Effects of Network Infrastructure on Universal Access: A Survey of ICT Access in Kenya

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Abstract

ICTs have been proven to have a positive impact on the society today, especially in the rural areas where they lead to improved productivity. This brings about improved income and quality of life among the rural inhabitants. Due to its importance, governments have thrived towards achieving universal access to ICTs by ensuring that telecommunication services are made available to all citizens in a country, without regard to geographical location, on an affordable basis. Quality network infrastructure at affordable prices is a key requirement in ICT development, adoption and use, since it is an accelerator to access in the rural areas. Therefore, development of the network infrastructure has been the main focus in most countries because of its role in universal access. Despite all this effort, there is still minimal access to ICT services in the rural areas. The study adopted a descriptive research design approach and was conducted among people involved in the implementation of universal access in Kenya. The findings from the study showed that there has been a tremendous increased access to ICTs through the use of mobile phones than through the use of Personal Computers because the results show that there are 80 and above mobile phone users and between 21 and 40 personal computer users in every 100 inhabitants in Kenya. The findings show that poor quality, low connectivity speed and low reliability of ICT infrastructure, low access to roads and high illiteracy levels are the infrastructure challenges affecting the technology adoption and have great contribution on UA to ICT in Kenya. The study recommended that market players, the regulator and policy makers should put in place measures and policies that will govern the services beings provided to the end user. Also the government should invest highly in ensuring that all sections of the country have access to roads so that all the services get to every Kenyan.

Key words: Network Infrastructure; Information and Communication Technology; Universal Access

1.0 Introduction

Governments are playing a key role in the development of ICTs, and are taking part in establishment of enabling environment which promotes reasonable and affordable access to basic telecommunication services for all (WTDC, 2006). The act of ensuring that telecommunication services are made available to all citizens in a country, without regard to geography, on an affordable basis is referred to as universal access (ITU, 1998). Infrastructure is the most important enabling agent in provision of many benefits brought about by ICTs to developing countries, especially the rural regions (WSIS, 2005). The Kenyan government has implemented reforms in the ICT market to achieve this goal. Some of the reforms in place include setting targets, goals and time frames, liberalization of the ICT sector, which has led to the introduction of competition into the market, including universal service obligations as part of license conditions for operators and a cross-subsidization mechanism to encourage operators wishing to provide services in uneconomic areas (ITU, 1998).

As reported by Consultoria (2011), Access to telephony services in Kenya has been increasing tremendously in the recent years due to the liberalization and privatization of the mobile telephone market. Despite this growth, there are still about 1119 sub locations (out of 7149) that don't have access to the voice services. Also, Access to internet services is still low. There has been a growth due to the installation of mobile 3G networks, but still there are only about 4.7 million of internet/data subscriptions in Kenya of which 84726 are broadband subscriptions (greater or equal to 256 kbps) this converts to approximately only 893 sub locations having access to broadband data services (CCK,2011).

2.0 Universal access models

2.1 Universal access gap model

Universal access gap model identifies two gaps namely, the market efficiency and the true access gaps. The market efficiency gap covers the areas which are still unserved, but the services would be profitable and the capital costs could be recovered if networks were extended to them while the true access gap covers the area where services cannot be provided profitably and subsidies will therefore be required if access is to become a reality. Xavier (2005) argues that, market efficiency gap can be addressed by increasing private sector participation in providing infrastructure and services, facilitated by effective competition, and by market-oriented policies and regulations that create a level playing field for new entrants. Access gaps are closed if the government provides subsidies to the market players to provide services to those areas.

According to Matthew Mitchell & Bill Gillis (2005), we must recognize three necessary interrelationships aiding in attaining the goal of adequate and equitable deployment of ICT infrastructure: First, there must be a market demand for ICT by the ICT user. Next, the regulatory environment must be stable and open such that fair competition is encouraged. The makers of public policy have a responsibility to develop and maintain an enabling regulatory environment that encourages investment by private organizations and businesses in ICT infrastructure. Finally, there must be a willingness by ICT investors to take a risk. Without the investment of private capital, the goal of adequate ICT deployment may never be realized. Hence, these three stakeholders (ICT user, policy makers and ICT investors) are bound in an interactive, inter-dependent relationship.

2.3 Review of empirical researches on Network infrastructure and universal access

Infrastructure plays a very crucial role as an enabling agent to accessing ICT (Kauffman and Techatassanasoontorn, 2005). Some of its benefits include access to online training, providing better healthcare, education among other benefits which lead to improved local economies (Michael & Mira, 2011). Although the benefits are many, majority of people especially those in the rural areas lack the infrastructure (Samarajiva & Zainudeen, 2008) due to as noted by Adams (2008) lack of basic infrastructure such as electricity and roads. Unaffordability is another challenge that faces access to infrastructure (Michael & Mira, 2011). Most infrastructures in the rural and remote areas is usually outdated to cater for the new services (Wasike, 2011), this affects the quality of services being offered in these areas.

Foreign investment is one way to improve network infrastructure (Michael & Mira, 2011) but it needs a fair legal and policy environment (Arturo (2010) with a body to implement and to enforce. The body should be transparent and should support participatory regulatory process. Government initiatives such as Universal service obligation may play a great role in improving network infrastructure through the use of universal service fund to subsidize the costs of reaching the uneconomical locations (Arturo (2010). USF has been recognized as one of the most efficient and transparent means of providing subsidization.

Public access points provide another effective method of ensuring that universal access to ICT infrastructure reaches to every person in uneconomical areas (World summit on Information Society, 2005). Governments have put measures to avail access to ICT infrastructure and services to all and the Kenyan government has not been left out in this. So much effort to reform the ICT sector has been witnessed since 1990's when the independent regulatory body CCK was created with the objectives of bringing affordable ICT access to all Kenyans, funding development of communication infrastructure in rural areas through the established Universal Access Fund. There has been growth in the number of mobile phone ownership over the years (RIA household survey, 2007) but the access to internet is still low even after the liberalization and the arrival of the fiber optic cable.

However there is a need for provision of basic infrastructure, support software development and promotion of local manufacturing to improve the poor basic infrastructure (Kandiri, 2008). There is also need to entertain the participatory of stakeholders in developing effective policy and regulation (Ikaira, 2004) who play an important role in promoting the expansion of affordable and appropriate ICT infrastructure and services.

3.0 Universal Access in Kenya

Liberalization and privatization in Kenya began in the late 1990's when an independent regulator CCK was established. It is committed to bring affordable ICT access to all Kenya's through the Universal Access Fund. Mobile penetration has been in increase ever since privatization, on the other hand, broadband market is undergoing a revolution following the arrival of fiber optic international cables. Since then, bandwidth prices have already fallen significantly following the liberalization of international gateway and national backbone network provision in 2005. The main objective of this study was to assess how quality, cost, availability, reliability of network infrastructure, access to roads, reliability of power supply and literacy levels affect the attainment of universal access to ICTs in Kenya.

3.1 Research Methodology

The research was a descriptive survey which involved both qualitative and quantitative methods. The target population was the parties directly involved with Universal Access implementation and monitoring this is because they would provide the required information on what they face during the efforts to implement universal access. The total number of target population was 300 people out of which 30% was the sample representative. Stratified random sampling method was the one mainly used to sample the interviewees. The population was first divided into two strata: 1) ICT policy formulation and monitoring and 2) market players. The two strata represented all the players within the ICT sector. After the division in two strata, systematic random sampling was used to get representatives for each stratum. This was done by having the names listed on a piece of paper in an alphabetical order, then picking one at random which would act as a starting point.

Table 1: Sampling Frame

Strata 1: Policy implementation and monitoring body			**Strata 2: ICT market players**		
Name	Total population	Representative size	Name	Total population	Representative size
CCK	13	4	Mobile Operators	94	28
Ministry of Information and Communication	16	5	Internet service providers	74	22
KIPPRA	23	7	Telecommunication Equipment Operators	50	15
ICT board	30	9			
TOTAL	**82**	**25**		**218**	**65**

Descriptive statistics was used to summarize the affordability and availability of ICT network infrastructure, factor analysis was used in the analysis of the current status of infrastructure. One-way ANOVA procedures was used to compare means between personal data (gender, education level and institution worked for) to establish if differences existed in the extracted factor scores.

4.0 Perception of respondents on Universal Access Attainment

The Universal Access attainment level was measured using the indicators discussed by ITU (2005). These indicators included the number of mobile phone subscribers per 100 inhabitants, the number of internet users per 100 inhabitants and number of Personal Computer users per 100 inhabitants. The results revealed that there were between 61 and 80 internet users in every 100 people, also, the mobile penetration level was rated at above 80 users per every 100 inhabitants. This could be attributed to the low cost of mobile phones, and the fact that majority of the people are using the same devices to access internet. The findings also showed that there are only between 21 and 40 Personal Computer users per every 100 people. This is a very low number and it may be due to various reasons including high cost of personal computers and also lack of training on how to use a computer.

4.1 Perception of respondents on Network infrastructure

Out of the 90 questionnaires distributed, 68 were correctly filled and returned. This represented a response rate of 75.5% which according to Mugenda and Mugenda (2003) is very adequate because they argue that a response rate of 50% is adequate, 60% is good and that of 70% is very good. Therefore 75.5% response rate reported for the study formed acceptable basis for drawing conclusions.

The respondents were asked to rate the infrastructure in terms of quality, speed reliability, cost, power and access to roads and the response was as shown in the Table 2 below

Table 2: perception of respondents on network infrastructure

Network infrastructure	Very high	Fairly high	average	Fairly low	Very low
Quality of transmission	7.4%	64.7%	0%	17.6%	10.3%
Cost of transmission	0%	34.8%	0%	65.2%	0%
Speed of transmission	45.6%	54.4%	0%	0%	0%
Reliability of transmission	7.4%	7.4%	14.7%	52.9%	17.6%
Reliability of power	8.8%	2.9%	17.6%	15.7%	52.9%
Literacy level	1.5%	10.3%	11.8%	13.2%	63.2%
Access to roads	0%	0%	14.7%	70.6%	14.7%

On quality of transmission, the results show that majority (64.7%) of the respondents said that the quality of transmission media is fairly high. This could be attributed to competition in the market. On cost of transmission, majority of the respondents (65.2%) said that the cost of transmission was fairly low. This could also be due to the drastic reduction on the prices of handsets. By 2003/2004, for example, a low end handset could retail at KES 1,000 to KES 2,000 in comparison to over KES 200,000 in 1999/2000. This has led to increased demand and usage of the telephones in rural and urban areas. On speed of transmission, majority 45.6% and 54.4% of the respondents said that the speed was very high and fairly high respectively. This could be due to increase in the bandwidth due to the installation of Fiber optic cable.

On reliability of transmission, majority of the respondents 52.9 said that the reliability was fairly low. According to Donner (2006) and Economist (2008), several reasons make mobile phones reliable. First, they offer benefits such as mobility and security to owners. Second, due to their unique characteristics, they work using the radio spectrum, therefore there is no need to rely on physical infrastructure such as roads and phone wires, and base-stations can be powered using their own generators in places where there is no electrical grid. Third, mobile phones only require basic literacy, and therefore are accessible to a large segment of the population. Fourth, mobiles enjoy some technical advantages that make them particularly attractive for development. In addition to voice communication, mobile phones allow for the transfer of data, which can be used in the context of applications for the purposes of health, education, commerce or governance. These characteristics discussed above seem not to be impacting the ICT infrastructure in Kenya since the majority argues that the reliability is low. Also, with the growth in internet usage, the internet infrastructure tends to decline in terms of its performance and reliability. This leads to regular failures of the internet backbone and delays in the access to the internet services.

The reliability of power was rated as very low by the majority (52.9%) of the respondents. The high cost of connection, electricity charges, frequent disconnections and delays in connections to power are main reasons causing power unreliabilty in Kenya, especially the rural areas. On literacy level, 63.2% of the respondents felt that it was very low, according to them, majority of citizens living in rural areas have very limited awareness of how ICT can improve their productivity and social economic welfare. Access to roads was also rated at fairly low by majority (70.6) of the respondents.

4.2 Affordability of PCs

The respondents were asked to rate the affordability of the personal computers. The findings in figure 4.1 show that (45.6%) of the respondents rated it fairly unaffordable and (39.7%) rated it as unaffordable. This shows that more than half of the people find personal computers unaffordable to under deserved areas.

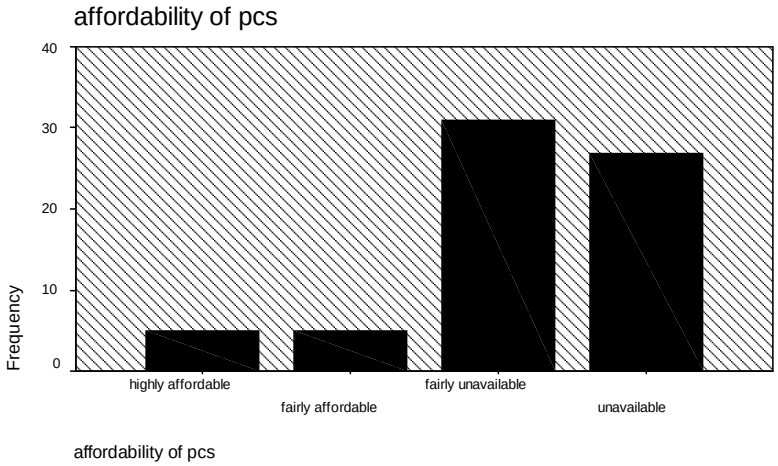

Fig 1: Affordability of PCs

4.3 Availability of Local Content

The respondents were asked to rate the availability of the local contents to be accessed on the internet. The findings in figure 4.2 show that (45.6%) of the respondents rated it poorly available and (39.7%) rated it as unavailable. This shows that there has not been much effort to create local contents to be accessed by the people in Kenya

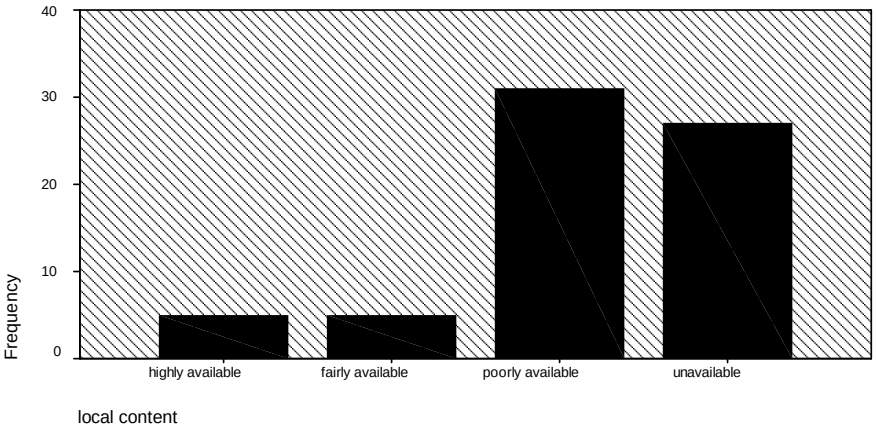

Fig 2: Availability of Local Content

4.4 Factor Analysis on ICT Network Infrastructure

To assess the key aspects that were significant in relation to ICT Infrastructure, principal component Factor analysis with varimax rotation was conducted. Before conducting the factor analysis, Kaiser-Meyer-Olkin (KMO) measure of Sampling Adequacy and Barlett's Test of Sphericity were used to examine whether the data set was appropriate for a factor analysis. Should the KMO value be below 0.5, then factor analysis would not be recommended (Field, 2000). The KMO value was o.593, hence adequate for a factor analysis. On the other hand, Barlett's Test of Sphericity was also significant (Chi-square = 46.093, degree of freedom = 21, at $p < 0.05$), indicating that the correlation matrix was not an identity matrix. Therefore, the results provide a justification on the use of factor analysis (Kline, 1998).

Two components out of the 7 items were extracted with eigenvalues greater than 1.00, accounting for 47.376% of the cumulative total item variance hence no further rotation could be made since only two factors were extracted from the first rotation. The factor variables of the extracted components were combined and two new variables were formed "ICT usage ability" and "infrastructure availability".

Table 3: Factor on ICT Usage ability

Network infrastructure ICT usage ability items that affect Universal Access
• quality of data transmission
• speed of transmission
• reliability of transmission
• access of roads
• literacy levels

Table 4: Factor on infrastructure availability

Network infrastructure availability items that affect Universal Access
• cost of transmission
• reliability of power

4.5 Analysis of Variance (ANOVA) using Factor Scores

Skewness ranged from 0.004 to 0.312 and kurtosis ranged from -0.158 to 0.252 for the six factors, proving that normality assumption was satisfied. Homogeneity of variance was determined using levene's test at 0.05 level with a null hypothesis that variances were equal. The results are presented based on the demographic variable followed by ANOVA and post hoc multiple comparisons where appropriate.

4.5.1 Gender

Table 5 shows the results of the test of homogeneity variance when the sample is grouped by gender. The significance of the levene statistic is greater than .05 for all other factors. This indicates that the null hypothesis of equal variances for the two factors should be retained. Since the equal variances assumption is satisfied, an ANOVA to compare male and female means is appropriate.

Table 5: Gender Homogeneity of Variance

Factor	Levene Statistic	df1	df2	Sig.
ICT usage	3.257	1	66	.076
Infrastructure Availability	.826	1	66	.367

Table 6 presents the results of the one-way ANOVA at the .05 level with gender as the independent variable and factor score as the dependent variable. The null hypothesis for this analysis was that the male and female means were equal. For the ICT usage factor, the observed F did not exceed the critical F of 4.00 and the results were also not significant (.375) at .05 level. This meant that the null hypothesis was retained. Therefore, male and female means were equal, meaning that their feeling on the ICT usage did not differ, they had the same feeling.

Table 6: ANOVA of ICT usage and Gender

Factor	group	Sum of Squares	df	Mean Square	F	Sig.
ICT usage	Between Groups	.373	1	.373	.796	.375
	Within Groups	30.907	66	.468		
	Total	31.279	67			

Table 7 presents the results of the one-way ANOVA at the .05 level with gender as the independent variable and factor score as the dependent variable. The null hypothesis for this analysis was that the male and female means were equal. For the Infrastructure Availability factor, the observed F did not exceed the critical F of 4.00 and the results were also not significant (.669) at .05 level. This meant that the null hypothesis was retained. Therefore, male and female means were equal, meaning that their feeling on the Infrastructure Availability did not have any difference, they had the same feeling.

Table 7: ANOVA of Infrastructure Availability and Gender

Factor	group	Sum of Squares	df	Mean Square	F	Sig.
Infrastructure Availability	Between Groups	.076	1	.076	.184	.669
	Within Groups	27.171	66	.412		
	Total	27.247	67			

4.5.2 Education level

With the sample grouped by education level (i.e., diploma, higher diploma, degree, and postgraduate studies), the Levene's statistic was computed to test for homogeneity of variance. As shown in Table 8, the two factors have non-significant values (values greater than .05) and the null hypotheses can be retained. Thus, the variances are homogeneous and further evaluation by ANOVA is warranted for these factors.

Table 8: Education Homogeneity of Variance

Factor	Levene Statistic	df1	df2	Sig.
ICT usage	.281	3	64	.839
Infrastructure Availability	.437	3	64	.727

Table 9 shows that the observed F did not exceed the critical F and the results were not significant at 0.05 significance level, meaning that the null hypotheses that the sample means are equal remain true. Therefore it can be concluded that the feeling about ICT usage is not really dependent on the education level of the respondents. All the respondents have the same feeling about ICT usage.

Table 9: ANOVA of ICT usage and education

factor	group	Sum of Squares	df	Mean Square	F	Sig.
ICT usage	Between Groups	.372	3	.124	.257	.856
	Within Groups	30.908	64	.483		
	Total	31.279	67			

Table 10 shows that the observed F did not exceed the critical F and the results were not significant at 0.05 significance level. This means that the null hypotheses that the sample means are equal remain true. Therefore it can be concluded that the feeling about Infrastructure availability is not really dependent on the education level of the respondents. All the respondents have the same feeling about infrastructure availability.

Table 10: ANOVA of Infrastructure Availability and education

factor	group	Sum of Squares	df	Mean Square	F	Sig.
Infrastructure Availability	Between Groups	.777	3	.259	.626	.601
	Within Groups	26.470	64	.414		
	Total	27.247	67			

4.6 Regression analysis

The two variables computed from the factor scores variable were used as the independent variable. Those factors included ICT usage and Infrastructure availability.

The indicators discussed by ITU (2005) were used to measure the level of achievement of UA in Kenya. These indicators included, the number of mobile subscribers per 100 inhabitants , the number of internet users per 100 inhabitants and the number of PCs users per 100 inhabitants. The dependent variable (Universal Access) was computed from the various indicators/parameters investigated in the study. These indicators included; number of mobile subscribers per 100 inhibitants and the number of internet users per 100 inhibitants. The two variable were averaged and given the name Universal Access, which became the predictor variable for the regression analysis. The regression was then performed on the indipendent variables with the computed dependent variable(UA).

The ANOVA results indicated that the regression model predicts the outcome model (Universal Access) significantly well. This is indicated by the statistically significant p-value of 0.047 less than 0.05 will indicate that the overall model applied is significantly good enough in predicting the outcome variable. The coefficients for the two variables are represented in the table below. The model derived from the results is that Universal access = 0.208(ICT usage ability) +0.031(Infrastructure availability). Also, by looking at the sig. column the constant, ICT usage ability and Infrastructure availability contribute significantly to the model derived from the results.

Table 11: Regression Coefficients

Coefficient	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	SE	Beta		
(Constant)	2.629	.773		3.400	.001
ICT usage ability	.208	.116	.216	1.789	.003
Infrastructure Availability	.031	.125	.030	.245	.004

a. Dependent Variable: UA

The second and third rows of data in the table 11 above show that the coefficients for ICT usage ability and infrastructure availability are statistically significant at 0.05 level. This indicates that these two factors affect the implementation of UA in Kenya. One unit improvement on the ICT usage ability leads to 20.8% increase in universal access in Kenya and one unit improvement in infrastructure availability leads to 3.1% increase in universal access in Kenya.

5.0 Conclusion and Recommendations

5.1 Conclusion

The findings on universal Access attainment level showed that access to internet and mobile phone in Kenya has been very high. But access to Personal Computers has been shown as very low. Quality of the infrastructure was rated as very high by the majority (64.7%), speed of infrastructure was also rated very high and fairly high by the majority (54.4% and 45.6%) and cost of the infrastructure was rated fairly low by the majority (65.2%). Therefore the study concludes that quality of infrastructure, speed of the infrastructure and cost of the infrastructure positively contribute to attainment of universal access to Internet and mobile phone. The findings on the perception of network infrastructure also showed that reliability of transmission, access to roads, literacy levels and reliability of power were rated very by the respondents that . It can therefore be concluded that they positively contribute to attainment of universal access to the network infrastructure because attainment level was still not fully achieved with at least 95 persons per 100 inhabitants having access to mobile phones, internet and personal computers.

The findings on the ANOVA carried out between gender and education and the two new variables namely ICT usage ability and extracted during factor analysis showed that the results were not significant therefore the conclusion was that there is no difference between respondents' gender and their feelings on ICT usage ability and also between respondents' gender and their feelings on infrastructure availability. On education, it can also be concluded that there is no difference between the respondents' level of education and their feeling on the ICT usage ability and also between respondents' level of education and their feeling on infrastructure availability.
The findings on the regression analysis of the two variables ICT usage ability and infrastructure availability showed that the coefficients for ICT usage ability and infrastructure availability are statistically significant at 0.05 level. Therefore it was concluded that the ICT usage ability leads to 20.8% increase in universal access in Kenya and one unit improvement in infrastructure availability leads to 3.1% increase in universal access in Kenya.

5.2 Recommendations

It was concluded that quality of transmission, speed of transmission and reliability of transmission positively contribute to the attainment of universal access but so far the reliability of infrastructure is still very low and therefore it is recommended that market players, the regulator and policy makers should put in place measures and policies that will govern the services beings provided to the end user.

Also, operationalization of the National Optic Fiber Infrastructure (NOFBI) should be done immediately to make broadband services available to many rural areas.

Access to roads was another aspect that was positively contributing to attainment of universal access but was rated low and therefore it is recommended that the government should invest highly in ensuring that all sections of the country have access to roads so that all services get to the every Kenyan, especially those in rural areas where the infrastructure is very poor. But again the government should also come up with regulation that will ensure that road and sewerage contractors compensate the infrastructure providers when they interfere with their facilities. This will help in ensuring that the costs of repairs are not passed to end users and hence the consumers will enjoy services at low rates.

Literacy levels was also another aspect contributing positively to universal access but from the study the literacy level was very low and therefore there is a need to ensure that USF, which highly improve attainment as shown from the findings, should be well monitored to enhance training and also to sensitize the public people especially those in rural areas on the impact of ICT services on their lives so that they will be able to utilize them. There is also need for policies and a body to govern the usage of the Fund. There was also a conclusion that unavailability of local content was an aspect that negatively influenced the attainment of universal access. Therefore it is a recommendation that all rural communities be allowed to reap the benefits of the Internet by presented service in their own languages. In addition, the Google search engine (www. google.co.ke) is offered in both English and Kiswahili.

5.3 Areas for further research

The study established the importance of universal access fund in the attainment of universal access but there was no look in how the Fund can be managed. Therefore there is a need for further research on the policies and strategies that should be put in place to ensure that universal service fund is well implemented so that it can fully benefit all the Kenyan people. The study realized an issue with the infrastructure in use however important it when it comes to the attainment of universal access. Therefore a further research needs to be done to establish how the fiber optic cable and other network infrastructure can be guarded and protected to ensure that it provides speed and reliability needed for the users to be satisfied.

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