategy to expand their network coverage across Kenya so as to leverage with Safaricom, they would have to partner with Safaricom due to its extensive network coverage. In addition Essar infrastructure has been taken over by Safaricom following the exit of Essar in the

Kenyan market. This also implies that for infrastructure sharing to be more successful in Kenya, Communication

Authority of Kenya CAK has to encourage Safaricom to share more including offering incentives to safeguard against their heavy investments.

The low levels of sharing can be improved if operators engage each other as business partners and CAK encourages or mandates sharing through a regulatory framework. There is need to attract more independent tower companies through attractive policies and incentives since research had shown that countries that had embraced independent companies like USA and India had shown rising levels of sharing.

Framework for ICT infrastructure sharing

Based on the flexibility of the TOE framework, the study tested 12 constructs for the three contexts. Decisions to adopt technology innovations by organizations were mainly driven by what existed. If the firm’s current ICT infrastructure could not support corporate strategy, the firm was forced to explore other options such as upgrading or renting the infrastructure from other operators so as to remain competitive. ICT infrastructure sharing had challenges such inability to integrate systems, technologies and policies. 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. A decline in economic performance affected the profit margins of operators hence reduced capital investment. Consumption of ICT services were likely to reduce due to weak purchasing power of the customers. This could force operators to explore cost cutting options such as adoption of infrastructure sharing. The stiff competition gave customers opportunity to switch between operators. To maintain and attract more customers, operators had to differentiate themselves by focusing more on product innovations and exploring new revenue streams such as infrastructure sharing.

The overall findings of the TOE framework showed that organizational context had the greatest 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 and top level management support. This compares to 2013 study by Borgman et al., where 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 [33]. 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 limited or no control over 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.

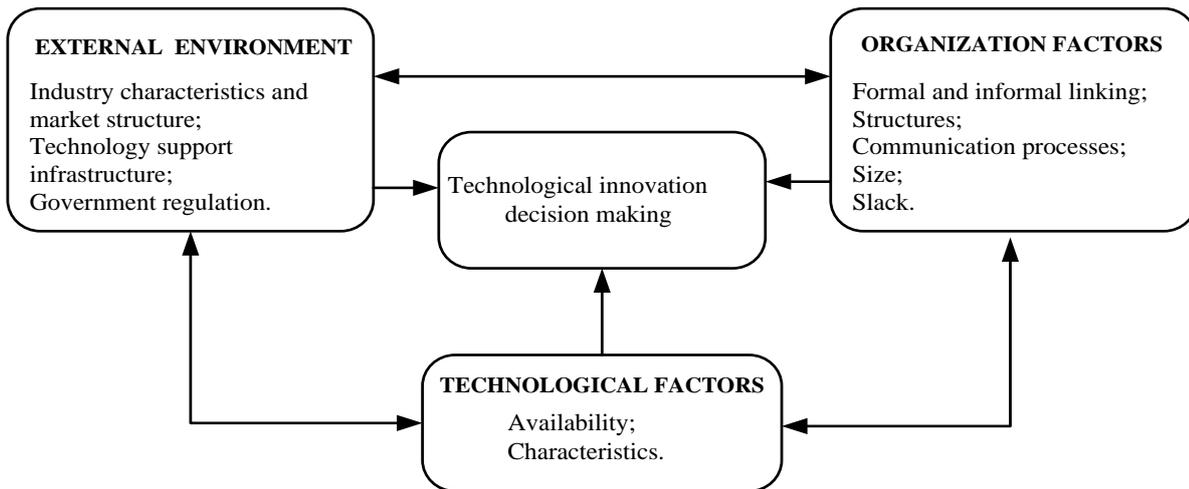


Fig 1: TOE framework Tornatzky and Fleischer 1990

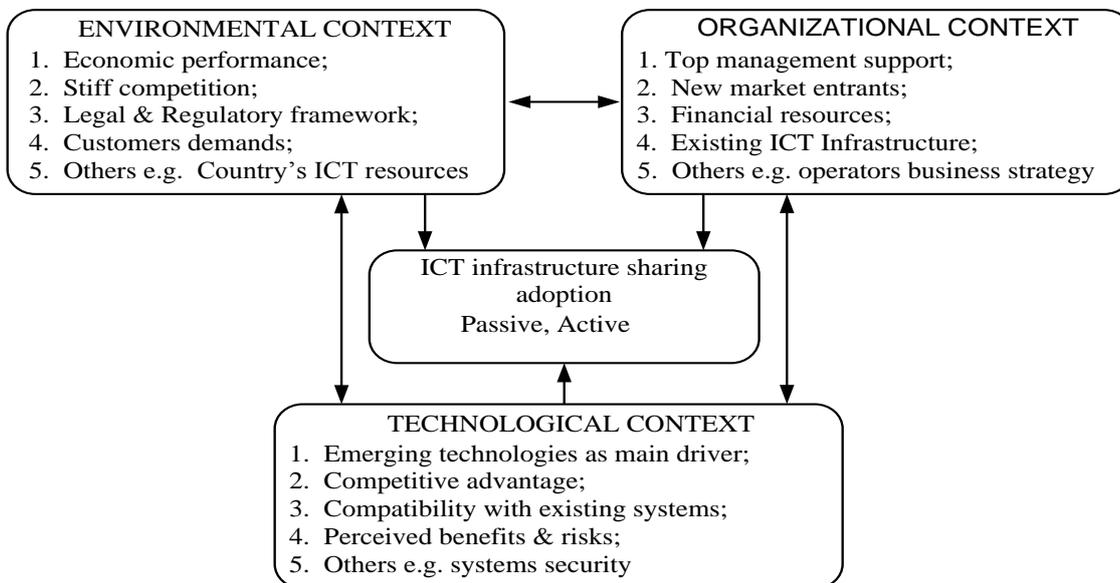


Fig 2: Proposed ICT infrastructure sharing framework

7. CONCLUSIONS

Infrastructure sharing levels in Kenya were low hence strategies to promote increased levels should be explored by the ICT stakeholders especially by CAK and ICT Authority. Safaricom's higher infrastructure and market share is attributed to heavy capital investment over the years Safaricom, 2014. This implies that for Kenya to increase sharing levels, other operators and government will have to engage Safaricom to open up more while at the same time protecting their business interests. One strategy is to give incentives such as concessions on tax and license fee to independent firms and operators so as to encourage sharing. 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, stiff competition, rising demand for infrastructure and services, high capital requirements and long payback periods, bank loans, emerging technologies, shareholders pressure and market saturation, infrastructure sharing adoption is key to

helping operators mitigate the risks and to remain competitive. To contribute to the growth of the ICT sector, Kenya requires an appropriate regulatory framework with strategies such as 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 available underutilized ICT resources and allowing sharing with other market players such as Kenya power, governments and Kenya pipeline. 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 framework can be replicated to other ICT operators in developing and emerging markets especially in Africa where



there is insufficient infrastructure and high demand/growth of ICT services.

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