



GLOBAL DIFFUSION OF THE INTERNET: THE INTERNET IN RWANDA

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ABSTRACT: The article uses the Global Diffusion of the Internet (GDI) framework to examine Internet diffusion in Rwanda along six dimensions: pervasiveness, geographical dispersion, sectoral absorption, connectivity infrastructure, organisational infrastructure, and sophistication of use. Internet access was launched in 1996, but it was only in 2004 that significant Internet penetration occurred, when the privatisation of Rwandatel to Terracom brought in new investments and technology and the ISP market was opened to competition. Access to the Internet grew to approximately 24% of the population in 2012 or 2.7 million subscribers. Internet growth is hampered by factors which include poor resource mobilisation, unrealistic implementation plans, shortage of qualified human resources, a miniscule private sector, low level of private sector involvement and low Internet usage awareness. Despite these challenges, Rwanda has attained Level 4 (pervasive) for pervasiveness, Level 3 (broad) for connectivity infrastructure, Level 2 (controlled) for organisational infrastructure, Level 3 (highly dispersed) for geographic dispersion, Level 3 (common) for sectoral absorption and Level 3 (transforming) for sophistication of use. This limited progress is due partly to the policy focus on addressing Internet access (Vision 2020), and financial support from multilateral and bilateral agencies. Further policy and regulatory action and heightened awareness of the Internet are required to translate the statistics for GDI into greater access.

KEYWORDS

Internet diffusion; GDI framework; ISPs; Rwanda

INTRODUCTION

In the early 1990s, when a transition was occurring in knowledge-based economies, Rwanda was engaged in a civil war that culminated in the 1994 genocide. These events impoverished the population and destroyed the country's fragile economic base. In 1996, the government of Rwanda (GoR) restored socio-political order and re-connected the country to the world through various means, including the Internet. Subsequently, the GoR embarked on political reforms to foster national reconciliation and citizen empowerment in political and development participation. However, political and media freedoms remain restricted (AfDB, OECD, UNDP & ECA, 2012).

The Internet was launched by the state-owned national telecommunications operator Rwandatel, with foreign aid. For many years, Rwandatel held a monopoly in the provision of Internet services, but opened up to limited competition with academic institutions and finally to open competition with private sector ISPs in 2004. International bandwidth and telecommunication charges were reduced and the first e-government project started in 2006. After nearly a decade of competition, about 24% of the population of 11.6 million have Internet access (Rwanda Ministry of Youth and ICT, 2012). Ngwenyama and Morawczynski (2009) assert that the level of ICT development impacts positively on the economic growth of a country. They view ICT as an enabling infrastructure to attract investors. The GoR recognised the importance of the Internet as a potential development enabler and incorporated it in its national strategic plan for development, (Ministry of Finance and Economic Planning, 2000). However, Internet growth appears to be hindered by a number of factors, including poor resource mobilisation, unrealistic implementation plans, shortage of qualified and experienced human resources, a miniscule private sector, low levels of private sector involvement, weak regulation of telecoms firms and low Internet usage awareness.

The purpose of this article is to examine the state of Internet diffusion in Rwanda and frame innovative ideas for measures to improve diffusion. An understanding of the determinants of the current Internet penetration in Rwanda will be useful to researchers wishing to conduct other national studies, by providing insights into the enabling factors and limitations that shape the state of the Internet in a particular country. The findings and measures will be beneficial to national governments and other stakeholders in efforts to increase Internet penetration. The article provides a background on the socio-economic context of the country, Vision 2020 and the telecoms sector. It presents the methodology used, the findings on the GDI dimensions, challenges and enabling factors.

SOCIO-ECONOMIC AND POLICY CONTEXT

The economy of Rwanda is characterised by its dependency on international donors in almost every sector. Rwanda's gross domestic product (GDP) was USD13.7 billion in 2012, per capita income was USD644, the annual growth rate was 8.8%, inflation was 5.7%, while public debt was 23.4% of GDP (Government of Rwanda, 2013; The Heritage Foundation, 2013). Rwanda has 123 000 small and medium enterprises (SMEs) which represent 98% of all businesses; 88% of these are informal businesses and therefore contribute only two percent of tax revenue. Most of the workforce (90.8%) is employed in the private sector (AfDB et al, 2012). Rwanda's challenges include low economic growth, limited natural resources, energy shortages, high population growth rate (2.75%), a high percentage of the population living below the poverty line (60%), heavy reliance on subsistence agriculture (90%), poor transportation linkage to other countries, and very limited investor interest.

As stated by Guerrieri, Luciana and Meliciani (2011) the decision to invest in ICT is highly dependent on the general business environment of the country. Due to reforms, Rwanda claimed to be the ninth easiest place to start a business and the sixth most competitive economy in Africa (Government of Rwanda, 2005), although these are moving indicators. In the past decade, Rwanda has improved its regulatory environment for business and is ranked the lead reformer in East Africa, third in sub-Saharan African and 45th in the World (AfDB et al, 2012). A special economic zone (SEZ) expected to attract sectoral investment, including ICT, was opened in the capital Kigali in 2012 (Rwirahira, 2012). According to Vision 2020, Rwanda is vying to become an African technology hub (Baldauf, 2007), hence government has implemented deliberate efforts to improve science and technology education and ICT skills, advance telecommunications infrastructure and promote high Internet access to facilitate this goal. Plans include Internet access at all administrative levels, all secondary schools and many primary schools, Internet services in rural areas and improved e-government.

Vision 2020 is a framework for the country's long-term development, indicating six priorities and three cross-cutting areas. Alongside the priorities of building a capable state, a knowledge-based economy, infrastructure development and regional economic integration, science technology and ICT form a cross-cutting focus. ICT policy was incorporated in the policy known as the National Information and Communication Infrastructure (NICI) Plans, part of Vision 2020. There were four successive NICI Plans: NICI I (2001-2005) placed priority on creating an enabling environment through establishing a legal and regulatory framework and liberalising the telecommunications market. NICI II (2006-2010) aimed at developing an enabling backbone infrastructure. This ushered in the introduction of the national fibre-optic backbone, community telecentres, the National Data Centre, the ICT Park and the Rwanda Communication Infrastructure Project (Rwanda Ministry of Youth and ICT, 2012). The NICI III Plan (2011-2015) focuses on services sector development, cyber security, private sector development, e-government, skills development and community development (Mayton, 2012). NICI IV (2016-2020) will focus on transformation to a knowledge-based economy by absorbing ICT into various social and economic sectors (Government of Rwanda, 2010). The NICI plans increased Internet access and service by improving ICT infrastructure, developing e-government and extending service to rural communities (Government of Rwanda, 2010).

ELECTRONIC COMMUNICATIONS NETWORKS IN RWANDA

Rwanda's telecommunications network dates back to 1930. Rwandatel was founded by government in 1993 to manage the telecommunications network and was the only telco licensed to operate in the country. Most of the telecommunications infrastructure was destroyed during the civil war, but was later rehabilitated and expanded. In 1996, Rwandatel launched Internet service and became the only ISP until 2004, when government privatised the fixed-line operator and liberalised the telecommunication sector. Internet penetration grew at a slow rate due to the monopoly of Rwandatel and dial-up access, while low disposable income of most of the population was an impediment to household computer ownership (Nsengiyumva & Stork, 2005). In 1999, the Kigali Institute of Science and Technology (KIST) and the National University of Rwanda (NUR) were awarded open licences to provide unlimited Internet services to their faculty, staff and students. The USAID Leland Initiative was instrumental in the initial introduction of the Internet, as well as in opening the market to the academic and research sectors.

In January 2002, the Rwanda Information Technology Authority (RITA) was established to facilitate national and sectoral ICT strategies and in 2003, the Rwanda Utilities Regulatory Agency (RURA) was established with authority over several market sectors including energy, transportation, communications and waste management. From a policy perspective, the founding of RITA and RURA was significant, because this led to the liberalisation of the telco sector. In July 2004, the Rwanda Internet Exchange Point (RINEX) was commissioned. The IXP plays a crucial role in Internet access and penetration as it enables ISPs to communicate directly and move traffic between them. According to Nsengiyumva and Stork (2005) “RINEX allows ISPs in Rwanda to exchange domestic Internet traffic without having to send data across multiple international hops”. The total cost to Africa of using international bandwidth for national or regional data transfer has been estimated in the order of USD400 million each year (Brian & Rulinda, 2005). Notwithstanding this, Africa has had the fastest growth of Internet diffusion in the world (2 450%) with Rwanda having a growth rate of 8 900% between 2008 and 2010 (Government of Rwanda, 2010), illustrating demand against a very low initial subscriber base. IXPs lower the costs, decrease the latency and improve the quality of Internet services (Kende & Hurpy, 2012).

Rwanda is served by three submarine cable systems, SEACOM, the East African Cable System (EASSy) and The East African Marine System (TEAMS), bringing broadband services to towns such as Kigali, Butare, Huye, Rubavu, Rusizi, Musanze, Muhanga and Rwamagana, among others. As a result of high speed Internet via these cable systems, Rwanda was ranked fourth in Africa in March 2012 and 103rd globally, with an average download speed of 3.03Mbps (Kanyesigye, 2012). In 2011, the roll out of fibre optic cable covering 2 560km in all 30 districts of Rwanda was completed, marking an end to the first phase of the “National Backbone” ICT project (Buhura, 2011).

INTERNET MARKET STRUCTURE

Rwanda has had nine licensed ISPs, of which seven are operational. Table 1 shows the players:

TABLE 1: ISPS IN RWANDA, SEPTEMBER 2012

ISPs	Year licensed	Status	Company profile
New Artel	2004	Operational	Owned by GoR and targets the remote areas market, using a VSAT system to provide voice and Internet access.
MTN Rwandacell	2006	Operational	A South African company (partly owned by the Rwandan government). The first cellular provider operating a GSM mobile network (Iumanaho, 2012a).
ISPA	2006	Operational	ISPA provides Internet connectivity and IP solutions to corporate, small/medium businesses and home users.
Altech Stream Rwanda (ASR)	2007	Operational	The South African-owned telco is an application service provider (ASP) that offers IP-based solutions and related value-added services.
Rwandatel S.A.	2008	Non-operational	Declared bankrupt and assets sold to Airtel and Tigo in 2012.
Tigo Rwanda S.A.	2009	Operational	87.5% owned by Millicom International Cellular S.A.
4G Network Rwanda	2009	Non-operational	Established to offer 4G wireless broadband Internet services to companies and households in Kigali; part of the Afrimax Group with ISP operations in other African countries.
Broadband Systems Corporation (BSC) Rwanda	2010	Operational	Rwandan IT company providing advanced technology in fibre optics and data storage Internet solutions, launched on 1 June 2012.
Airtel Rwanda Ltd	2011	Operational	Owned by Indian company Bharti, the world's fifth biggest telco; planned investment of more than USD100 million over three years.

Source: RURA, June 2011

Over the two decades from 1993 to 2013, the fixed telecoms market saw the incumbent operator Rwandatel S.A. sold to Terracom in 2005. Terracom deployed fiber optic cable around the country to bring Internet and broadband services to more than 150 locations; however, due to failure to achieve licence obligations and failure to provide information, government reacquired Rwandatel in 2006 (Rwanda News Agency, n.d.) and sold it to LAP Green of Libya.¹ In 2008 Rwandatel ventured into the mobile market and was the first to introduce 3G networks. The company's mobile licence was rescinded by RURA on 5 April 2011 due to poor coverage, poor quality service and failure to make the planned investment targets. It continued to provide fixed telephony and Internet access (TeleGeography, 2011). Following UN sanctions on LAP Green, Rwandatel went bankrupt and its assets were sold to Airtel in May 2012 (Kanuma, 2012; Kwibuka, 2013), therefore the main operator today is MTN Rwandacell (RURA, 2012).

Rwanda has three mobile operators, namely MTN Rwandacell, Tigo (Rwanda) S.A. – Millicom and Bharti Airtel (RURA, 2012). According to RURA statistics, as at September 2012 MTN Rwandacell had the greater mobile subscriber market share (60.3%), followed by Tigo (32.8%) and Airtel Rwanda (6.9%) of the total subscriber base of 5 690 751 out of a total population of 11.6 million (Rwanda Ministry of Youth and ICT, 2012). In terms

1 LAP Green was a Libyan-owned company that fell under UN sanctions. Rwanda imposed a freeze on all LAP Green investments including Rwandatel (Rwanda News Agency, 2011).

of geographic and population coverage, MTN Rwandacell had 98.12% and 98.01% respectively, Tigo 78.95% and 98.83% respectively, and Airtel Rwanda 6% and 15% respectively. These figures account for subscribers who have more than one SIM-card (RURA, 2012).

VALUE OF THE GDI METHODOLOGY

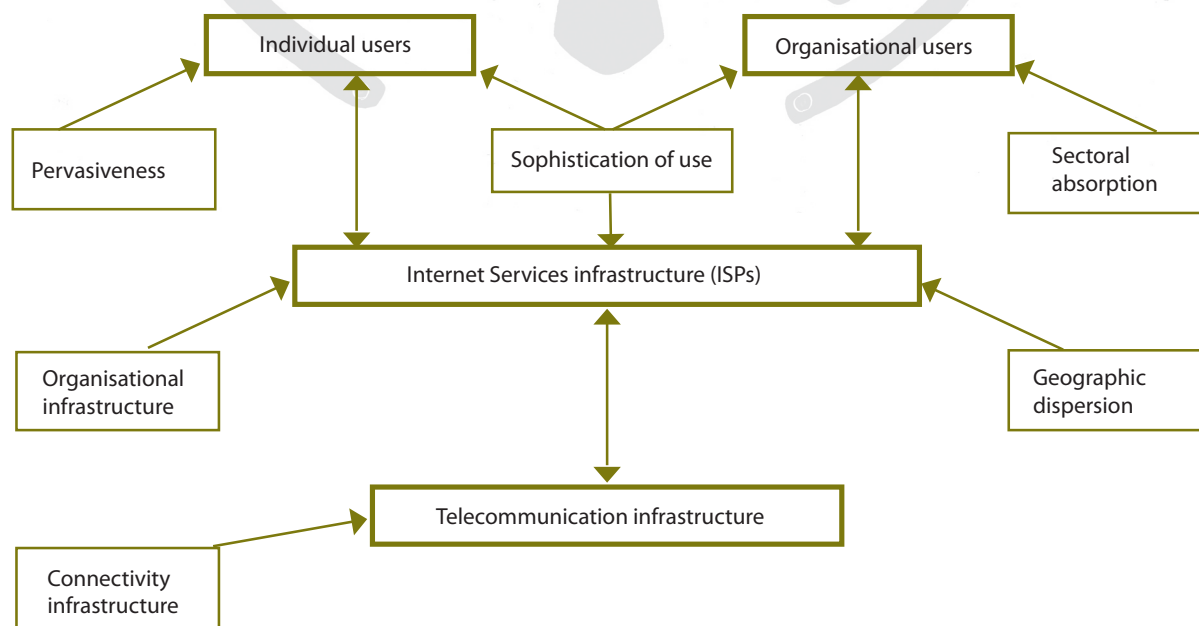
The researchers employed a qualitative research design using the Global Diffusion of the Internet (GDI) framework, a methodology described by Wolcott, Press, McHenry, Goodman and Foster (2001), to assess Internet diffusion in Rwanda. According to Lee (as cited in Muganda & Bankole, 2012), the qualitative approach allows examination of the rich organisational and political processes whereby a given set of information technology is instantiated and does not confine the analysis of data to any predetermined variables. The GDI methodology was selected because of the intricacies of the multifaceted telecommunications infrastructure development that takes place over a lengthy period of time, as is the case in Rwanda where the infrastructure has been progressively built since 1994. The framework is suitable for making country-wide assessments of the Internet as a collection of technologies (Wolcott et al, 2001) as was the case in this study.

Ojuloge and Awoleye (2012) developed a system of equations to explain the variability in the diffusion and adoption of the Internet technology, using Internet User (IU), as a function of Internet Host (IH), Telephone Density (TD), Investment in Telecommunication Infrastructure (ITI) and Gross Domestic Product per capita (GDP). Kolko, Wel and Spyridakls (2003) used the Internet point survey, an instrument used to assess the state of Internet technology and its accessibility. Menkova (2004) used the number of Internet hosts per capita and the number of Internet users per capita to determine the diffusion of Internet in 72 countries. However, these methods do not indicate the various dimensions of Internet diffusion that the Wolcott framework helps to elucidate.

The GDI framework has been used in over 40 studies around the world, but has never before been applied to Rwanda. The framework examines Internet diffusion along six dimensions: pervasiveness, geographical dispersion, sectoral absorption, connectivity infrastructure, organisational infrastructure, and sophistication of use, presenting a rich and multifaceted view of the diffusion. These can broadly be categorised into two general facets: (i) the extent to which the Internet is used (connectivity, organisational infrastructure and sophistication of use) and (ii) range of usage (geographic dispersion, pervasiveness and sectoral absorption) (Akpan-Obong, Thomas, Samake & Mbarika, 2009).

For the reasons given above, the methodology was considered as the most suitable to apply to Rwanda. However, the framework criteria used to investigate the various dimensions proved very demanding in terms of collecting data on the current Internet structure. It often does not suffice to use only aggregated country-level analysis (Ruth & Choudhury, n.d.), which may give a skewed picture for those parts of Rwanda that experience a significant digital divide. Despite this, the authors conclude that the most detailed and tested aggregate approach to examining Internet diffusion in developing nations is the GDI framework. Figure 1 below presents the GDI framework of Wolcott et al (2001) showing the dimensions and the multiple facets that are to be considered.

FIGURE 1: CONSTITUENTS OF THE INTERNET TECHNOLOGY CLUSTER



Source: Wolcott et al (2001)

Data was elicited mainly from government agencies, policy documents, other studies, press reports, newspaper articles and Internet-based sources. Only secondary data was used because of the guarded nature of the GoR, making it very difficult for the respondents we contacted to freely give primary data. The data was analysed according to the dimensions of the framework and the results presented using a Kiviati diagram, a graphical method of displaying multivariate data in the form of a two-dimensional chart of three or more quantitative variables represented on axes starting from the same point.

GDI STUDIES IN OTHER DEVELOPING COUNTRIES

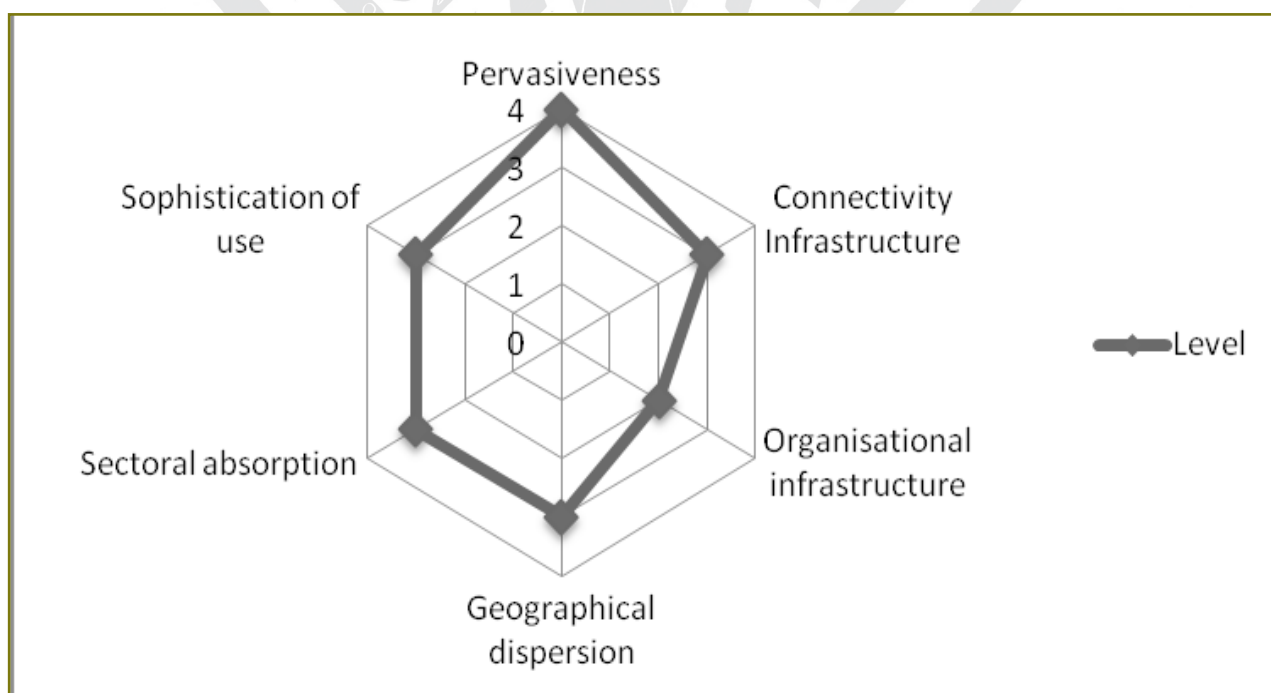
Beilock and Dimitrova (2003) adopted the framework to study the diffusion of the Internet in 105 countries. Internet diffusion has been studied in African countries, including Kenya, Uganda, Nigeria, Cameroon, and South Africa, using the GDI framework and associated methodology. The GDI studies have helped map the growth of the Internet in these countries and their policy recommendations have been factored into this article. The diffusion of the Internet in Kenya was reviewed by Muganda, Van Belle and Brown (2008) and the results indicated that less than 10% of the mostly urban population has access to the Internet. It showed that there was potential for further diffusion in sectors such as commerce, education, health and the public service. The study of Internet diffusion in the south (Brown, Collins, Maleka, Morrison, Muganda & Speight, 2007) found a relatively sophisticated ICT infrastructure, but limited Internet access for around 10% of the population. The potential for further development of the Internet in the education, health and commercial sectors and in the public service was noted. A study conducted by Muganda and Bankole (2012) found a significant role played by the government of Nigeria in encouraging the Internet as a means to contribute to the economic revival of Nigeria. The authors point out, however, that the government of Nigeria has been ineffective in its role as strategist, builder and integrator.

The role of government as a regulator, leader, builder and investor in development of national information infrastructure has been explicated (Muganda & Bankole, 2012; Muganda et al, 2008) and this research needs to be used to ensure growth of both ICT and the Internet. Wide geographical spread and development of Internet infrastructure alone does not guarantee faster diffusion (Brown et al, 2007).

FINDINGS: SIX DIMENSIONS OF INTERNET DIFFUSION

The results are presented using a Kiviati graph to show the levels reached by Rwanda for the various dimensions of the GDI framework. According to the results in Figure 2 below, Rwanda has attained Level 4 (pervasive) for pervasiveness, Level 3 (broad) for connectivity infrastructure, Level 2 (controlled) for organisational infrastructure, Level 3 (highly dispersed) for geographical dispersion, Level 3 (common) for sectoral absorption and Level 3 (transforming) for sophistication of use, with respect to Internet access and services. More detailed presentation and analysis of the dimensions are found in the discussion that follows.

FIGURE 2: KIVIATI GRAPH SHOWING THE GDI DIMENSIONS



DIMENSION 1: PERVASIVENESS

The pervasiveness measure is based on users per capita and the degree to which non-technicians are using the Internet (Muganda, Van Belle & Brown, 2008). In 2000, the number of Internet subscribers was around 1 000 and in 2002, with only 25 000 users, Rwanda was ranked 160th in total number of Internet users. Table 3 presents key ICT indicators for various years from the period 2004-2012.

TABLE 2: ICT INDICATORS, VARIOUS YEARS, 2004-2012

Year	2004	2005	2008	2009	2010	2011	2012
Telephone lines	22 972	23 903	16 852	33 451	39 664	38 901	Not available
Teledensity	0.27(1.6%)	0.30	14%	24.8%	34.38%	36.4%	Not available
Mobile subscribers	143 113	222 978	1 322 637	2 429 252	3 548 761	4 446 194	5 690 751
Telecommunications revenue (USDmillions)	57.5	57.8	Not available	Not available	Not available	82.4	134.5
Satellite dishes/antennas (VSAT)	452	490	Not available	Not available	Not available	Not available	Not available
Internet Service Providers (ISPs) – operational	2	2	6	6	7	6	10
Internet subscribers	2 875	2 949	8 483	147 837	1 233 422	909 634	2 778 939
Percentage of population using Internet	0.43	0.56	4.5	7.7	13	8	24
Internet bandwidth	512Kbps	1024Kbps	267Mbps	774Mbps	1 643Mbps	2 156Mbps	5 879Mbps

Source: RURA, 2009; RURA, 2011; RURA 2012, Rwanda Ministry of Youth and ICT 2012

The chart indicates a significant growth in Internet subscribers between 2004 and 2012. There is a sharp increase from 2005 to 2010 with an 8.9% increase of Internet users between 2008 and 2010. A 2008 survey found that 86.5% of Internet users gain access at Internet cafes, and very low access exists at household level. In terms of frequency of Internet usage, 11% of Internet users accessed the Internet every day, 38% once a week, and 39% at least once a month (Gillwald & Stork, 2008). Rwanda continued to lag behind in Africa compared with Ghana, Kenya, Nigeria, Tunisia and South Africa (Calandro, Gillwald, Moyo & Stork, 2010). Mobile and Internet diffusion dropped in 2011, mainly as a consequence of RURA terminating Rwandatel's mobile license (The New Times, 2011a and 2011b) but rose sharply in 2012. This big leap can be attributed to the 75% decrease in Internet connection charges, due to the purchase of additional bandwidth from Uganda and Tanzania (Rwanda Ministry of Youth and ICT, 2012). Today, Rwanda's Internet penetration of 24% is higher than the average Internet penetration of 15.6% and Internet users of 7.0% in Africa (Internet World Stats, 2012).

Consequently, Rwanda has attained Level 4 (pervasive) with the ratio of Internet users per capita in the order of magnitude of at least one in ten (10% or greater). This conclusion may be crude, as one subscriber may have more than one user, for example a company employing 100 employees may be considered as one subscriber. A limitation of the data is that it is difficult to accurately obtain the number of Internet users because people access the Internet in different ways and many share Internet accounts (Wolcott et al, 2001).

TABLE 3: PERVASIVENESS OF THE INTERNET IN RWANDA

Level 0	Non-existent: The Internet does not exist in a viable form in this country. No computers with international IP connections are located within the country. There may be some Internet users in the country; however, they obtain a connection via an international telephone call to a foreign ISP.
Level 1	Embryonic: The ratio of users per capita is less than one in a thousand (less than 0.1%).
Level 2	Established: The ratio of Internet users per capita is at least one in a thousand (0.1% or greater).
Level 3	Common: The ratio of Internet users per capita is at least one in a hundred (1% or greater).
Level 4	Pervasive: The Internet is pervasive. The ratio of Internet users per capita is at least one in ten (10% or greater).

Source: Wolcott et al (2001)

DIMENSION 2: CONNECTIVITY INFRASTRUCTURE

The connectivity infrastructure dimension assesses the connectivity and access capacity of Internet infrastructure. It comprises the aggregate bandwidth of the domestic backbone(s) and of the international IP links, the number and type of interconnection exchanges, and the type and sophistication of local access methods being used (Wolcott et al, 2001).

(i) DOMESTIC BACKBONE FOR NARROWBAND AND BROADBAND COMMUNICATIONS

Internet infrastructure in Rwanda was initially deployed by Rwandatel. Following the implementation of the NICI-2005 plan, various companies were licensed to provide communication backbone network service including data, voice (fixed and mobile) and video services. Licences were awarded to MTN Rwandacell, Terracom Communications, Artel and the Rwandan Academic and Research Network (RAREN). In May 2011, the Rwanda Ministry of Youth and ICT announced plans to construct a countrywide broadband backbone infrastructure, interconnecting the 30 districts via fibre optic cable. The Kigali Metropolitan Network (which comprises 97 government sites, at least 227 sites for schools, hospitals, and police stations) was to be connected to the backbone. The roll-out conducted by EASSy covered 2 560km and was completed in the same year, marking an end to the first phase of the NICI 2015 National Backbone project (Buhura, 2011).

New Artel Communications installed a VSAT network covering 30 districts throughout the country, mostly in rural districts. By 2008, Artel had installed over 250 VSAT in rural areas (National Institute of Statistics of Rwanda, 2008). The RAREN project is ongoing and the NUR and KIST are interconnected by a 128Kbps link. They share local traffic through the RINEX. Furthermore, over 39 schools are interconnected via a broadband wireless network that is used for data and Internet traffic, including VoIP applications.

(ii) INTERNATIONAL LINKS

Rwanda has been actively cooperating with foreign carriers and telecommunication administrations such as the International Telecommunication Union (ITU), Akagera Basin, Intelsat, Belgacom, MCI (Vericon Communication), Telkom South Africa, Kenya Telecom, France Telecom and more recently, Tanzania Telecommunication Limited (TTCL) for connectivity. Four cross-border links between neighboring countries and the backbone network are implemented on cable and microwave. The system is currently used as a means of interaction between the East African member countries in management matters relating to international communication.

Rwanda has insufficient international bandwidth to promote broadband Internet access for the majority of companies and households. The landlocked nature of the country means that it relies on neighbouring countries for connectivity, thereby increasing connectivity costs. All international traffic to and from Rwanda travels via satellite. Table 5 below shows the distribution of the 5 879Mbps international bandwidth capacity among the operational ISPs.

TABLE 4: INTERNATIONAL LINKS, 2012

	MTN	Rwandatel	New Artel	Altech Stream	Tigo Rwanda	ISPA	BSC	Airtel Rwanda
Uplink	777Mbps	43Mbps		313Mbps	145Mbps	6Mbps	1 500Mbps	20Mbps
Downlink	777Mbps	148Mbps	155Mbps	322Mbps	145Mbps	8Mbps	1 500Mbps	20Mbps

Source: RURA, 2012

(iii) INTERNET EXCHANGES

The Rwanda Internet Exchange Point (RINEX) has enabled ISPs to conduct data transfer between local ISPs. RINEX has five members, namely Altech Stream Rwanda, Broadband Systems Corporation, MTN Rwandacell, New Artel and Rwandatel (Rugondihene, 2011). Rwanda has only one IXP, similar to Uganda and Kenya (Mulira, Kyeyune & Ndiwalana, 2010; Waema, Adeya & Ndung’u, 2010), while Tanzania has four (Materu-Behitsa & Diyamett, 2010).

(iv) ACCESS METHODS

From 1999, ISPs started to provide Internet access using VSAT systems. In 2004, Terracom launched wireless Internet access and by 2010 the country had approximately 40 operational broadband VSAT companies. Internet access is also available using 3G modems and at wireless hotspots. Rwanda has domestic backbone access speeds of about 300Mbps (Butera 2012a), international links of 1.244Gbps (Itumanaho, 2012b; Namata, 2012) with one internet exchange (RINEX) (RURA, 2012). Rwanda therefore falls under Level 3 (broad) connectivity infrastructure.

TABLE 5: CONNECTIVITY INFRASTRUCTURE OF THE INTERNET IN RWANDA

Levels	Domestic backbone	International links	Internet exchanges	Access methods
0: Non-existent	None	None	None	None
1: Thin	<= 2Mbps	<= 128Kbps	None	Modem
2: Expanded	> 2–200Mbps	> 128Kbps–45Mbps	1	Modem, 64Kbps leased lines
3: Broad	> 201Mbps–100Gbps	> 46Mbps–10 Gbps	More than 1; bilateral or open	Modem, 64Kbps leased lines
4: Extensive	> 100Gbps	> 10Gbps	Many; both bilateral and open	< 90% Modem, 64Kbps leased lines

DIMENSION 3: ORGANISATIONAL INFRASTRUCTURE

The organisational infrastructure dimension measures the strength of the Internet by assessing the level of competition and the existence of the organisations that support and promote the industry. This is on the assertion that the greater the competition, the more and better the services offered by ISPs and ASPs (Wolcott et al, 2001). Rwanda has made significant progress in opening up the telecommunications sector. Government sold 99% of its shares in the national telecommunications company Rwandatel to Terracom (Telecom Paper, 2005) and ushered in liberalisation in the sector. Rwandatel experienced competition from six mobile operators leading to mobile substitution effects.

Rwanda has seven operational ISPs (New Artel, ISPA, MTN Rwandacell, Altect Stream, Tigo Rwanda, Bharti Airtel and Value Data Rwanda) and one Internet Exchange point (RINEX) (RURA, 2011). The growing number of ISPs has led to improvement in services by lowering Internet costs and introducing new services such as mobile money transfer. However, a monopoly on international links still exists, with only one IXP (RINEX). The sector regulator, Rwanda Utilities Regulatory Association (RURA) plays a role in improving the quality of telecommunication services through the International Gateway Traffic Verification System (IGTVS), a system that allows the monitoring of the performance of the telecoms sector including traffic measurement, accurate billing, quality of service assessment, market surveillance, interconnection dispute resolution and fraud management. It is engaged in promoting efficiency and effectiveness and putting in place investment-friendly conditions and fair competition in the telco sector. Therefore Rwanda can be placed at Level 2 (controlled) for organisational structure.

TABLE 6: ORGANISATIONAL INFRASTRUCTURE OF THE INTERNET IN RWANDA

Level 0	None: Internet is not present in the country.
Level 1	Single: A single ISP has a monopoly in the Internet service provision market. The ISP is generally owned or significantly controlled by the government.
Level 2	Controlled: There are only a few ISPs and the market is closely controlled through high barriers to entry. All ISPs connect to the international Internet through a monopoly telecommunications service provider. The provision of domestic infrastructure is a monopoly.
Level 3	Competitive: The Internet market is competitive. There are many ISPs and low barriers to market entry. The provision of international links is a monopoly, but the provision of domestic infrastructure is open to competition and vice versa.
Level 4	Robust: There is a rich service provision infrastructure. There are many ISPs and low barriers to market entry. International links and domestic infrastructure are open to competition. There are collaborative organisations and arrangements such as public exchanges, industry associations and emergency response teams.

DIMENSION 4: GEOGRAPHIC DISPERSION

The geographic spread of the Internet can be estimated by investigating the Points of Presence (PoP) located in a geographic area. Rwanda is administratively divided into 30 districts, most of which are rural. The Internet was first established in the capital, Kigali, and later spread to other districts. Most ISPs are concentrated in Kigali but a few, like New Artel, focus on rural areas, where 94% of the population resides, providing Internet connectivity in all 30 districts.

The programmes to increase geographic dispersion include a community telecentre programme to establish 50 computers in each of the 30 districts, with one telecentre operational in each district; ICT buses or mobile telecentres (Odoobo, 2009); Rwanda Communication Infrastructure Project: a USD24 million World Bank-funded project to increase the reach of broadband networks, and lower international broadband connectivity prices (RURA, 2011); Kigali ICT Park, a multi-hectare technology development zone comprising 13 ICT companies (Odoobo, 2009); village phone operators(VPOs): a collaboration between MTN and Grameen Foundation where villagers rent phones earning a small profit, of which there are now over 5 000 VPOs (Grameen Foundation, n.d.).

TABLE 7: GEOGRAPHIC DISPERSION OF THE INTERNET IN RWANDA

Level 0	Non-existent: At this level the Internet does not exist in a viable form. There will be no computers with international IP connections. There may be some Internet users in the country, but they will obtain their connection via a telephone call to an ISP located outside the country.
Level 1	Single location: The ratio of Internet users will be less than one in a thousand. The growth of the Internet is still in its very early stages with only a few networks connected to an international IP network. The user community will be mainly technical people in the networking industry.
Level 2	Moderately dispersed: The number of Internet users will be at least one in a thousand. The user group will have moved out of the networking community.
Level 3	Highly dispersed: The number of Internet users will be at least one in a hundred. The necessary infrastructure will be established, but not on a wide scale.
Level 4	Nationwide: At this level the growth of the Internet will have diffused with Internet users in the ratio of one in ten. Internet access will be a common service.

The introduction of telecentres countrywide at least to district level implies a “highly dispersed” distribution level of the Internet. Despite the geographic spread, only 24% of the population, or approximately 24 in 100, accesses the Internet (RURA, 2012). Given the almost free nature of the service and high level of maintenance by the donor community, Rwanda has been propelled to Level 3 (highly dispersed Internet), though long-term sustainability will be a challenge.

DIMENSION 5: SECTORAL ABSORPTION

The sectoral absorption dimension evaluates the extent of adoption of the Internet in a number of economic sectors. According to the NICI Plans, the key sectors identified for Internet access are the education, governance, health, agriculture and finance sectors (Rwanda Ministry of Youth and ICT, 2012). The following initiatives were taken:

EDUCATION SECTOR

A ScanICT Baseline Survey Report (National Institute of Statistics of Rwanda, 2008) presented Internet access statistics for private and public schools in Rwanda including primary and secondary schools, teachers training colleges and technical/commercial/vocational institutions. However, the data is difficult to interpret. A more recent study indicates that by the end of 2012, 6.2% of primary schools, 18.5% of secondary schools and 100% of tertiary institutions were connected to the Internet - 463 out of 4 091 institutions, or 11.3% (Rwanda Ministry of Youth and ICT, 2012). Through the “One laptop per child” programme, 152 768 laptops had been deployed to more than 292 primary schools across the country. Other education initiatives include ICT teacher training, science and technology scholarships, SchoolNet to advance Internet connectivity, RwEdNet to connect institutions of higher learning to other institutions and research networks worldwide, and the Rwanda Education Commons, an education portal (Rwanda Ministry of Youth and ICT, 2012).

HEALTH SECTOR

According to the National Institute of Statistics of Rwanda (2008), 100% of public health institutions use computers, with only 24% of these institutions having access to the Internet while a meagre 9% have a website. In the private health sector, 100% of the institutions use computers with 42% using the Internet, but none has a website.

The NICI 2010 project promoted telemedicine with projects such as OpenMRS, an open source medical records system used to facilitate nationwide tracking of patient data; and TRACnet, a central repository of clinic health information to enable tele-treatment and mobile e-health (Rwanda Ministry of Youth and ICT, 2012).

Government and private sectors

TABLE 8: PERCENTAGE OF INSTITUTIONS WITH INTERNET ACCESS AND WEBSITES

	Public sector	Private sector	NGOs	UN system
Internet	87	69	97	100
Website	48	34.5	62	100

Source: (NICI-2015, 2010; National Institute of Statistics of Rwanda, 2008)

By 2010, 48% of the public sector and 34.5% of the private sector had a web presence (NICI-2015 Plan, 2010). Business process outsourcing (BPO) is on the increase mainly for IT industry help desk services, desktop management, data centre services and on the spot support services. Other accomplishments are online trade information portals, business incubators, online tax calculators, land administration and management information systems, credit reference bureaus, electronic case management systems, online banking and e-transaction regulatory systems, e-Soko (an online exchange platform for accessing agricultural markets via mobile devices) and Agricultural Management Information Systems (Rwanda Ministry of Youth and ICT, 2012). Government applies ICT in issuing national identity documents and driving licences, workflow management systems, e-Cabinet, financial management systems, e-Parliament, human resource management system, document tracking, e-tax, single e-window system, passenger clearing, and document tracking (Rwanda Ministry of Youth and ICT, 2012).

TABLE 9: SECTORAL ABSORPTION OF THE INTERNET

Sector	Percentage
Academic	11
Health	24 - public health institutions, 42 - private health institutions
Commercial	69
Public	87

Source: (Rwanda Ministry of Youth and ICT 2012)

The public sector has the highest percentage of Internet access and usage at 87% and the academic sector has the lowest at 11%. The high Internet usage in the public sector is mainly due to the mandatory government policy to allocate 5-10% of the budget to ICT development and use.

TABLE 10: ABSORPTION OF THE INTERNET BY SECTORS OF RWANDA'S ECONOMY

Sector	Minimal (1 point)	Medium (2 points)	Great majority (3 points)
Academic (primary and secondary schools, universities)	> 0-10% leased-line Internet connectivity	10-90% leased-line Internet connectivity	90% leased-line Internet connectivity
Commercial	> 0-10% Internet servers	10-90% Internet servers	90% Internet servers
Health (hospitals and clinics)	> 0-10% leased-line Internet connectivity	10-90% leased-line Internet connectivity	90% leased-line Internet connectivity
Public (top- and second-tier government entities)	> 0-10% Internet servers	10-90% Internet servers	90% Internet servers

Key sectors in Rwanda have Internet connectivity between 11 and 87% (Table 10 above), attaining two (2) points (medium) (Table 11 below), according to the GDI framework. This gives a minimum sectoral point total of eight (8) for all the four sectors, hence a sectoral absorption rating of Level 3 (common) as seen in Table 12 below.

TABLE 11: SECTORAL ABSORPTION OF THE INTERNET IN RWANDA

Sectoral point total	Absorption dimension rating
0	Level 0: Non-existent
1-3	Level 1: Rare
4-6	Level 2: Moderate
7-9	Level 3: Common
10-12	Level 4: Widely used

DIMENSION 6: SOPHISTICATION OF USE

Sophistication of use entails an analysis of how many people use the Internet and how they use it (Wolcott et al, 2001). The Internet usage should be innovative (Muganda et al, 2008). Rwandan telecommunication companies are working to enable mobile money transfer. MTN Rwandacell introduced the service in 2011 and since then 260 000 subscribers have been registered by the different mobile operators (Butera, 2012b). More than 3.4 million mobile subscribers pay for utilities such as electricity and airtime via mobile phones (Government of Rwanda, 2005). Individuals can access broadcast programming on the Web and the adoption of social media like Facebook is on the increase. The President, Ministers and other public figures use social media to communicate with the population (Habumuremyi, 2011; Kagire & Kaitezi, 2012).

e-Commerce services include e-payments, the fertiliser voucher management system being used by 2.4 million farmers, video conferencing connecting 16 government agencies, national identity documentation registration with over 10 million citizens registered and driver licensing with 141 777 licences issued (Rwanda Ministry of Youth and ICT, 2012). Government has promoted ICT usage in the education sector with projects like the Education Management Information System (EMIS), the establishment of a national library network, and converting existing e-learning content to Kinyarwanda (Farrell, 2007). All businesses have to be registered electronically with the Rwanda Development Board (RDB) (Government of Rwanda, 2010) and, by 2012, 8.6% of businesses had been registered online with the Board (Rwanda Ministry of Youth and ICT, 2012).

The e-Soko system allows farmers to access markets through providing market analysis information using mobile phones. By 2012 over 54 000 e-Soko transactions had been made (Rwanda Ministry of Youth and ICT, 2012). The Civil Aviation Authority of Rwanda can track air traffic using the Air Traffic Management System to make informed decisions. Government uses the Imihigo participation and accountability system for projects used by local government and communities to set project goals and track progress. The National Data Center has installed a cloud computing platform to host applications and services (Rwanda Ministry of Youth and ICT, 2012).

TABLE 12: SOPHISTICATION OF USE OF THE INTERNET

Level 0	None: The Internet is not used, except by a very small fraction of the population that logs onto foreign services.
Level 1	Minimal: The user community struggles to employ the Internet in conventional mainstream applications.
Level 2	Conventional: The user community changes established practices somewhat in response to or in order to accommodate the technology, but few established processes are changed dramatically. The Internet is used as a substitute or straightforward enhancement for an existing process (eg, e-mail vs post). This is the first level at which we can say that the Internet has taken hold in a country.
Level 3	Transforming: The use of the Internet by certain segments of users results in new applications, or significant changes in existing processes and practices, although these innovations may not necessarily stretch the boundaries of the technology's capabilities.
Level 4	Innovating: Segments of the user community are discriminating and highly demanding. These segments regularly apply, or seek to apply, the Internet in innovative ways that push the capabilities of the technology. They play a significant role in driving state-of-the-art systems and have a mutually beneficial and synergistic relationship with developers.

With respect to the GDI framework, Rwanda is seen to be at Level 3 (transforming), noting the innovative ways in which people and institutions are using the Internet. Work on the NICI III (2015) plan, focusing on ICT skills development with the main aim of increasing innovation in ICT, may propel Rwanda to Level 4 upon completion of the Vision 2020 program.

CHALLENGES AND FACTORS TO ENABLE FUTURE INTERNET DIFFUSION

The rapid diffusion of the Internet in Rwanda can be attributed to government policy action, a focused national plan, financial support from international donor agencies (IDA) and liberalisation of the telecommunication sector. Notwithstanding the current level of diffusion, only 24% of the population have Internet access, thus greater effort is needed to promote the next phase of development of Internet access and usage if Rwanda is to move any closer towards becoming a knowledge-based society in any form.

The NICI 2005 plan encountered poor resource mobilisation (Dzidonu, 2005), which was acknowledged by government (GoR, 2010), hence civil service departments and public sector organisations are required to set aside 5 to 10% of their annual budgets for ICT budgets. However, this policy is difficult to implement due to budget constraints. The NICI 2005 Plan was estimated to require USD500 million, of which the GoR was to contribute 46% of the funds and the remaining 54% was to come from IDAs, NGOs, private sector and other sources. GoR has continuously funded the ICT initiative and solicited more funds from various bilateral and multilateral donors. This donor-driven approach has crippled the sectoral absorption of the Internet in Rwanda, because some donors dictate where the money should be invested, like the OpenMRS funded by International Development Research Centre.

Another notable challenge is the lack of expertise to implement ICT programmes (GoR, 2010; Nsengiyumva & Stork, 2005). Many agencies had difficulty in understanding their assigned plan activities (Dzidonu, 2005). The Achilles heel of the NICI strategy is the high turnover of experts involved in implementation. Due to the failure to retain necessary expertise, it is difficult for Rwanda to further improve the sophistication of use of the Internet, as most users are just adopters of current forms of usage and not initiators of new forms.

Some targets set in the NICI plans are unrealistic and tend to have a demotivating effect. Rwanda has an energy constraint - only 13% of the population have access to electricity and there are regular power outages (NICI-2015, 2010, Nsengiyumva & Stork, 2005). This impedes the geographic dispersion and pervasiveness of the Internet in many rural areas.

Moreover, the limitations of international bandwidth availability and the high cost of Internet access in Rwanda further contribute to this challenge of pervasiveness. A turnaround may be possible with the introduction of fibre optic cabling and wireless broadband (WIBRO). While VSAT coverage has been a suitable early solution, it is not a suitable long-term solution for high-speed bandwidth availability. Addressing the international bandwidth access and broadband requirements for future Internet access establishes new infrastructure requirements and a new hurdle for government and the private sector.

Rwanda's private sector, in particular the ICT sector, is very small. The GoR is working to grow the sector through projects like the Kigali ICT Park, which is expected to attract sectoral investment. This will improve the organisational infrastructure for new ICT companies, if the Park can offer high bandwidth availability. Another factor hindering sectoral absorption is that government departments continue to work in seclusion from each other rather than fostering e-government, as required by Vision 2020. The realisation of extensive e-government would be pivotal to future Internet diffusion.

CONCLUSION

This GDI study has expanded the knowledge of the global diffusion of the Internet by presenting a perspective of a mainly rural country that is making progress in Internet growth due to government propulsion and policies, while experiencing many limitations and challenges. Reviewing this work, other African governments, experts, donors and investors in the telecommunication and ICT sectors in the East African region and on the African continent can make informed decisions on how to employ their finances in similar contexts. The article is particularly significant for scholars and researchers of Internet diffusion in landlocked countries with small, mainly rural populations and low GDP per capita, such as Burundi, Burkina Faso, Lesotho, Swaziland and Zimbabwe.

The GDI study showed that Rwanda has seven ISPs with 2 778 939 (24%) people having access to the Internet. According to the dimensions of the diffusion framework, pervasiveness is at Level 4 (pervasive); geographical dispersion at Level 3 (highly dispersed); sectoral absorption is at Level 3 (common); connectivity infrastructure is at Level 3 (broad); organisational infrastructure is at Level 2 (controlled); and sophistication of use is at Level 3 (transforming). Rwanda was ranked among the top six developing countries that are most dynamic in ICT development and performance (Kanyesigye, 2013). The study enables the reader to consider diffusion with respect to six critical dimensions and thus to tailor policy, strategy and programmes in ways which can advance future access.

The Internet has been used as a vehicle for economic development in many countries. However, few have tried to deploy it as a means for moving from an agriculture- to knowledge-based economy. The diffusion of the Internet in Rwanda has not yet achieved the goals set for this transition. Impediments such as poor resource mobilisation, unrealistic implementation plans, shortage of qualified and experienced human resources, minuscule private sector, low level of private sector involvement, limited competitiveness in the telecommunication sector, limited broadband availability and low Internet awareness all present continued challenges for policy, regulation and investment in the next phase of Internet diffusion.

Enabling factors for Internet diffusion in Rwanda and states with similar socio-economic environments include a stronger push for sectoral absorption in the major economic sectors as well as governmental focus on Internet-enabled e-government.

FUTURE-ORIENTED POLICY AND REGULATION

A key focus of governments should be to attract investors in the telecommunication sector and promote competition in the provision of Internet services as proposed by Brown, Collins, Malik, Morrison, Muganda and Speight (2007). Competition among ISPs translates into lower Internet accessibility charges, thereby increasing the number of users (Andres, Cuberes, Diouf & Serebrisky, 2007). In addition, regulators such as RURA should regulate favourable terms of competition for telecoms operators and service providers in order to increase competition in the domestic infrastructure market, particularly to foster the broadband market, and encourage the formation of additional IXPs. These regulatory actions could propel the organisational infrastructure dimension to the next level. In the age of the Internet, effective policy and regulation are important elements in exercising leadership, in both Rwanda and other developing countries.

Furthermore, the GoR should tap into the advantage accruing from the country's unilingual setup. According to Andres et al (2007, p. 5) "Sharing a common language has a positive impact on the spread of Internet use". Speaking one language is beneficial for call centres, electronic government and raising awareness of Internet availability. Government departments should therefore commit resources to put extensive government content (education, health, other) online in the local language Kinyarwanda. In addition, they should give due consideration to the full range of services that can be offered through e-government channels, smart devices and telecentres. This will help increase the pervasiveness of the Internet.

Applications for mobile phones should be fostered, possibly through an innovation fund for mobile apps, extending value from mobile money transfers and mobile bills payment to include services such as mobile polling, marketing and many other m-services. The boom of Web 2.0 also presents an opportunity for Rwanda to increase its Internet diffusion, including access to social media at lower prices. More private and public sector entities such as tourism bodies, government departments and entertainment houses should also be persuaded to build their presence via social media applications to increase their use for leisure and business. This will further boost pervasiveness.

Attention to the dimensions of pervasiveness, geographical dispersion, sectoral absorption, connectivity infrastructure, organisational infrastructure, and sophistication of use are necessary for effective e-leadership.

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