The cloud over Africa

Alison Gillwald and Mpho Moyo (South Africa)

with Lishan Adam (Ethiopia), Fola Odufuywa (Nigeria), Godfred Frempong (Ghana), Farouk Kamoun (Tunisia)

Acknowledgements

This policy paper pulls together a number of background case studies that were prepared for the United Nations Conference on Trade and Development *Information Economy Report 2013: The Cloud Economy and Developing Countries*. The papers however do not reflect the views nor are they the endorsed by UNCTAD.

The authors thank Torbjorn Fredriksson from UNCTAD for his detailed comments and suggestions on the country case studies though all views and errors remain those of the authors. The authors also thank the International Development Research Council for their support in gathering much of the underlying data provided by Research ICT Africa for the country studies.

Editor: Alison Gillwald, Research ICT Africa

Assistant to Editor: Chenai Chair

Proofreading: Liz Sparg

Published by:

Research ICT Africa

209 The Studios

Old Castle Brewery

6 Beach Road

Woodstock

Cape Town

www.researchICTafrica.net

Table of contents

Executive summary

Cloud computing is viewed as having the potential to significantly bolster economic growth through the provision of cost savings and efficiencies, including the cost of management of data and security. Some of the benefits of cloud computing could be immediately realised with the small-medium enterprise (SME) sector and the public sector. Within the SME sector, cloud computing provides access to advanced IT technologies, which were previously only accessible to larger enterprises, thereby enhancing entrepreneurship and innovation. Furthermore, the public sector stands to gain from the cost-efficiencies offered by cloud computing. Though cloud providers are offering targeted cloud solutions for the SME sector, the use of these services has been limited. The paper highlights that the informal sector, which forms a significant part of businesses in Africa as it provides livelihoods to the poor and marginalised, has the potential to enjoy benefits associated with the large-scale hardware and software investments in the formal sector through cloud services. Although cloud computing is dominated by global US-based countries, it has the potential to open up African companies to unchartered offshore markets, thus contributing to economic development and competitiveness, and for African businesses to aggregate international cloud services to meet local needs.

Cloud provision in most of the selected countries is supply-side driven rather than demand- side driven. The state in most of the selected African countries has been playing a key role in the cloud services market by promoting public cloud services as a delivery model for their e-government services. The use of the public cloud by the state will go a long way towards creating awareness and trust building in cloud-computing services. In addition, the education sector is increasingly taking an interest in cloud services through research and development efforts and conferences. Some educational institutions have migrated parts of their administration onto the cloud, while others have developed an education cloud that will bolster e-learning initiatives. South Africa is an exceptional case, as the growth of cloud-computing services is demand-side driven through the corporate sector; however there is a preference for private cloud services due to concerns around data protection and security. Nonetheless, it is believed that more companies will be forced to migrate to public cloud services and take advantage of the economies of scale offered, as a cost-cutting measure. The enactment of legislation on data and security in line with global standards will go a long way towards driving adoption of these services.

Cloud computing falls within the broader ICT ecosystem as it relies on broadband internet connectivity. Broadband infrastructure development in Africa is uneven. While there has been significant growth in international bandwidth capacity and decline in costs through the landing of a number of international submarine cables, terrestrial fibre backbone infrastructure remains inadequate, as does last-mile connectivity. Most countries rely on ADSL connections and mobile broadband networks are widespread. As a result, mobile phones are fast becoming the primary method of connecting to the internet in Africa. However, in order to deliver cloud services for the corporate and public sector, there is a need to build up the national terrestrial backbone infrastructure.

Several factors inhibit the widespread adoption of cloud services within developing countries. The availability, accessibility and affordability of underlying technology is a key determinant of the successful diffusion of cloud computing and is currently the major inhibiter to cloud deployment in developing countries. Other factors that are hindering the growth of cloud services relate to concerns around security, privacy and surveillance, particularly amongst highly regulated and risk-averse sectors, such as financial services.

This paper analyses and explains how the cloud-computing economy fits into the broader ICT ecosystem. It presents case studies and provides an assessment of the

market and regulatory frameworks in order to assess the cloud readiness of a selected number of African countries (Ethiopia, Ghana, Kenya, Nigeria and Tunisia). Several African governments are increasingly realising the benefits of adopting cloud computing and are taking on cloud strategies. This paper presents the key market trends regarding cloud computing within selected African countries in terms of the services currently on offer, the sectors using cloud services, and the perceived risks and regulatory challenges that pertain to the adoption of cloud computing within African states. Finally, the paper provides policy recommendations on how to facilitate growth of the secure cloud services market within developing countries and thereby facilitate growth and development of an economy, while safeguarding the interests of their citizens.

Introduction

Much of the hype around cloud computing in Africa is as a result of the adoption of high-end technology and software by industries such as financial services, oil and gas; and of advanced next-generation networks by the telecommunications operators. The emergence of cloud computing in Africa is viewed as a natural extension of the deployment of advanced IT technologies by high-end users in both the consumer and enterprise services markets. In addition, cloud computing offers economies of scale that can dramatically reduce the cost to end-users. On the demand side, the use of shared computing facilities improves efficiencies in infrastructural use as users effectively only pay for what they use.

SMEs and public services stand to gain the most from the adoption of cloud services, which provides immediate access to the infrastructure and services previously only available to big enterprises able to invest heavily in IT. Cloud computing can create significant efficiency gains and enhance innovation and entrepreneurship (Gillwald, Moyo and Altman, 2012). Yet the adoption by the public sector and the SME sector has been slow, with some exceptions.

The underlying reason for this failure of the cloud to take off is the on going problem of limited and uneven development of enabling infrastructure for the delivery of cloud services across the African continent. Investment in international submarine cables has led to a significant rise in international bandwidth capacity at a reduced cost. There has also been significant investment in the rollout of broadband backbone infrastructure by public and private companies across the continent. However, this has not been sufficient and what is there is often not effectively regulated. Fair competition is achieved by ensuring wholesale access to the essential facilities. Incumbent operators also often retain dominance over essential facilities, including infrastructural backbone and the last mile. The unavailability and price of terrestrial backbone backhaul networks remain the bottlenecks in broadband uptake, together with the ongoing problem of last-mile connectivity.

This means that the informal business sector, which provides livelihood for the majority of poor Africans, is an untapped market for the delivery of public cloud services via mobile phones. Given the lack of a stable of power supply in most African markets, cloud computing presents an attractive value preposition for those wishing to eliminate the high costs of investment in infrastructure. At the same time, power outages can act as a deterrent to the adoption of cloud services.

In some countries in Africa, like other parts of the world, limited access to finance and the need to minimise costs during the financial crisis have focused attention on the cloud as a means of reducing capital expenditure and optimising IT resource utilisation amongst even the most risk-averse companies. The migration of such entities onto the cloud has been managed by creating private clouds that provide these companies with a perceived level of control or ensure that they are aware of where their data is located, which governance rules and what legislation may shortly demand. The public cloud, however,

offers even greater reductions, security and cost savings as a result of the economies of scale, especially useful for companies that are under financial pressure. It is, therefore, believed that cost-cutting pressures will force IT-intensive enterprises to migrate to the cloud in an attempt to take advantage of the economies of scale offered by cloud providers.

In all the countries selected for this study, cloud-computing services are in the early growth stages. Recently, governments in Ethiopia, Ghana and Kenya have played a lead role in the promotion of cloud services as part of the rollout of e-government strategies. In addition, there has been increased cloud activity amongst the education sector.

While cloud adoption in most of the selected markets has been public-sector driven, in South Africa private-sector demand of services is stimulating growth of cloud-computing services. The provision of cloud services is mostly supply-side driven, with global and some local IT companies acting as intermediaries, with a few exceptions, where South African-owned companies with a pan-African reach, like Dimension Data and Internet Solutions compete directly with the global payers and large local IT companies, like Seven Seas Technologies in Kenya. On the other hand, telecommunications companies are trying to differentiate their offerings and broaden their revenue streams by leveraging their existing infrastructure and offering cloud services. The services offered by these entities can be differentiated between those intended for large-scale enterprise purposes, SMEs, individual end user, or for personal use. The focus until now has been on Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS), which is where cloud development is and where issues of competitiveness will become most pertinent; all of which raise distinct questions around business modelling and regulatory challenges. From the user perspective, however, irrespective of size, cloud computing is a “dynamic utility” that is always available, paid for according to the amount consumed, and can be consumed in any quantity (Kushida, Murray and Zysman, 2012: 65).

Cloud computing is part of the ICT ecosystem, as cloud-computing services require ICT networks and internet infrastructure to function. While there is much hype around the cloud, a critical determinant of cloud diffusion is the availability and affordability of underlying infrastructure (Gillwald et al, 2012). Other concerns are regulatory in nature, including concerns around security, privacy, surveillance and reliability of networks to further constrain the uptake of cloud services especially in risk-averse sectors like financial services (Gillwald et al, 2012). Although cloud computing falls within ICT, no provision is made for cloud services in all ICT regulatory frameworks in the selected African markets. Finally, there is a shortage of highly skilled personnel to implement and maintain the solutions.

Definitions relating to cloud computing

Generally there is disagreement on how cloud computing should be defined and the term means different things to different stakeholders. According to Gillwald et al (2012), the term “cloud computing” has generally been misused to refer to all forms of data outsourcing and online services.

Cloud computing is also used to refer to a means of delivering applications, services or content to end users. This is achieved by making use of storage capacity of large-scale data centres with high-bandwidth communication infrastructure that can achieve economies of scale. Cloud computing is based on a utility model for the use of information technology assets and resources, whereby companies pay for what they use. Virtualisation technology constitutes the core cloud-computing technology (that is from infrastructure to terminals), as well as the automation of infrastructure and application processes, which includes configuration, provisioning, auto-scaling and failure recovery (Gillwald et al, 2012).

A widely accepted definition is that of the US National Institute of Science and Technology, NIST (2011) that defines "cloud computing as a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction."

It is important to make a distinction between cloud services and cloud-based services:

The International Telecommunications Union (ITU) (2012) defines cloud services that are provided and utilised "on demand at any time, through any access network, using any connected devices [that use] cloud-computing technologies". Further, cloud services utilise software and applications that are held in the cloud and not on users' own devices (ITU, 2012). These are used for internal administration by cloud users or for the management of service delivery to end users. An example is customer relations management.

On the other hand, cloud-based services include mass market applications in social networking and webmail offered over the internet to end users. Applications include Facebook, You-tube store videos and other data that are then posted on the cloud. That is, the data does not sit on the individuals computers but is stored remotely in data centres. Gmail and hotmail operate in the same manner (Gillwald et al, 2012).

Cloud types

A distinction is made between private and public cloud services. However the distinction is not clear cut, as cloud providers offer both public and private services and make use of the same data centres. Government and private companies may use more than one cloud service and multiple cloud providers. In this regard, interoperability in the cloud becomes critical as it allows flexibility, facilitates competition and allows companies to switch between one cloud provider and the other (UNCTAD, 2013)

A public cloud "is an open resource open to the public". Examples include mass market services like Dropbox and webmail, Apple's i-cloud and Facebook that are funded by advertising revenue. In addition these services are able to achieve massive economies of scale (UNCTAD, 2013: xii).

A private cloud refers to "a dedicated resource provided by a cloud service provider for a single client/user (for example a government or large business user)" (UNCTAD, 2013: xii).

A community cloud is "a resource/service provided for and shared between a limited range of clients/users. It might be considered half-way between public and private cloud provisioning" (UNCTAD, 2013: xii).

A hybrid cloud "is a mixture of the deployment models described above, for example a mix of public and private cloud provision" (UNCTAD, 2013: xii).

Models of cloud computing

Infrastructure as a Service (IaaS)

IaaS is a virtual, cloud-based replacement for physical hardware, such as processors and hard drives (Kushida et al, 2012). Users make use of the storage, networks and other computing resources that allow them to deploy their own software, applications and operating systems. The underlying cloud infrastructure is managed and controlled by a third party. The user has control over the storage, operating systems and deployed applications, but may have limited control over networking components such as host firewalls (Kushida et al, 2012).

Software as a Service (SaaS)

Cloud applications are usually delivered in the form of SaaS. Under this model users are able to remove complexities and costs involved in the installation, maintenance and upgrading of complex IT systems in their own environment (Gillwald et al, 2012). In addition, users take advantage of providers running cloud infrastructure. Users can access

the cloud through either a thin client interface, such as a web browser (e.g. web-based e-mail) or a programme interface and have no control over underlying cloud infrastructure (Kushida et al in Gillwald et al, 2012).

Platform as a Service (PaaS)

PaaS involves the deployment of a user's own applications on platform tools, including programming tools that are on infrastructure owned and managed by the cloud provider. For example, application developers working on mobile applications usually use cloud-based platforms to develop and launch their services. The consumer does not manage or control the underlying cloud infrastructure, including network, servers, operating systems, or storage, but has control over the deployed applications and possibly configuration settings for the application-hosting environment (Gillwald et al, 2012). The PaaS platform enables them to access a full repertoire of features, which make up the platform. For example, a developer working on Android applications can use PaaS to ensure that an application can automatically take advantage of changes implemented in, and follow the look and feel of, new releases of the Android operating system as they appear (Kushida et al in Gillwald et al, 2012).

Cloud providers

According to Kushida et al (2012) cloud providers "create, configure, run and distribute services". Aggregators and system aggregators are players that act as intermediaries for cloud providers and manage the cloud migration process by matching their knowledge of global cloud computing technologies with local needs (Odufuwa, 2013). Cloud brokers are third party service providers that act as intermediaries between the end users, original equipment manufacturers (OEMs) and system integrators (Odufuwa, 2013).

Locating cloud computing in the broader ICT eco-system

Figure 1 below is an illustration of the ICT ecosystem. It provides a conceptual framework in which to analyse the relationship between different elements and the outcomes resulting from their interactions. According to Kaplan (2005) "An ICT ecosystem encompasses the policies, strategies, processes, information, technologies, applications and stakeholders that together make up a technology environment for a country, government or an enterprise. Most importantly, an ICT ecosystem includes people – diverse individuals – who create, buy, sell, regulate, manage and use technology". Cloud computing is located within the broader ICT ecosystem as cloud services are delivered via an internet connection. As a result, the reliability of cloud computing is critically dependent upon the availability of underlying broadband infrastructure.

The networks, services, applications and content, which together are now conceptualised as the broadband ecosystem (Kim, Kelly and Raja, 2010) and access to and affordability of these services are an outcome of the market structure, institutional arrangements and effectiveness of regulation, which in turn are an outcome of the policy and legal framework (Gillwald, 2012). Users, including consumers and citizens, have been placed at the centre of the ecosystem and factors such as price and quality of service are a measure of access and affordability of services provided (Gillwald, 2012).

The ability of the policy and legal framework to provide a favourable environment is a major determinant of investment in order to drive growth of the sector and economy.

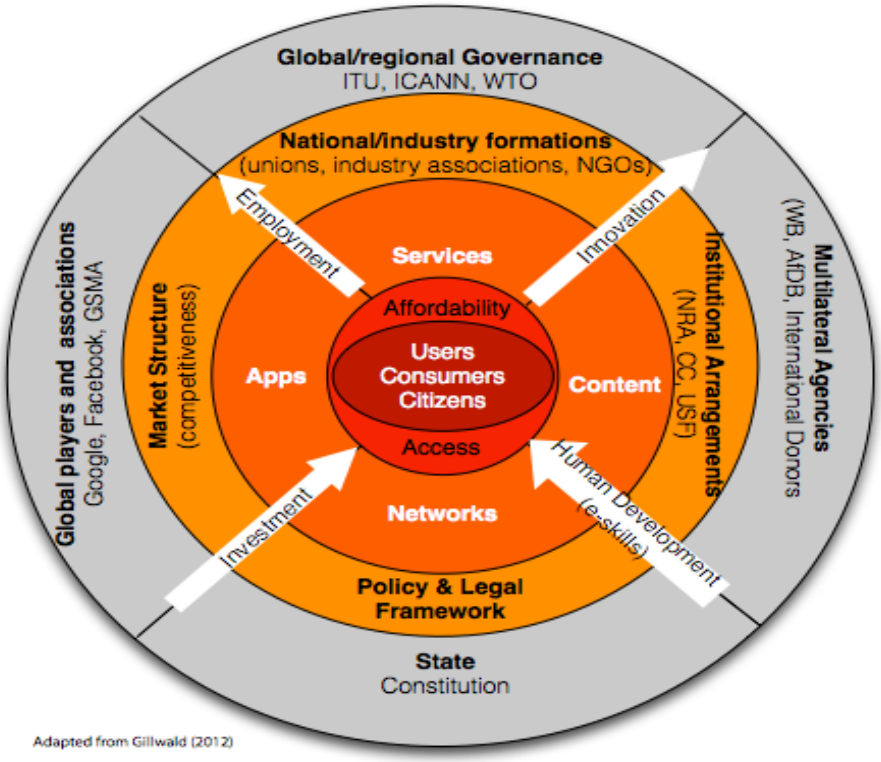

Figure 1: ICT ecosystem

The next section describes the ICT landscape in the selected markets as an indicator of the cloud readiness of a country.

Cloud presence in Africa

Cloud computing in the selected African markets is in its early growth stages, although there is relatively higher cloud activity within South Africa, with demand arising from the private sector and a number of South African-based companies like Internet Solutions providing cloud services in other African markets. Cloud providers are mostly global US-based players with some local presence in the selected countries, or services are provided through intermediaries. Local IT providers and telecommunications companies are also competing within the cloud-computing market.

Cloud presence in Ghana

There are over 20 cloud providers in Ghana, many of which are local companies. The cloud services provided mostly consist of IaaS and PaaS, together accounting for 69% of the cloud-computing market. Most of the local cloud providers act as intermediaries for global cloud-computing providers. For example, MTN provides Averiware, Microsoft Dynamics (CRM) and MacAfee end point and e-mail protection suite to its customers. In addition, Net Solutions Ghana Limited is an intermediary for IBM (Business Partner), IBM PureSystems, Business Analytics and Oracle business, technical and industrial solutions (Frempong, 2013). Other providers are pan-African in nature, including South African-based companies Dimension Data and Internet Solutions. Finally, there are some companies like Internet Ghana, Ostec, Ecoband Networks Limited, Computer Information Systems Ghana Ltd, among others, providing hosting and managed services and data centres that have the potential to grow their business into cloud business (Frempong, 2013).

Cloud presence in Nigeria

The Nigeria cloud market mainly consists of global IT companies offering some kind of IaaS, SaaS and PaaS solutions. Key players within the market include Amazon, Cisco, EMC, Google, HP, IBM, Microsoft, Sales Force and SAP that are mostly headquartered in the Unites States of America (Odofuwa, 2013). A number of local, pan-African and international aggregators and system aggregators act as intermediaries for the global IT companies and manage the cloud migration process. The main players in the space include Computer Warehouse (Nigeria), Datagroup IT (India), Business Connexion (South Africa), Resourcery (Nigeria), Gateway Communications, CIS (Nigeria), City Business Computers (Nigeria) and Dimension Data (South Africa). The main cloud brokers in Nigeria include Decasio (Nigeria), a local google apps reseller, and AppZone, which provides a managed cloud offering called BankOne, designed for Microfinance banks (Odofuwa, 2013). Finally, mobile operators MTN, Glo and Airtel have launched mobile cloud offerings targeted at the SME market. The Nigerian cloud-computing market is in the early growth stages, with emphasis being on IaaS, particularly storage and infrastructural services. NetApp, EMC and HP are market leaders.

IBM and Sproxil, two American-based cloud providers, are implementing solutions that allow drug manufacturers in Nigeria to prevent drug counterfeiting in real-time. Consumers are able to use the solutions to verify the authenticity of drugs and prescriptions using mobile phones by scratching and texting a code embedded in the packaging. Service providers host the data in the cloud and state that results are obtainable by buyers within matter of seconds (Odufuwa, 2013).

In December 2012, MTN launched a cloud service brokerage product in Nigeria and Ghana targeted at its SME customers. This followed a successful six-country pilot. As a result, MTN has become the first mobile network in Africa to offer cloud services on the continent. MTN Cloud is a small business suite that consists of Human Resources, accounting, e-mail and collaboration, video conferencing, storage and backup, and customer relationship management (CRM) packages – all offered as a service to small businesses. MTN Cloud's offering also includes a SaaS application that provides microfinance institutions with a service platform with which to run their banking operations. According to MTN, its cloud offering has already been embraced by businesses in manufacturing, hospitality, microfinance and advertising (Odufuwa, 2013).

Cloud presence in South Africa

There is growing awareness of the benefits of cloud computing for various sized companies. Global players like AWS, Google and Microsoft are operational in South Africa. AWS has massive shared computing capacity (EC2); Google and software vendor Microsoft are aggressively marketing cloud services and are competing with established local carriers and large managed services providers, such as Internet Solutions (a division of South African-based Dimension Data, now owned by NTT) (Gillwald et al, 2012).

In the IaaS market AWS's virtual servers are global leaders. AWS competes with local companies such as MTN solutions, Internet Solutions and Telkom. In South Africa, cloud computing is an extension of hosting and data centres, key concepts that underpin it. Cloud computing is viewed as the logical next step up the value chain (Gillwald et al, 2012).

Within the PaaS space, Microsoft provides a Windows Azure platform and Google's App Engine is present within South Africa. Microsoft is supporting the SME sector to use their platform for developmental purposes (Gillwald et al, 2012).

Salesforce.com is one of the leading providers in the SaaS space. The company provides CRM and related cloud-computing application solutions and development tools for the business web. Applications and content services, which include Google Apps and Microsoft Office, offer productivity services, e-mail, customer relationship management

and enterprise resource planning via the cloud (Gillwald et al, 2012).

Integration as a service is a delivery model where the functionality of system integration is put into the cloud. The South African-based company Pamoja is providing integration services between different cloud providers, using application programme interfaces. This model allows users the flexibility to use services from multiple cloud providers that best need their specifications at the best price. Pamoja is a subsidiary of SEACOM, which is significant as the company has access to redundant bandwidth capabilities that are critical for the delivery of cloud-computing services on the African continent.

Cloud presence in Kenya

Cloud services in Kenya are mostly supply-side driven and competition is emerging between local and international companies. At the IaaS level, Kenya Data Network (KDN), MTN Business and Safaricom Ltd are leaders. KDN is very well established, with a data centre market, and provides rack services, redundant power and security services. By having the largest private sector optic fibre network of 7,000 km, KDN is in a position to provide a network to link customers to its data centre (Mureithi, 2013).

The PaaS offerings in Kenya include the provision of servers, operating systems, storage and backup systems. Safaricom, the incumbent operator, entered this space in partnership with an integrator, Seven Seas Technologies Ltd, in Oct 2011. The operator is offering IaaS but also PaaS – servers, storage, backup and operating systems. The range of the platforms is, however, limited to one operating system environment in its service offerings (Mureithi, 2013).

The advantage of the partnership with Seven Seas Technologies is that the company has an established reputation. The company's entry in the market is significant and has changed market dynamics by making potential users explore local clouds as a feasible alternative to foreign clouds. One of the best practices in the Kenyan market is that a provider needs to be a multivendor to gain market share.

Safaricom has decided to bring the M-PESA platform to Kenya on the basis of improved quality of service through the reduction in outages currently prevalent in the market. This move has strengthened its position with the cloud-computing market (Mureithi, 2013). The SaaS space includes software applications, such as communications, e.g. MS Exchange, enterprise resource planning (ERP) and video conferencing.

The SaaS space is competitive, with Kenyan companies having to compete with global players. Unfortunately, the Kenyan market is not able to generate the economies of scale to compete with large, foreign-based public clouds. An attractive business model would be for local companies to collaborate with global SaaS providers. Key actors targeting the market to include the following:

Pamoja Cloud Services

Pamoja, incorporated by SEACOM in 2011, is SEACOM's value-added services business unit, and its strategic arm is leading the entry into content aggregation and associated cloud computing services. Pamoja's business model is built on the growing demand from SMEs for IT as a service, coupled with the need for service providers to increase the value of their existing offerings and grow broadband revenue. In addition to other markets where SEACOM operates, Kenya is a significant market where it has established an office and is now developing partnerships to offer services (Mureithi, 2013).

Xtranet Communications Ltd

Xtranet allows customers to buy the software and bring it to their servers. Customers also lease Xtranet software on a monthly basis, or bring their own servers to the company's premises. The company is an anchor tenant for Pamoja Cloud, intended to boost their SaaS model (Mureithi, 2013).

Kenyan Cloud Ltd

Kenyan Cloud Ltd provides a range of services including mail, data recovery and storage. Most of the services are sold through service

integrators who include Xtranet Communications Ltd (Mureithi, 2013).

Sofgen

Sofgen launched the Temenos T24 cloud-based banking software solution in the Kenyan market. This is a microfinance institution (MFI) banking software solution that provides the client with a pre-configured model bank based on microfinance and community banking best practices. The target market is the emerging MFI sector (Mureithi, 2013).

Cloud presence in Tunisia

There is a growing awareness of the potential of cloud solutions in Tunisia, reflected in the increasing number of scientific conferences, workshops, exhibitions, business and technology events linked to this new technology. Software vendors, such as Microsoft and Oracle, and equipment manufacturers, such as HP, are increasingly advertising their cloud solutions. Furthermore, universities and other specialised institutions are beginning to introduce courses and research in this area (Kamoun and Chaabouni, 2013).

Several cloud providers that provide public clouds have emerged within Tunisia. At present, there are no official statistics on the deployment of private clouds. Local cloud providers include the incumbent telecommunications operators, Tunisia Telecom, Smart Host and Axelaris. International operators with a local presence include OVH (France), Microsoft (United States) and Google (United States). Services of other international operators like Amazon are hardly used in Tunisia, due to the foreign exchange regulations.

IaaS services are mainly targeted at SMEs, which constitute the majority of the Tunisian economic market. Given that SMEs tend to have limited financial resources, this limits their ability to purchase software, such as CRM or enterprise relationship, whose cost is relatively high.

Table 1 shows the types of services offered by the different operators on the Tunisian market, and Table 2 shows the types of SaaS services available on the Tunisian market.

Table 1: Cloud services available on Tunisian market as at June 2013

	Tunisia Telecom	Smart Host	OVH	Axelaris	Microsoft	Google
Mail	X	X	X	X	X	X
Collaborative work	X	X	X	X	X	X
Call centre service	X	X				
CRM enterprise		X		X		
CRM university		X				
ERP				X		
Private cloud		X	X	X		

(Compiled by Kamoun and Chaabouni, 2013)

Table 2: SaaS services as at June 2013

	Tunisia Telecom	Smart Host	OVH	Axelaris	Microsoft	Google
IaaS		X	X	X		
PaaS	X	X	X	X		
SaaS	X	X	X	X	X	X

(Compiled by Kamoun and Chaabouni, 2013)

Market and cloud trends

General trends can be identified across the selected African markets. US-based cloud providers, including Google, Amazon and Microsoft, dominate the cloud market. In most countries local companies act as intermediaries for the global players. Large local IT players in established markets like South Africa, Kenya and Tunisia are competing directly with the global players. In a number of countries there is increased presence of South African-based pan-African cloud providers, such as Dimension Data and Internet Solutions. African telecommunications companies and mobile operators are also leveraging their own existing infrastructure to deliver cloud services, in order to diversify their revenue streams due to a decline in traditional voice revenue.

Historically, the state has played a lead role in stimulating demand by spearheading the deployment of new technologies. For example, in South Africa and Kenya the state has played a lead role in the rollout of national broadband backbone networks. In Ethiopia, a national broadband network is being rolled out through a public-private initiative (PPI). Nonetheless, the terrestrial backbone networks remain limited and are a bottleneck to the deployment of cloud services. A number of submarine cables have landed in the selected countries, resulting in a significant increase in bandwidth capacity, followed by a subsequent decline in bandwidth prices.

In terms of the adoption of cloud-computing technology the governments of Ethiopia, Ghana, Kenya and Nigeria are actively promoting the adoption of cloud-computing technology as part of the deployment of their e-government strategies. However, the cloud-computing initiatives remain supply-side driven rather than demand driven. South Africa is an exceptional case in that cloud computing is being driven by demand from the corporate sector and the technology is being extensively used throughout the country. While the governments in the selected African countries are promoting public cloud-computing services, in South Africa there is a preference for private cloud services, as this provides companies with a sense of security and control over their data (Gillwald et al, 2012).

The usage of cloud-computing technology by the public sector has been limited. However, industry commentators in South Africa stated that the global financial crisis is likely to force corporates to consolidate expenditure and move to public cloud in order to take advantage of the economies of scale and cut down costs. In this regard, security, data protection and governance rules will be important factors to address (Gillwald et al, 2012). The education sector is one of the drivers of ICT take up. In Ethiopia, Nigeria and Tunisia the education sector has adopted cloud-based strategies, opening up the universities to the global market and stimulating demand for e-learning.

Broadband infrastructure as an enabler of cloud computing

The telecommunications sector in most of the selected countries have been liberalised and have continued to grow despite the policy and regulatory bottlenecks. The mobile market has experienced significant growth and mobile broadband access has become a

competitor to fixed broadband access. With the limited availability of ADSL in some areas and poor quality of service, the mobile phone is becoming the primary method of accessing the internet. In addition, mobile broadband prices are comparatively lower than fixed broadband prices.

Competition in the broadband market has increased, resulting in significant increases in the availability of bandwidth. The landing of a number of international submarine cables has further bolstered international bandwidth capacity. Despite the decline in bandwidth pricing, prices in Africa remain high in comparison to other developed markets. Although the deployment of international submarine cables has led to significant increases in the bandwidth capacity at an international level, territorial national backbone networks in Africa remain inadequate, despite the attempt by African governments to build these. The private sector has also invested in broadband backbone infrastructure; however this is concentrated in urban areas and centres of economic activity. Policy and regulatory challenges have hampered investment in the expansion of networks to rural and under-serviced areas.

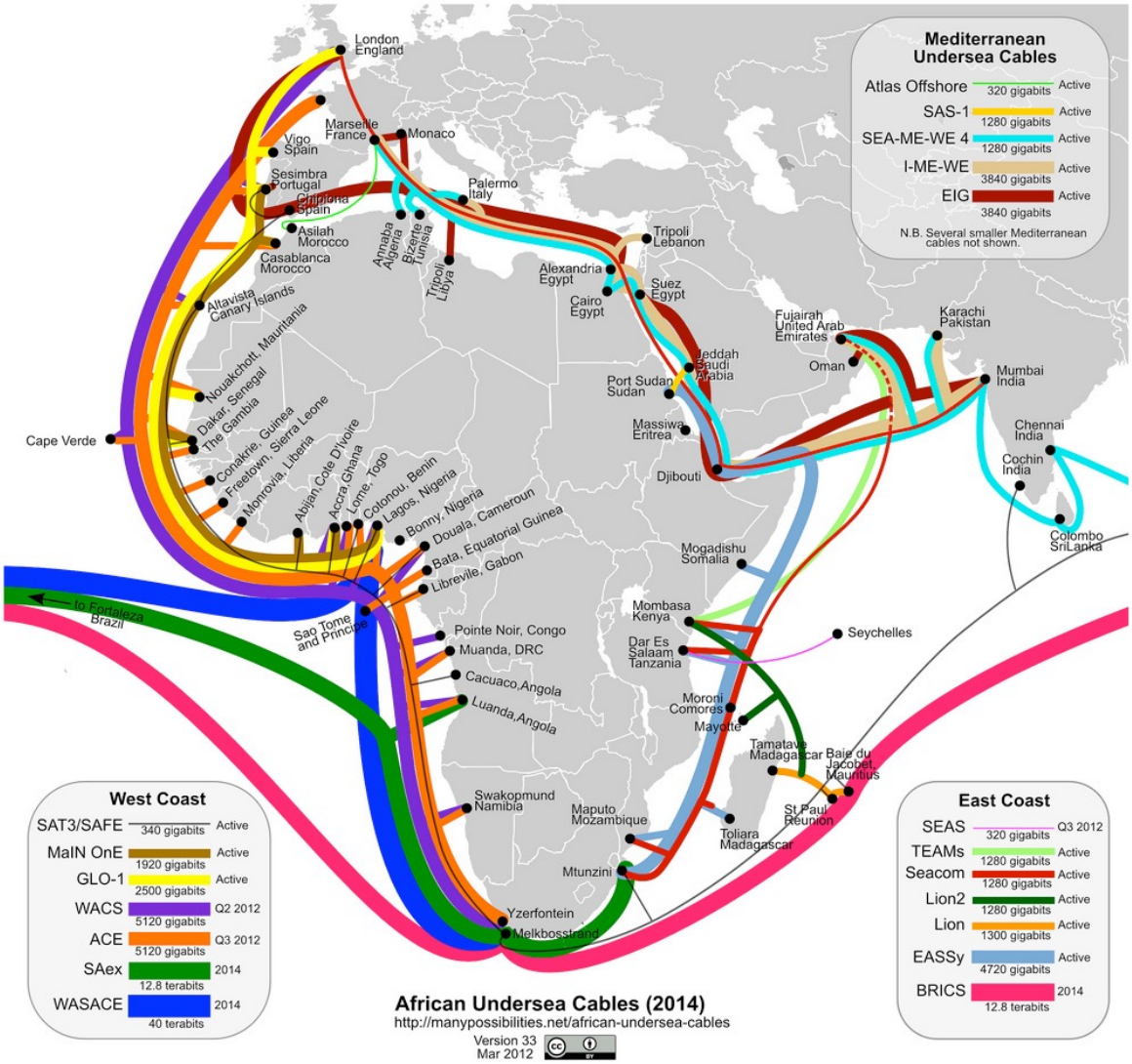

Figure 2: African undersea cables (2014)

Submarine and fibre-optic projects

Broadband in Tunisia

Broadband internet bandwidth in Tunisia has grown significantly from 27.5 Gpbs in 2009 to 82.5 Gbps in 2012. In addition, the state-owned incumbent operator, Tunisia Telecoms, owns all the ADSL and leased lined connections. In 2013, Tunisiana and Orange-Tunisia obtained government approvals to install a shared submarine data transmission cable between Tunisia and Europe, with a capacity of 16 Tbps for each of the operators.

Broadband in Ghana

In Ghana, the National Communication Backbone Company, a subsidiary of Vodafone Ghana, owns the main fibre network. It has been rebranded Vodafone Wholesale and covers all major towns and cities. In addition, a 600 km fibre network is under construction in the Eastern part of Ghana, financed by Danida (Frempong, 2013). Additionally, all the mobile operators have constructed fibre networks concentrated in main commercial and industrial areas in Ghana in the Southern part, ACCRA and Western region of the country (Frempong, 2013).

Broadband in Kenya

In Kenya, there has been massive investment in the expansion of ICT infrastructure, particularly through the investment in a number of submarine projects, and the deployment of a national fibre optic network. The government has also taken initiative to eliminate a number of taxes, in order to facilitate access to a number of IT tools, including computers, software and cellular phones, resulting in greater penetration of internet capable devices within Kenya (Mureithi, 2013).

Broadband in South Africa

South Africa enjoys services from four new submarine cable systems, resulting in a significant decline in prices and improvement in international bandwidth capacity. The privately held, open access SEACOM cable was the first competing cable to land, in 2009. SEACOM is 17,000 km long and had an initial capacity of 1.2 Tbps, which is being upgraded to 4.2 Tbps (Gadget, 2013). The SEACOM cable is the only cable servicing the eastern seaboard of the continent and links South Africa, Mozambique, Madagascar, Tanzania, and Kenya with India and Europe. The Eastern Africa Submarine Cable System (EASSy) landed in South Africa in 2010 and is 10,000 km long with a capacity of 4.72 Tbps (EASSy, 2013). The MainOne cable landed in 2010, and the West Africa Cable System (WACS) become operational in late 2011. WACS is 17,200 km long, with an initial capacity of 500 Gbps, upgradable to a mammoth 5.12 Tbps (WACS, 2013). The African Coast to Europe (ACE) cable came online in South Africa in 2012, with a capacity of 5.12 Tbps and a length of 17,000 km (ACE, 2013).

The introduction and extension of fixed broadband networks in South Africa resulted in the Department of Public Enterprises (DPE) embarking on the process of establishing a state-owned broadband infrastructure company, Broadband Infraco. The fibre optic networks of Transnet and Eskom, which were to have been set aside for the second network operator, were taken from Neotel by the DPE (just as Neotel was signing its final licence agreements) and transferred to the wholly state-owned Infraco in 2007 (Gillwald, Moyo and Stork, 2012). Broadband Infraco was licensed for the provision of wholesale services and became operational in 2009, following licensing delays relating to determination of the kinds of services it would be entitled to offer. Infraco has since invested in national and international backbone communications networks, and is one of the main investors in WACS (Gillwald et al., 2012b)

Cloud computing in the education sector

Cloud computing is believed to be a powerful tool for the rapidly expanding education sector in Africa, due to its socio-economic benefits and potential to facilitate distance

learning, language and cultural exchange and rapidly move data via the cloud. However, movement of data restrictions in some countries may hinder the deployment of such services.

Cloud-computing adoption in the South African education sector

The South African Research and Education Network (SANReN), which is operated by the Tertiary Education and Research Network (TENET) on behalf of the Department of Science and Technology, has sourced its own international bandwidth through a 10 GPs circuit to London on the SEACOM cable for a fraction of the cost of nationally commercial available bandwidth and dimensioned its network to conform with contemporary research expectations and meet some of the technical conditions for cloud computing (Gillwald et al, 2012). TENET intends to extend the benefits of SANReN to other campuses across South Africa, in addition to fibre rings in Johannesburg, Pretoria, Cape Town and Durban (Gillwald et al, 2012).

However, there does not seem to be complete confidence in moving entire university administration systems to the cloud. Some of TENET's university clients were considering moving their dedicated e-mail systems. Furthermore seven universities stated they were willing to migrate to the cloud, but the availability of redundant and reliable international connectivity remains a draw back. Any potential disruption is likely to undermine the value of migrating to the cloud (Gillwald et al, 2012).

The University of KwaZulu-Natal in Durban provides PaaS support for remote developers working on an open source global mHealth application suite, by leveraging SANReN and other related networks. Nevertheless, data regulations may limit its utility for international cloud-based service provisioning (Gillwald et al, 2012).

AWS makes its platform available to universities for free and a number of research computing projects are expected to migrate to its platform. However, issues around data privacy and security remain a key concern amongst university. Alternatively, the potential cost saving derived from cloud-computing services is likely to drive adoption of cloud services.

Cloud-computing adoption in the Nigerian education sector

The first publicly announced education cloud is a public-private partnership (PPP) collaboration between Obafemi Awolowo University and TTC Technologies. The cloud project aims to provide a school management system – which manages courses, transcripts, student records, and accounts – as well as a learning management system – which provides online classrooms and curriculum management – among other features. The current status of this project cannot be determined (Odufuwa, 2013).

Cloud-computing adoption in the Tunisia education sector

The interest in cloud in education in Tunisia started with the Ministry of Education, which launched its first major project. In addition, specific training modules have been introduced in universities and some research projects have been initiated. The National Centre for Education Technologies (CNTE) of the Ministry of Education serves 6,000 sites between schools and colleges. The CNTE project involves setting up a data centre based on cloud architecture for the entire primary and secondary public educational sector. This data centre will utilise state-of-the-art technology for next generation learning. It will also provide a centralised digital library for students and teachers (Kamoun and Chaabouni, 2013).

An experimental cloud-computing project called "Cloud Jasmine Tunisia" has been initiated between several Tunisian academic institutions, in cooperation with French universities. The name of this project is not accidental: it came at a symbolic moment in Tunisia, marked by the democratisation of social and academic life after the fall of the authoritarian regime (the Jasmine revolution) (Kamoun and Chaabouni, 2013).

Taking advantage of the new climate of freedom, several Tunisian academic institutions have agreed to cooperate to develop an ecosystem for the emergence of innovation in the field of cloud computing and the establishment of an academic cloud. These institutions come from diverse backgrounds: the entity in charge of the management of Elgazala Technopark, CNTE of the Ministry of Education, the National School of Computer Science (NSI), the School of Communications (SupCom), the National School of Engineers of Sfax (ENIS), the School of Applied Sciences and Management (SESAME) (Kamoun and Chaabouni, 2013).

Given that cloud computing has cost-benefits for academic institutions, the intention of the project is to make software platforms and powerful computing and massive storage capabilities remotely accessible for researchers, students and business enterprises through light terminals (PC, electronic tablet, smartphone, etc.). Jasmine Cloud, formed by computing servers and storage distributed among the different sites of the participating institutions, is to be at the service of training, research and development, and innovation (Kamoun and Chabani, 2013)

The project also aims at providing researchers with collaborative electronic publication platforms. Cooperation between researchers and professors will extend to the production of online courses, using a Massive Open Online Courses (MOOC) platform to be installed on the Jasmine Cloud, and to be shared at national, African and international levels.

More precisely the aims of Jasmine Cloud Tunisia are to:

- conduct awareness and training sessions for engineers and researchers;
- deploy an experimental platform for developers and researchers to test and validate their architectures and software components on a real cloud platform;
- conduct research and development for the federation of distributed clouds;
- provide a collaborative platform for the development of educational content.

E-government as a driver of the cloud-computing market

Recently, African governments have been promoting the adoption of cloud-computing services and are creating trust and awareness of such services as a delivery model for e-government services. To this end, several African governments are investing in data centres dedicated to hosting public data.

E-government initiatives in Nigeria

The public sector in Nigeria has adopted cloud-computing architecture to deliver public services. With World Bank support, the Nigerian government moved the public sector payroll systems to the cloud through a SaaS arrangement. The federal government of Nigeria claims to have saved NGN 14 billion (USD 70 million) through this initiative (Odufuwa, 2013). Over 180 government ministries, departments and agencies have since migrated their pay role systems to the cloud. Galaxy Backbone, a state-owned internet provider, has an exclusive agreement to provide connectivity to the public service. The company also hosts government websites and applications in its data centre (Odufuwa, 2013). The company is in the process of implementing national cloud infrastructure that will deliver IaaS, SaaS and PaaS solutions. In 2012, the Nigerian Petroleum cloud is believed to have implemented a closed cloud in a tier-3 data centre, running applications such as procurement, collaboration, enterprise services and email, among others (Odofuwa, 2013). The Central Bank of Nigeria is in the process of implementing cloud for e-transactions through Wi-Fi hotspots, which will provide merchants shared access to services. In April 2012, the Rivers State government launched its own private cloud

named "RivCloud", built on cloud solutions provided by MTN and Glo Nigeria. RivCloud is equipped to provide storage and application hosting service to government departments, ministries and agencies. The government has further announced plans to launch a tax application for citizen filings (Odufuwa, 2013).

E-government initiatives in Ethiopia

The government of Ethiopia has played a lead role in the development of the cloud-computing market through the adoption of a cloud-computing strategy. The government further intends to develop a community cloud system for the public sector, building on its experience in developing data centres (Adam, 2013). In 2013, the Ethiopian government reached an agreement with the Republic of Korea for support in the upgrade of its data centres into the cloud environment. The Ethiopian government has started rolling out applications that will underpin cloud ecosystem such as e-procurement, human resources management, e-office, e-mail, financial management and information system. The e-government strategy envisages the implementation of 219 e-services; 79 informational/interactive and 140 transactional services over a five-year period (Adam, 2013). The e-government services will be delivered through six projects, including a national payment gateway, enterprise architecture framework, public key infrastructure, national data set, national enterprise service bus, and national integration authentication framework. In addition, the government of Ethiopia is building a wide area network (WAN) in order to facilitate the implementation of the e-government strategy (Adam, 2013).

E-government initiatives in Ghana

The government of Ghana has also taken the initiative to promote cloud computing as part of its e-government strategy. This will involve the extension of the national backbone to all in order to connect all public institutions to a single shared communications and computing infrastructure and facilitate the effective delivery of government services to all citizens (Frempong, 2013). The proposed network is expected to reach 1,050 sites, of which 550 will contain wireless last-mile access networks. The government of Ghana, under the e-Ghana project, is constructing three data centres, with the purpose of delivering disaster recovery services. The data centres will host the data from all government institutions, departments and agencies (Frempong, 2013).

The relevance of cloud computing in the informal sector in Africa

SMEs are being targeted for cloud solutions in the selected African countries, as often these companies lack the financial resources to build in-house IT capacity. Thus they stand to gain from the economies of scale offered by public cloud-computing services.

The international standard industrial classification (ISIC) and the SMEs classification used for businesses are often not practical, especially in the case of the informal sector in African countries, due to the nature and structure of these businesses. Instead, classification of businesses into "informal" and "formal" appear to be more suitable, as these terms classify businesses that are marginalised and that require more appropriate developmental policy more appropriately. This section looks at the relevance of cloud computing for informal businesses, which constitute the majority of businesses within Africa. Personal cloud services delivered through the public cloud, like Google Apps, are of relevance to the informal sector and e-government services. With the proliferation of mobile phones, the expansion of mobile broadband networks and the increased access to the internet via the mobile phone, the delivery of mobile-based cloud services is becoming important in the African context.

Table 3 draws on the approach used by Esselaar, Stork, Ndiwalana and Deen-Swarray, (2007), and is further modified by Deen-Swarray et al (2013) to classify businesses by formality. A formality index was developed and used to classify businesses into formal, semi-formal and informal businesses. The

classification was based on the variables, form of ownership, tax registration, employees having employment contracts and the separation of personal from business finance.

Businesses were grouped according to the type of ownership, with those listed as a Proprietary Limited Company (Pty) or a Closed Corporation (CC) considered more formal, as it is mandatory for them to be registered, unlike those grouped into sole proprietorship or partnership. Paying VAT requires more sophisticated keeping of financial records, which forces business to keep their personal and business finances separate, all of which add to the degree of formality of a business. Whether businesses have a written employment contract for their employees, or not, is also an indication of how formal a business is, as it obliges them to adhere to stipulated labour laws. These variables used in distinguishing the level of formality of businesses were given values, with 5.5 points as the maximum possible value. Businesses are then categorised into the informal, semi-formal and formal categories based on these values. The range of index points and the share for each country in the final classification are shown in Table 3 below (Deen-Swarray, Moyo and Stork, 2013).

Table 3: Distribution across formality classification (unweighted)

Index points	Informal less or = 1.5	Semi-formal 2 to 3	Formal 3.5 or more	Total sample
Uganda	82.0%	17.4%	0.6%	500
Kenya	85.0%	11.1%	3.9%	513
Tanzania	82.3%	14.9%	2.9%	491
Rwanda	85.6%	12.3%	2.0%	640
Ethiopia	97.0%	2.3%	0.7%	841
Ghana	86.8%	10.8%	2.4%	500
Cameroon	91.5%	6.7%	1.7%	520
Nigeria	89.5%	8.5%	2.0%	554
Namibia	71.7%	15.8%	12.6%	374
South Africa	68.7%	15.9%	15.3%	627
Botswana	78.2%	10.9%	10.9%	386

(Source: Deen-swarray et al, 2013)

The informal business survey was conducted in conjunction with the household and individual surveys, using a population census sample frame. The focus is, therefore, on businesses in residential and semi-residential areas, which limits the analysis to mainly informal and semi-formal businesses in order to be representative across the various countries.

Table 4 below shows the various ICTs used by the informal businesses. It is evident that mobile phones are the most commonly used form of ICT, while the use of fixed lines and internet is negligible. Although the informal sector is comprised of businesses that are not registered and are unrecognised in terms of their contribution to the economy, it provides domain for the poor and marginalised, which constitute the majority within the African continent. Targeted initiatives are required that aim at providing business-enabling public cloud services over mobile phones, in order to boost business development and employment and facilitate economic growth and development.

Table 4: Informal business use of ICTs

	With a working fixed line	Using mobile phones for business purposes	With a working computer or laptop	With a working internet connection
Uganda	6.9%	67.9%	3.2%	2.0%
Tanzania	1.0%	44.4%	2.8%	0.1%
Rwanda	1.3%	53.4%	2.0%	0.7%
Ethiopia	0.3%	12.3%	0.1%	0.0%
Ghana	0.7%	44.9%	1.3%	0.7%
Cameroon	1.3%	56.2%	4.4%	2.2%
Nigeria	0.2%	44.2%	2.7%	0.1%
Namibia	4.1%	51.9%	2.5%	2.2%
Botswana	3.5%	42.3%	4.2%	2.9%
Kenya	0.1%	67.4%	3.5%	3%
South Africa	15%	49.4%	11.5%	10.5%
Mozambique	0.7%	22.1%	0.7%	0.3%

(RIA Data 2012)

Bottlenecks to cloud computing

Inadequate terrestrial broadband backbone

The fixed-line segment in most African markets continues to be dominated by state-owned incumbent operators. In most of the selected African countries the sector has historically been characterised by licensing restrictions, which limited market entry and thus stifled competition in the sector. This has resulted in a vertically integrated market structure and a legacy of monopoly fixed-line operators with significant control over essential facilities, including backbone networks (Calandro and Moyo, 2012). Even in established markets like South Africa, institutional capacity problems have resulted in the inability to regulate wholesale access effectively.

Calandro and Moyo (2012) argue that, prior to a state deciding to embark on a public-funded backbone initiative, regulatory tools that encourage market entry and competition should be adopted. The introduction of technologically neutral licensing regimes, the effective management and regulation of scarce spectrum and the regulation of access to dominant operators' networks can produce an environment conducive to encouraging private investment in backbone networks.

In countries like South Africa, Kenya and Ethiopia, policy and regulatory conditions have not been met that encourage investment in terrestrial backbone infrastructure. Instead, the countries have witnessed a rise in state interests through state-led investment in broadband backbone networks.

The Kenyan market has experienced a rise in state interests especially with the broadband backbone market. In addition, the fixed-line incumbent Telkom Kenya retains a monopoly over the fixed-line sector. The government of Kenya has played a central role in the National Optic Fibre Backbone Initiative (NOFBI) through its 49% equity in Telkom Kenya, which manages the project. Between 2009 and 2010, 4,300 km was rolled out through the initiative. Phase II of NOFBI has not yet commenced but the contract was awarded to the Chinese company Huawei. Nevertheless, the use of the network built under Phase 1 has been limited to a few countries. The growth in the demand for internet-enabled services, including cloud computing, is likely to boost demand for terrestrial fibre.

In South Africa, market entry into the fixed-line segment has been stifled by a policy of "managed liberalism" and, following licensing delays, the fixed-line market was eventually opened up to competition through the licensing of Neotel. However, Neotel has

struggled to compete with Telkom, the incumbent operator and has focused its strategy on provision of services to the corporate segment. Following licensing delays of the state-owned company Broadband Infraco, in 2009 Neotel and mobile operators started to co-build a national backbone infrastructural network, especially in the main metros (Gillwald et al , 2012b). However, weak state coordination has led to insufficient investment in state-owned company Broadband Infraco and 12,000 km network remains limited in terms of the size of the South African economy.

High costs of broadband access (last-mile) limit growth of the cloud-computing market

Last-mile connectivity refers to "the physical network infrastructure that connects to end users" (Kushida et al, 2012). The limited availability of last-mile connectivity within most African countries serves as a barrier to the provision of cloud-computing services, which includes wireless and fixed networks. While there has been a remarkable improvement in broadband connectivity in the selected African countries and in the many parts of Africa, last-mile connectivity is limited. In most countries, companies rely on mobile broadband and ADSL connections to access services. Table 5 below depicts fixed broadband product baskets that have been separated in data and speed categories. The first category consists of 1GB, 5GB and uncapped data packages and the second category includes speed ranges of 1 Mbps and below, above 1 Mbps up to and including 4 Mbps, above 4 Mbps up to 10 Mbps and above 10 Mbps. All three data packages were paired with all of the different speeds (except for the speeds over 10 Mbps, which was only considered for 5GB and uncapped packages). Most countries in Table 5 do not have speeds above 4 Mbps; South Africa is the only country that has speeds over 10 Mbps.

Table 5: Cost of fixed broadband baskets per month (US$)

	Monthly cost 1GB up to 1 Mbps	Monthly cost 1GB up to 4 Mbps	Monthly cost 1GB up to 10 Mbps	Monthly cost 5GB up to 1 Mbps	Monthly cost 5GB up to 4 Mbps	Monthly cost 5GB up to 10 Mbps	Monthly cost 5GB over 10 Mbps	Uncapped up to 1 Mbps	Uncapped up to 4 Mbps	Uncapped up to 10 Mbps	Uncapped at over 10 Mbps
Botswana	39.59	68.35	8578.65	39.59	68.35	8578.65					
Cameroon	61.59	411.79		61.59	411.79						
Ethiopia	23.09	38.77		38.77	38.77						
Ghana	31.39			31.39							
Kenya	34.56	52.02		34.56	52.02			38.13	345.9		
Mozambique	58.17	123.61		58.17	123.61						
Namibia	40.16	100.55	477.99	40.16	100.55	477.99		40.16	100.55	477.99	
South Africa	42.65	60.36	76.36	42.65	60.36	76.36	93.78	53.72	66.8	121.15	211.74
Tanzania	24.4	24.4	24.4	42.7	42.7	42.7		24.4	91.5		

(Source: Generated by authors of this paper)

In September 2013, South Africa ADSL prices remained significantly high for 1GB and 5GB packages (both up to and including 1 Mbps) in comparison to similar packages in Ethiopia, Ghana and Kenya.

In terms of mobile broadband 1GB packages, Tanzania, Ghana and Kenya had lower prepaid packages in comparison to other countries. Nigeria's prices, in contrast, were higher in the prepaid segment, at USD 20. In the post-paid segment, South Africa had the lowest priced 1G package.

Table 6: Monthly cost of 1 GB in USD (September 2013)

	Post-paid				Prepaid			
	< 7.2 Mbps	7.2 Mbps	7.2 to 21.6 Mbps	> 21.6 Mbps	< 7.2 Mbps	7.2 Mbps	7.2 to 21.6 Mbps	> 21.6 Mbps
Botswana	26.7	26.7			81.21	81.21		
Cameroon					20.5			
Ethiopia	17.61	24.88						
Ghana	11.98	11.98	11.98		9.26	9.26	9.26	
Kenya	11.02	11.02	11.02	14.77	10.01	10.01	10.01	14.02
Mozambique	22.38	22.38			18.8	18.8		
Namibia	30.25	30.25	49.77	49.77	33.52			
Nigeria	20.1	20.1	21.16		20.1	20.1	21.16	
Rwanda					14.19			
South Africa	9.63	9.63	9.63	10.85	14.61	14.61	16.39	31.38
Tanzania	10.4	10.4	10.4		6.8	9.6	9.6	
Uganda	16.29	16.29	16.29	17.69	11.14	11.14	11.47	15.67

(Source: RIA ICT Access and Use Survey 2011/12)

Table 7: Monthly cost of 5 GB in USD

	Post-paid				Prepaid			
	< 7.2 Mbps	7.2 Mbps	7.2 to 21.6 Mbps	> 21.6 Mbps	< 7.2 Mbps	7.2 Mbps	7.2 to 21.6 Mbps	> 21.6 Mbps
Botswana	308.41	308.41			401.64	401.64		
Cameroon					20.5			
Ethiopia	65.96	73.8						
Ghana	33.97	33.97	44.59		22.84	22.84	22.84	
Kenya	36.8	36.8	36.8	40.73	34.05	34.05	34.05	38.06
Mozambique	54.6	54.6			54.6	54.6		
Namibia	43.67	43.67	49.77	49.77	119.07			

	Post-paid				Prepaid			
	< 7.2 Mbps	7.2 Mbps	7.2 to 21.6 Mbps	> 21.6 Mbps	< 7.2 Mbps	7.2 Mbps	7.2 to 21.6 Mbps	> 21.6 Mbps
Nigeria	51.84	51.84	52.9		48.66	48.66	49.19	
Rwanda					25.88			
South Africa	26.35	26.35	28.13	32.8	20.32	20.32	21.85	31.5
Tanzania	29.6	29.6	29.6		6.8	19.2	19.2	
Uganda	41.6	41.6	41.6	43	40.59	40.59	40.59	41.99

(Source: RIA ICT Access and Use Survey 2011/12)

Poor quality of service hampers growth of cloud-computing services

Quality of services considerations have increasingly become important for the delivery of cloud computing. As mentioned above, the infrastructural backbone in most African markets is limited, resulting in poor quality of service. A number of countries have started monitoring the quality of service especially in the mobile market following complaints by consumers. Further, a number of pilot studies have been conducted to measure the quality of service in the broadband sector. In order for effective and quality cloud-computing services, there is a need for a stable and reliable internet connection. Poor quality of service as a result of inadequate infrastructure is one of the deterrents to the adoption of cloud-computing services.

Broadband quality of service in Nigeria

The prevalent optic fibre cuts arising mainly from vandalism, with consequential loss of service, have degraded connectivity services and continue to pose a major challenge in Nigeria. The frequency and severity of fibre cuts is astounding and degrades the customer experience, which has a profound impact on cloud services. In response to the rampant vandalism the government has enacted legislation declaring the vandalism as an economic crime, with huge fines for culprits.

Broadband quality of service in South Africa

In a report released by Ookla, an international broadband testing company, South Africans are, on average, only getting 74% of the speeds they sign up for, which is lower than the global average of 85%. Ookla's (n.d.) Household Promise Index ranks South Africa number 55 out of 64 countries. The Ookla findings are supported by a broadband quality of service pilot study conducted in 2012 by RIA in South Africa in all nine provinces, which found that consumers in South Africa are not getting advertised speeds (Gillwald et al, 2012). The study also demonstrated that mobile 3G and LTE services out-perform fixed broadband. Using host-based measurements from MyBroadband, where measurements are taken (i.e. to a local or international server), mobile speeds are faster than fixed-line speeds. The median downstream throughputs of the LTE connections are the highest, at around 25 Mbps. The 3G connections also generally experience higher download throughput than the fixed-line service plans. The download speed of mobile broadband is far outperforming fixed-line broadband speed in South Africa (Gillwald et al, 2012).

Limited power supply hinders growth cloud-computing market

Power supply remains a significant challenge in Africa due to the lack of infrastructure. This acts as a hindrance to the deployment of ubiquitous cloud-computing solutions. Industries like financial services or the oil and gas industries cannot afford to have any down time and companies in countries with limited power supply are forced to rely on alternative power resources, significantly increasing running costs.

In Figure 3 below, in Ethiopia only 18% of households were connected to a main electricity grid in 2012. In Nigeria, only 58% of households had access to a main electricity grid. Despite the increase in internet access, the network remains unreliable as power outages are common (Odufuwa, 2013). In addition, the national power grid supply is sub-optimal, as it generates only 10% of an estimated demand of 40,000MW. Businesses have to make use of alternative power sources, including generators, solar panels and batteries. It is common for large corporations in Nigeria, able to afford dedicated data centres and links, to have three levels of electricity supply for every network resource. This is not the case for smaller companies with limited resources (Odufuwa, 2013).

In 2012, only 60% of households in Kenya were connected to the main power grid. The lack of reliable power and quality of connectivity remains a major concern towards the deployment of cloud-computing services.

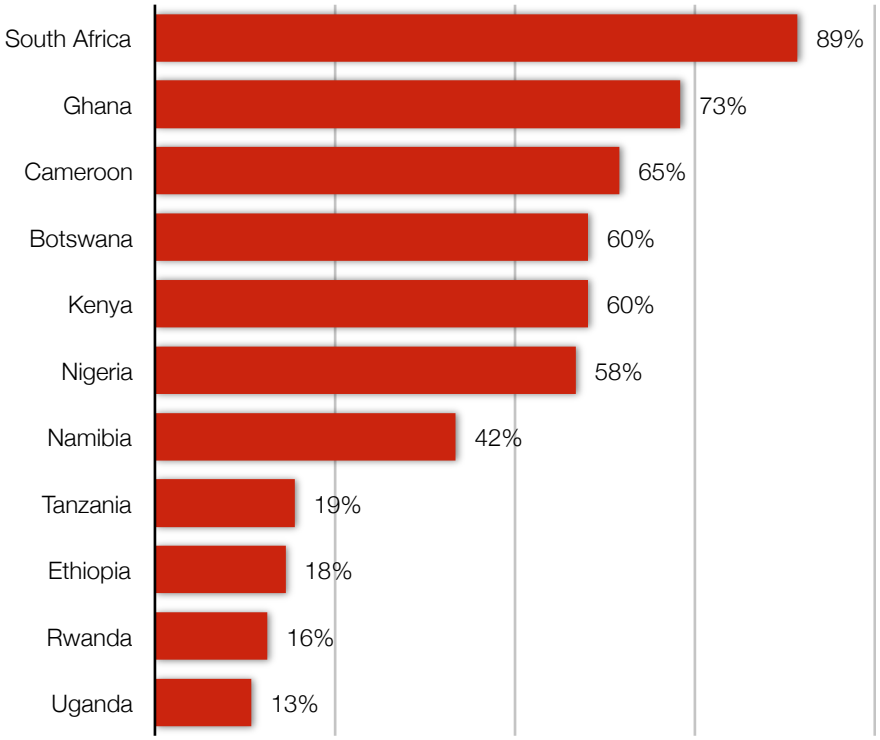

Figure 3: Number of household connected to a main power grid

The absence of data protection and security legislation

Concerns around data protection, security and privacy remain a major hurdle to the adoption of cloud systems in place. In most cases, legislation addressing these pertinent issues is absent. Although cloud computing falls within the wider ICT ecosystem, there is no mention of issues that relate to cloud computing.

Absence of data protection in Ethiopia

The government of Ethiopia has adopted e-transaction and e-commerce laws in line with international standards. In addition, Ethiopia adopted digital signature law and data protection law (Adam, 2013). Controversially, Ethiopia has also imported very comprehensive data surveillance equipment that will enable filtering of what is considered “undesirable content” (Human Rights Watch, 2014).

Absence of data protection in Ghana

Although the Ghanaian telecommunications market is competitive, the National Telecommunications Policy only provides a general framework. Further, a national broadband policy framework is yet to be finalised, with a focus on creating a competitive and favourable market for investment, especially in last-mile connectivity. In addition, there is no legislation around security, privacy, anonymity and government surveillance that pertains to cloud computing (Frempong, 2013). Even though some cloud-computing companies have put up firewalls to prevent the theft of data, the absence of appropriate legislation is a key challenge in Ghana (Frempong, 2013).

Absence of data protection in Nigeria

At present there is no framework governing e-commerce within Nigeria. While a number of laws are undergoing reform, these are still pending at the national assembly, including the Cyber Security and Protection Bill, Electronic Transactions Bill, National Internal Security Bill, Security Communications Interception and Monitoring Bill, Critical Infrastructure Protection Bill, Computer Security and Protection Bill, Electric Commerce (Provision of Legal Recognition) Bill, Electronic Fraud (Prohibition) Bill, and Cyber Security and Data Protection Agency (Establishment) Bill of 2008 (Odufuwa, 2013). There are no data protection and privacy laws in Nigeria, and therefore no criminal sanctions or civil damages available when user rights are breached. Nigeria is reported to have the third highest percentage of perpetrators of cybercrime in the world, at 5.7%. Inadequate levels of data security would thus appear to be a major limitation to the adoption and penetration of the cloud in Nigeria (Odufuwa, 2013).

Absence of data protection in Kenya

In Kenya there is no data protection legislative framework. The government of Kenya has drafted a bill on data protection and is waiting for the bill to be deliberated in parliament (Mureithi, 2013). Given the above, potential cloud users have voiced concerns over control and location of data.

Absence of data protection in Tunisia

Although the Tunisian telecommunications sector has undergone reform, no data protection and security legislation has been enacted.

Absence of data protection in South Africa

At present, the Electronic Communications and Transactions Act (2002) has limited privacy protections for information collected electronically (Business Software Alliance, 2012).The Act is currently being reviewed. Further, in November 2013, following a long period of consultation and much controversy, the Protection of Public Information (POPI) Act was passed in order to bring South Africa's data protection frameworks in line with international standards. It has yet to become operational. There is some concern that this act has not yet provided clarity with regards to the protection of information in the cloud. This has been a major constraint in attracting investors to South Africa (Microsoft South Africa, Interviewed 29 June 2012). Once the POPI Act comes into force, it is expected to affect the way companies collect, process, and transmit personal information. The Act stipulates that information cannot be collected from individuals (natural or juristic) without their consent and agreement on reasons for collection. Organisations such as banks, retailers or any other entity that determines the need to collect particular information are responsible for ensuring compliance. The Act further includes restrictions on transmitting, storing, or processing personal information outside South Africa, unless the destination country has the same levels of regulatory protection in place. Also, the Act requires service providers to proactively inform affected parties in the case of security or privacy breaches that could potentially impact on their reputations. The Act has implications for consumer-focused sectors, including telecoms, healthcare, retail and financial sectors. It also impacts on cloud services. Companies need to ensure that internal IT

staff members are knowledgeable of the legislation, in order to ensure compliance. The legal implications of the Act are that companies are more likely to find it risky to move data outside South Africa due to the more stringent privacy laws. In addition, it is likely to limit the places in which a company can do business cost effectively, as companies will be reluctant to be liable for any breaches of a customer's privacy. It is argued that local companies are not able to offer the same economies of scale offered by companies that provide cloud services on a global scale (Pamoja, interviewed17 July 2012).

Security and piracy

A study by the Business Software Alliance South Africa (2012) raises issues relating to software licence abuse and piracy through the cloud. According to this study, about 42% of businesses that use paid cloud services around the world share their log-in credentials within their organisations, while 45% in emerging economies and only 30% in mature markets share their credentials internally. Even though some licences allow sharing of accounts, cloud service providers do not charge by the seat but by the amount of computing resources consumed. About 56% businesses that use cloud services believe that sharing log-in credentials is software piracy.

Cost associated with migration limits adoption of cloud computing

The cost of migration to cloud architecture is a limiting factor, especially when a corporate has invested heavy amounts in legacy networks. This is a major concern for risk-averse sectors, such as financial services, that perceive the cost of loss of management and ownership of data to be too great a risk. For example, in Ghana one of the main perceived risks of migration to cloud computing was the cost of migration. This cost can be mitigated if the migration is gradual and the benefits of moving to the cloud can be proven. Other challenges involve the risk of vendor lock-in and the costs involved in changing from one cloud provider to another (Frempong, 2013).

Shortages in skilled personnel

Most African countries lack a large pool of resources with the skill set to design, manage and implement advanced high-technology cloud-computing solutions, particularly in the area of virtualisation, data centre design, security and advanced distributed networking (Adam, 2013; Frempong, 2013). African governments are challenged to build a pool of highly skilled personnel, in order to have local expertise to manage new high-technologies.

Conclusions

Cloud computing in Africa is in the early growth stages. The cloud-computing market in Africa is dominated by global US-based companies, although some local IT companies are competing within this space and local telecommunications companies leverage existing infrastructure to provide cloud-computing services. Cloud computing falls within the broader ICT ecosystem and its adoption is inhibited by the same institutional and regulatory challenges that have historically faced new services since the opening up of the telecommunications sector two decades ago. While much progress has been made in all countries in increasing international bandwidth capacity through a number of submarine projects, terrestrial broadband backbone infrastructure and last-mile connectivity remains limited. Incumbent operators retain dominance over fixed-line markets and control essential facilities. The slowness in progress within the fixed-line markets is a result of policy and regulatory failure to open up the market to competition and effectively regulate access to essential facilities, including backbone networks and last-mile connectivity.

Most countries have had to rely on ADSL connections and mobile broadband networks have been extensively deployed. In addition, with the widespread adoption of mobile phones, this is fast becoming the primary method of accessing the internet. In most selected countries, the market has witnessed a rise in state interests in the development of national broadband backbone connectivity in response to what is deemed "market failure"

when the regulatory conditions that encourage private investment in broadband networks are absent.

The public sector and the SME sector are believed to stand to benefit the most from cloud-computing services. In most of the selected African countries the promotion of cloud computing is supply driven by the state as the means of delivering its e-government initiatives. To this end, governments are investing in data centres in order to deliver public cloud services. South Africa, on the other hand, is an exceptional case whereby the corporate sector demand is driving the growth of cloud-computing services. The private sector has started transitioning into making use of private clouds, but in the long term South African companies will be forced to move onto public clouds, in order to take advantage of economies of scale and streamline costs.

Similarly in Kenya, there is growing adoption of cloud-computing services within the corporate market. While the use of cloud-services in the SME sector has been limited, the informal sector, which constitutes a large share of African markets and provides livelihoods for the poor and unemployed, is a potential target area for government public cloud services over the mobile phone. This would promote development and in turn encourage economic growth and development.

Other commonalities in the challenges of the adoption of cloud-computing services relate to: the absence of legislation on data privacy and security, especially public cloud services; power shortages; and concerns over cost of migration, due to significant investments made in legacy systems.

It is important for data and security legislation to meet international standards. However, some legislation may hinder trust building in cloud-computing services, as it allows government to access personal data in matters regarded to involve “national security”. As a result, some countries are concerned about locating data outside of their national borders.

Recommendations

While there are commonalities across the market, each market has its own unique challenges, and the recommendations are, therefore, country specific.

Recommendations for Ethiopia

Ethiopia trails other countries in many respects. The telecommunications sector has not been liberalised and its broadband backbone infrastructure remains limited and of poor quality. The slow progress in this sector is due to the monopoly market stricture. In order to facilitate market growth and create a market conducive for the delivery of cloud-computing services, there is need for a policy and legal framework that promotes market entry, competition and investment, especially in broadband backbone networks that are critical for cloud-computing services. Further, the targeted investment in the national power grid is important to boost the power supply, which is currently at 18%.

Recommendations for Ghana

In Ghana, in order to facilitate the growth of the cloud services market, there is need to finalise the national broadband policy and promote competition and investment in broadband backbone connectivity and last-mile connectivity. Finally, there is need to improve awareness of the benefits of cloud-computing services and enact data and security legislation.

Recommendations for Nigeria

In order for there to be widespread adoption of cloud computing in Nigeria, there is a need to address challenges related to power and terrestrial broadband backbone infrastructure, legislation and security. The government of Nigeria has already taken steps to establish a framework for electronic commerce and cyber security, although there is still some work to be done in order to complete the legislative processes.

Recommendations for Kenya

Kenya has taken steps to develop legislation on security and privacy of data, and, once the Bill has been passed cloud providers will have a framework within which to handle personal data. Another concern that needs to be addressed relates to the location of servers. There is also a need to build up trust regarding cloud computing, but this is dependent on the national laws of other countries. Further, there is a need for investment in terrestrial broadband backbone networks, in order to improve the quality and cost of bandwidth. With regards to the broadband connectivity and rampant cable vandalism that has impacted on the quality of service, the government has taken steps against perpetrators and enacted legislation that declares vandalism as an economic crime with huge fines for those who break the law.

Recommendations for South Africa

In South Africa the growth of fibre backbone infrastructure and affordability of services will go a long way towards driving growth of cloud-computing services. Regulatory challenges around wholesale access to essential facilities need to be addressed. The government could promote the growth of cloud services and innovation by utilising them in the area of education or for the delivery of e-government services. Addressing the policy gaps regarding protection of private information, as well as data and cyber security, will contribute towards building trust in cloud services. This will also open up the country to offshore markets and thereby drive economic growth and competitiveness.

The review of the ICT infrastructural legal and regulatory framework has created favourable conditions for the deployment of cloud-computing services. The broadband network continues to expand and advances are being made through the digital Tunisia project. In order to build trust in cloud computing, there is a need to enact data and security legislation that protects personal data.

Lastly, in all the above countries, there is a need to build local skills and knowledge in high-technology, including cloud computing.

References

Adam, L. (2013). Cloud computing for developing countries with limited Information Communication penetration (unpublished).

Business Software Alliance South Africa. (2012). “Shadow Market” 2011 BSA Global Software Priracy Study. 9th edition. Accessed at https://www.arxan.com/wp-content/uploads/assets1/pdf/2011_BSA_Piracy_Study-Standard.pdf.

Calandro, E. and Moyo, M. (2012). Investment models and regulatory constraints for broadband backbone rollout in selected African countries. In *Special Issue: Connectivity and convergence: the uneven story of Africa.* Emerald Publication.

Deen-Swarray, M., Moyo, M. and Stork, C. (2013). ICT access and usage among Informal Businesses in Africa; Info, Vol. 15 Iss: 5; 2013.

Esselaar, S., Stork, C., Ndiwalana, A., and Deen-Swarray, M. (2007). “ICT usage and impact on profitability of SMEs in 13 African countries”, *Information Technologies and International Development* 4(1): 87–100.

Frempong, G. (2013). Cloud economy outlook in Ghana (Unpublished).

Gadget (2013). Seacom trebles capacity. available at: www. gadget.co.za/pebble.asp?relid=6081 (accessed May 2013

Gillwald, A (2012). Review of the Department of Communication's Colloquium on an Integrated National ICT policy, available at http://www.researchictafrica.net/docs/ICT_colloquium_SA.pdf.

Gillwald, A., Moyo, M. and Altman, M. (2012). Cloud computing in South Africa: Prospects and Challenges. In Cowey, P. and Kleeman, M. (2012) Special Report on Cloud Computing and Broadband in Emerging Markets, prepared for ITU (currently unpublished).

Gillwald, A. Moyo, M. and Stork, C. (2012b). Understanding what is happening in ICT in South Africa –A supply- and demand-side analysis of the ICT sector. http://www.researchictafrica.net/publications/Evidence_for_ICT_Policy_Action/Policy_Paper_7_-_Understanding_what_is_happening_in_ICT_in_South_Africa.pdf

Human Rights Watch (2014). Ethiopia: Telecom Surveillance Chills Rights , available at http://www.hrw.org/news/2014/03/25/ethiopia-telecom-surveillance-chills-rights.

Kamoun, F. and Chaabouni, J. (2013). Case study of the cloud economy in Tunisia (unpublished).

Kaplan, J. (2005). Roadmap for open ICT Ecosystems, Berkman Center, Harvard Law. Accessed October 2012, at http://cyber.law.harvard.edu/epolicy/roadmap.pdf .

Kim, Y., Kelly, T., and Raja, S. (2010). Building broadband: Strategies and policies for the developing world. The World Bank.

Kushida, K. E., Murray, J. and Zysman, J. (2012). *The Gathering Storm: Analyzing the Cloud Computing Ecosystem and Implications for Public Policy In Communications & Strategies.* No 85, 1st quarter 2012.

NIST US National Institute of Science and Technology, NIST (2011)

ITU (2012). Focus group on cloud computing technical report part 1: Introduction to the cloud ecosystem: definitions, taxonomies, use cases and high-level requirements. ITU. Geneva.

Mureithi, M. (2013), Kenya cloud economy: The state of play of a nascent market (unpublished).

Odufuwa, F. (2013), Nigerian cloud report (unpublished).

Ookla (n.d.), "Household promise index", available at: www.netindex.com/promise/ (accessed 6 August 2013)

West Africa Cable System (WACS) 2013. http://wacscable.com/index.jsp