A PEEP INTO THE ICT SERVICES ECOSYSTEM IN SUDAN

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ABSTRACT

Purpose: To analyse the ICT services performance against the telecommunications and ICT purpose and mandate, taking into account stakeholders' role in the ecosystem.

Design/Methodology/Approach: This article presents a benchmarking analysis on the ICT services performance in Sudan between 2005-2015. It uses qualitative and quantitative analysis to measure the effectiveness and efficiency of ICT services and the underlying ecosystem. A set of 12 commercial, 10 financial, 7 technological and 6 traffic utilization Key Performance Indicators (KPIs) were selected as data collection measures. Data were collected from various public sources, including the International Telecommunications Union (ITU) and the World Bank. Similarity grouping was performed using demography, development and socio-economic data in order to find the set of countries with similar underlying characteristics and environment to Sudan. A machine learning K-means clustering algorithm was implemented for this purpose.

Findings: Results describe Sudan's position among the World countries belong to its cluster. Benchmark graphs are presented highlighting how the ICT sector performs in economic, social and technical competencies. The discussion of results includes the efficiency and effectiveness, competitiveness, accessibility and affordability, market and services transformation, and the readiness of the ICT market to take an enabling role in socio-economic development.

Originality/Value: The article offers a critical study of the status of ICT in Sudan, and maps it to the country's national ICT mandate and objectives, allowing recommendations to be drawn by various ecosystem stakeholders. Insights gained offer valuable conclusions that feed into policy analysis and recommendations of the interventions needed to put ICT to effective use, positively impacting the ICT sector.

Keywords: ICT services; Sudan; ICT diffusion, access and penetration; Competitiveness Index, Human Development Index, Innovation; Mobile Digital Economy.

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INTRODUCTION

The growing role of ICT infrastructure in driving productivity and growth in global economies is increasingly an important aspect of both developing and developed countries. It is now accepted that the creation of new ICT networks directly creates new products and services, minimizes distances, and provides people with increased ability to interact, communicate and improve social and economic activities (Sein, 2004). This growth has been both directly and indirectly attributed to the development of ICT infrastructure and ICT solutions. Contemporary discourses on development have consistently identified ICT as a requirement for economic growth and the improvement of social conditions. International development agencies have pointed to the opportunities ICT opens for development.

A general association between socio-economic development effects and ICT has been highlighted by many researchers and professionals. This 'effect' of ICT from information systems project can occur in a situated manner within the communities in which it is implemented (Sahay, 2000; Odedra-Straub, 1996). One also has to be aware of the theoretical analysis for the propositions on the impact of ICT. The understanding of ICT-based information systems is generally viewed from universalist terms. For example, the interventions driven by the 'digital divide' gap in order to develop ICT services in poor countries implies economic benefits from participating in international market and regulatory interactions. The 'tool-and-effect' link between ICT and economic development is exemplified in various influential publications (World Bank, 2002; Porter *et al*., 2002, p.29). Moreover, the dynamics and characteristics of the economic growth from ICT differ between developing and developed countries, as well as among comparative developing countries with similar characteristics and development environment.

To this effect, this article presents a benchmarking analysis of the ICT services performance in Sudan between 2005-2015. The aim is to describe Sudan's position among a group of countries with a similar environment, highlight how the ICT sector performs, and key aspects that help give insights to the functioning of the ICT ecosystem.

LITERATURE REVIEW

In developed nations more than 50% of the GDP comes from information-driven industries such as ICT. Country level studies have shown that there is a direct, positive and significant relationship between ICT, growth and productivity (Dewan, 2000). In developing nations there is no strong evidence of such a relationship; this may be attributed to a lack of critical infrastructure investment, lack of integration and alignment between industry and academia, short-sighted ICT strategies towards integration with the overall digital and economic policies, and lack of a knowledge base to support effective use of the ICT. It could also be attributed to certain conditions and policies for the country under study.

These reasons are what have created a gap between developed and developing countries (Mbarika *et al*., 2003). For example, in the case of Sudan, the historic contribution of the infrastructure to economic growth (transport, water and sanitation, power, ICT, irrigation) was 1.75% to the per capita Gross Domestic Product (GDP) across all parts of Sudan (including South Sudan before cession in 2011), out of which, 1.6% is attributed to ICT during the period 2000-2005 (Pohjola, 2001). Future predictions show that improvements in ICT would contribute an additional 1% growth on GDP. In Sudan the annual average of infrastructure spending is 7% of the GDP (in the year 2011), with water and transport taking 80% of this total. This figure is not high enough to meet the needs of the country while other challenges exist, such as the $580 million a year loss due to inefficiencies (2.7% of the GDP in the year 2011) (Pohjola, 2001).

It is important to consider that an improved ICT infrastructure without a rational theory that explains the involvement of socio-economic factors, may not improve growth in developing nations (Dewan, 2000; Mbarika *et al*., 2003). ICT, in the context of developing nations, has the potential to serve as a critical enabler to achieve many of the development goals agreed by the World leaders at the United Nation Millennium Summit (www.wiss-online.net). The UNDP quantifies ICT as 'enabling' for development effects. Technological innovations enhance human capabilities, which in turn are important for technological innovations (Porter *et al*., 2002a).

Other major research reports discuss the contribution that an ICT ecosystem makes to development. For example, the 'networked world' report (Kirkman *et al*., 2002) pinpoints that the link between ICT and development is that the technology enhances market functionality, e.g. information flow between producers and consumers. The 'Network Readiness Index' measure is presented in the report. It is composed of (a) measurements of diffusion of ICT components and services, (b) factors affecting the quality of use of ICT services and applications, e.g. Infrastructure, network access, level of competition, education level, and other factors affecting the ICT ecosystem in industry and government sectors. The existing capacity of ICT and its impact in the socio-economic context is considered a condition of 'readiness' for the progressive development of ICT activities. Diffusion of ICT in all sectors of society, regulations, and favourable market mechanisms, are examples of desirable policy targets and 'readiness' conditions.

Porter *et al*. (2002b) has presented a theory for the process of economic development from ICT at various country income levels. The ICT role and impact, therefore, varies with the country's market economy and competitive advantage. The competitiveness advantage of more successful economies would suggest that they have more capability for technology innovation compared to less successful economies. The report shows that the transition between different levels of development attributed to technology lies in the adaptation process to new institutional conditions, and to the market consideration of the social conditions that sustains it. We take such factors into the analysis and quantitative approach employed in this paper on ICT ecosystems in Sudan.

ICT ECOSYSTEM

The above sections highlight the role of ICT in development and the importance of socio-economic factors. Such a role would also be closely examined by studying the status of the ICT ecosystem. The ICT ecosystem defines the effectiveness and efficiency of the level of development of services. When analysing the ICT ecosystem for Sudan, it is important to consider that this is performed comparing countries that have similar economic and social and readiness conditions. Hence similarity grouping of the World countries (188 countries) is performed in order to identify a cluster of countries with similar underlying characteristics and environment to Sudan. A machine learning K-means clustering algorithm is implemented for this purpose (MacQueen, 1967). While it is still possible that variations exist within the identified group/'cluster', we anticipate that this approach will be quite insightful for the ICT ecosystem and benchmarking analysis.

Clustering countries with similar socio-economic conditions

To this end, a set of 19 economic, social and developmental features data were collected for all the World countries. The data were categorized into economic (e.g. GNI per capita, GDP per capita, economically active population), demographics (e.g. age groups, percentage of urban population, mean year of schooling (male and female)), and developmental (e.g. Human Development Index (HDI), percentage of Internet users, fixed telephone subscriptions, efficiency measures, global competitive index). A clustering technique (K-means) from the machine learning and data science field was utilized for analysing the collected data and for identifying the clusters.

K-means is one of the simplest unsupervised learning algorithms that solve well-known clustering problems. The procedure follows a simple and easy way of classifying a given dataset through a certain number of clusters (assume k clusters) fixed *a priori*. The main idea is to define K centroids, one for each cluster. These centroids should be placed as far away from each other as possible. The next step is to take each point belonging to a given dataset and associate it to the nearest centroid. When no point is pending, the first step is completed and an early groupage is done. For a given K clusters as input, K-means clustering initializes with these K groupages. Further steps of the method calculates an entity called 'within sum of squares (WSS)', a measure of how close the identified countries data features are to each other, between the same data points and the nearest new centroid. This process is performed iteratively until no changes are done and hence centroids no longer move. This is the point where the groups/cluster is obtained.

Because the K-means algorithm results will change if a different number of clusters K is used, we have first identified the optimum number of clusters, which optimally fits the data collected and results in good clusters/groups. The optimum number found is 16. Results from the clustering have identified Sudan to be in a group of 16 countries (Kyrgyzstan, Cambodia, Tajikistan, Ghana, Mauritania, Kenya, Côte d'Ivoire, Sao Tomé and Principe, Bangladesh, Nepal, Zambia, Cameroon, Lesotho, Tanzania, Myanmar, Papua New Guinea). We note that the list contain countries from West Africa, East Africa, North Africa and South East Asia. In the next section, this will be explored further in relation to the ICT ecosystem performance.

BENCHMARKING OF ICT ECOSYSTEM IN SUDAN

For the identified cluster, a set of 12 commercial, 10 financial, 7 technological and 6 traffic utilization Key Performance Indicators (KPIs) are selected as data collection measures. Data were collected from various public sources, including the International Telecommunications Union (ITU) and the World Bank. Analyses of these data aimed to highlight the combination of factors that influenced the ICT ecosystem of the countries in the Sudan cluster. Example features of the collected data are detailed here.

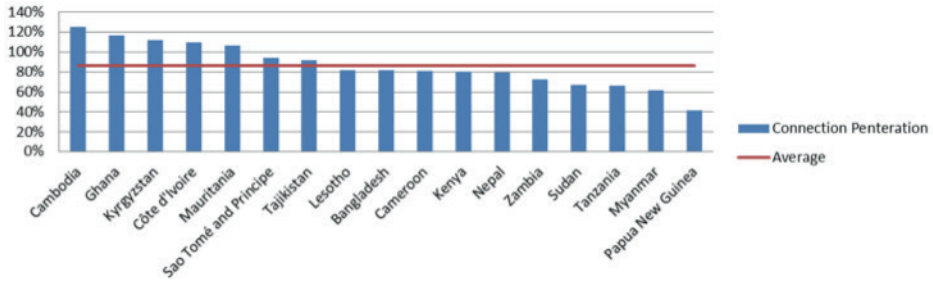
Example traffic utilization KPIs include number of connections, amount of data traffic (Giga Bytes), adoption and penetration. Example commercial KPIs include GDP, revenue, data revenue, ARPU, EBITA. Example financial KPIs include OPEX/Revenue, CAPEX/Revenue, EBITA Margin and example technological KPIs include the number of voice subscribers and Network Readiness Index (NRI).

BENCHMARKING RESULTS

Benchmarking results are shown in Figures 1, 2 and 3. Figure 1 shows the mobile connection penetration for the Sudan cluster and depicts the average penetration in a red vertical line. The mobile service is selected as an example because the fixed telephony and fixed Internet sector has not demonstrated much growth; because of this there is an overwhelming preference for mobile phones. Sudan is 4th from last in the list.

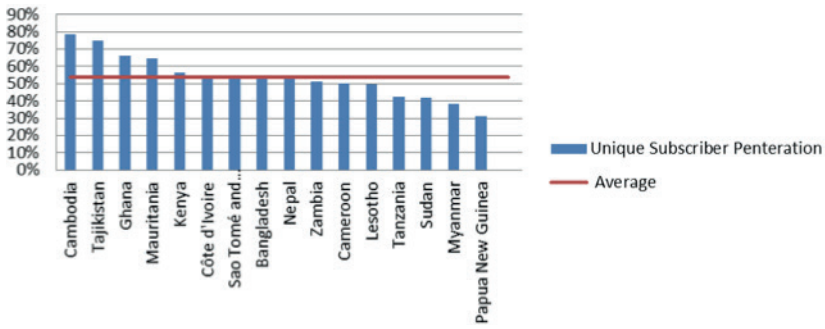
Figure 2 shows the corrected mobile subscribers' penetration, using the Subscriber Identification Module (SIM) index ratio, for the countries in Sudan cluster. The unique mobile penetration takes into account that subscribers can possess several SIM cards from different mobile operator companies. Sudan's SIM index ratio is currently 1.58. We note a slight change in the order of countries with the highest penetration with the unique penetration rate, but a consistent trend can be extracted from this analysis. That is, mobile penetration can be improved with subscriber mobility and adoption of new services provided by the competing mobile operator companies.

Figure 1 Mobile subscriber's penetration for Sudan cluster



Source: Output of the clustering analysis

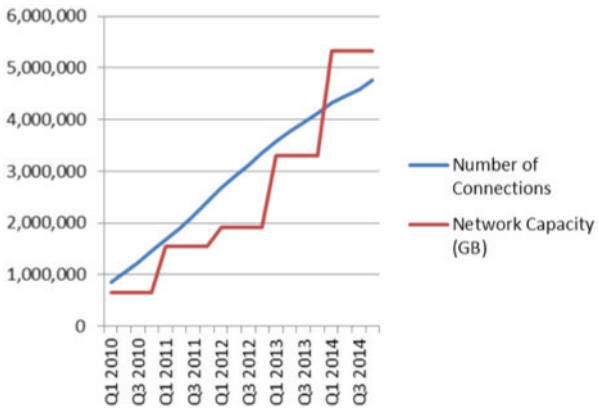
Figure 2 Unique Mobile subscriber's penetration for Sudan cluster



Source: Output of the clustering analysis

Figure 3 looks specifically at Sudan's mobile subscriber connections and shows the growth in the number of data subscriptions over time for a period of five years (blue curve), and the associated data capacity growth of the mobile networks (red curve). Interestingly, we note a step shaped curve trend of growth for the network data capacity. This growth coincides with network expansion activities commissioned by mobile operator companies in a frequent manner (roughly every year with the expansion taking around quarter). We produced other figures (not shown) showing that the subscriber share of the data (data traffic (Mbytes) per subscriber) follows a similar step increase over the same period of five years.

Figure 3 Unique Mobile subscriber's penetration for Sudan cluster



Source: Output of the clustering analysis

Other ICT measures are summarized in Table 1. Sudan's smart phone adoption rate of ICT services is above average in the cluster (this is what drives the data growth depicted in Figure 3). However, we note the huge difference to the highest in the group (Maynamar). Similarly Sudan's SIM index ratio is above average but lower than the highest in the cluster (Côte d'Ivoire). These measures are selected as they directly indicate the status of the ICT services and subscribers usage. Competition in the ICT market can be measured using the HHI (Herfindahl-Hirschman Index), a measure of the size of ICT providers in relation to the industry. HHI is also an indicator of the amount of competition in the ICT sector. It is in the range between 0 and 10,000 points. Large values of HHI indicate a decrease in competition and increase of market power by few ICT providers. Sudan's HHI is close to the average of the group, and far below the threshold of 10,000; this indicates a mix of market power dynamics. We note here that the HHI index should not be taken in isolation of the regulatory environment of the ICT services in Sudan. This is beyond the scope of this paper and is subject to future work. Finally, the ARPU for Sudan is slightly below the average of 6.8 and almost half the maximum of the cluster (Mauritania). Various factors affecting the ARPU come into play, including the foreign exchange rate of the Sudanese currency and some of the technological and commercial sanctions on the import and transfer of technology and hard currency.

Table 1: ICT diffusion and Adoption figures

Measure	*Highest*	*Lowest*	*Average*	*Sudan's value*
Smart phone adoption (%)	66.4 -Maynamar	17.54 – Kenya	27.70	29.44
HHI	7742-Sao Tomé and Principe	2632- Tanzania	4186.1875	3,468
SIM index	1.9893- Côte d'Ivoire	1.2229- Tajikistan	1.5710438	1.58
ARPU	10.8869-Mauritania	2.7881-Bangladesh	6.817588	5.9459
Data Revenue (%)	17 - Côte d'Ivoire	1 – Nepal	13	16
NRI	3.82 - Kenya	2.58 - Mayamar	3.07	-

Source: Output of the clustering analysis

Unfortunately data are not available for Sudan for the Network Readiness Index (NRI). However, the position of Sudan in NRI can be estimated by looking at the performance in other ICT ecosystem features. It is estimated that Sudan's NRI is lagging and would be in the tail of the list of countries within its cluster. When benchmarking based on the NRI, it is found that Kenya sits at the top (NRI of 3.82), followed closely by Ghana (NRI of 3.49). Kenya's mobile connection penetration is 80%, with a unique mobile connection penetration of 56% and smart phone adoption of 17.54%. Kenya also performs well in financial KPIs, namely EBITA margin 43.75%, data revenue 11%, ARPU of 6.33, and Effective Price per Minute EPPM ($) of 0.0635. We note Kenya's HHI of 5,082, which is likely to be a result of the Safari Telecom domination of the ICT market.

Comparing the top performer of NRI Kenya to Sudan reveals that Sudan's ICT sector has mature ICT financial KPIs (EBITA margin, OPEX/revenue, CAPEX/revenue, 47.10%, 58.64 % and 30.70% respectively). Sudan also performs very well in Smart phone adoption, mainly for data usage (30%). The Sudan ICT ecosystem is also doing well in data revenues (16%), but is characterized by relatively high EPPM (0.1203) compared with its cluster. This suggests an examination of the affordability barrier in order to seek whether it can or can not explain the lower mobile connection penetration and lower unique mobile subscriber penetrations (40%). The high SIM index for Sudan is an undesirable phenomena for the overall ICT ecosystem, hence it indicates the existence of issues around unsustainable short-term bundles and pricing offers. It also indicates that those offers from competing mobile operator companies do not fully satisfy the subscriber's needs and hence subscribers are pushed to possess many SIM cards. Moreover, it implies population coverage gaps across different mobile operator companies (Sudan's population coverage is only 89%).

Sudan's ICT KPIs also fall short in comparison to Ghana, mainly in mobile connections penetration and data revenues (33% for Ghana). This is a direct desirable benefit of the high network readiness that implies that ICT has more contribution and role in government, finance and business. Overall economic status and GDP figures for Ghana and Kenya would corroborate this finding. For example, e-commerce and usage of mobile services for agriculture, e-payment and other

advanced socio-economic usages of ICT have shown success in Kenya (e.g. mMoney M-PESA project (Jack and Suri, 2013).

CONCLUSIONS

This article takes a quantitative data analysis approach to the benchmarking of the ICT ecosystem in Sudan. First, 19 developmental, demographic and economic data were collected for 188 World countries. K-means clustering was performed on these data to produce a cluster/ group of countries with similar developmental and economic conditions to Sudan. ICT benchmarking analysis was then performed on the identified group of countries. Results showed that the ICT ecosystem in Sudan performs worse in terms of mobile penetration since it is below the average of the group in penetration. Although some affordability issues were observed from the analysis presented in this paper, further exploration into why Sudan lags considerably behind its peers is needed. On the other hand, Sudan performs well on smart phone adoption (which increases the potential of data usage): this is clearly reflected from the high percentage of data revenue since Sudan report close to 16% compared to 33% of Ghana as the lead of the cluster. This conclusion is also backed up by Sudan's above average ARPU. The market conditions and competitiveness of Sudan's ICT market is found to exhibit a moderate competiveness (medium HHI value of 3468), a maximum of 10,000 indicates acute market monopoly and a zero value indicates perfect competitiveness. Sudan's HHI value indicates rather stable market power conditions that may welcome and allow competition. We, however, note that this would still need to be cross-checked with an analysis of Sudan's ICT regulatory policies and environment.

We hope the analysis presented in this paper would allow for more discussion and further recommendations to be drawn by various ecosystem stakeholders. From the benchmarking results it can be assumed that Sudan's steady growth in the mobile telecommunications industry will continue, and this in turn can be a key enabler for a better economic value to improve the contribution of ICT in different sectors, such as health and education, in a fashion that covers the needs of the different stakeholders in the ICT ecosystem.

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BIOGRAPHICAL NOTES

Dr. Hassan Hamdoun, is a Research Fellow at the School of Natural and Computing Sciences, University of Aberdeen, UK. His research portfolio is in broadband networks service delivery, ICT Energy Management and data science/complex network analytics. He is a telecommunications and data engineering professional with 10+ year's research, teaching and industry experience and over a dozen publications. Technical and research roles for multinational mobile operators and research projects include Swansea University where he focused on the energy efficient 4G networks, University of Aberdeen where he built wireless routers for differentiated services Internet provisions for rural areas, Zain group (Sudan) where he led the implementation of 2.5G and 3G, and the central Bank of Sudan on setting up the first Electronic Payment Network. He has a PhD in Advanced Telecommunications Engineering (Swansea University, UK), an MSc (ENG) in Electronics Engineering (University of Sheffield, UK) and a BSc (Hons) in Electrical Engineering from the University of Khartoum.

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