



An Exploration of the Situation of Educational Technology Infrastructure in Sudanese General Education: A Case Study

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Abstract: In the last two decades, policymakers have considered Educational Technology Infrastructure (ETI) as a prerequisite for the successful implementation of Educational Technology Policies (ETP). This study aims to measure the situation of ETI in Sudan and display its importance in supporting ETP. Content analysis is used to demonstrate how specific attention is paid by US, UK, and China toward ETI as a crucial element in their ETP implementation, and how several factors are then determined to assess the infrastructure in Sudan based on experiences that the US, China, and World Bank have obtained. These include policies towards ETI; electricity supply; schools or classrooms connected to the internet; the ratio of students to computers; internet speed; and availability of digital resources. Recent years have witnessed e-learning projects and digital resources under construction by the Sudanese National Center for Curricula and Educational Research (NCCER) and UNICEF, but Sudan still faces various ETI problems, including (1) a lack of policy and vision towards ETI in Sudan; (2) Sudan's ETI challenge of being a developing economy; (3) a sizable population living in areas without electricity coverage; (4) a low ratio of student to computer usage in public high schools (merely about 28:1). We conclude with proposing several workable solutions for improving the current situation of ETI in Sudan.

Keywords: Educational technology infrastructure, educational technology policy, SABER, Sudan

1. Introduction

Educational Technology Infrastructure (ETI) has recently attracted policymakers' attention in developed and developing countries. ETI is mainly composed of hardware and software, and effective methods by which these two major components work together to enable educational practices (Baquero, Aguilar, and Ayala, 2015). The continuous improvement of the educational system depends on several factors such as people, processes, learning resources, policies, and sustainable models. In addition, broadband connectivity, servers, software, management systems, and administration tools are also important factors (NETP, 2010). To put it simply, ETI refers to the school's Information Communication Technology (ICT) network and its related parts (Lockwood and Cornell, 2013; Saidi et al., 2018).

The role of ETI is to facilitate communication in schools, encourage the application of technological tools, and support engagement between learners and instructors (Tairabet al., 2016). Schools call for ICT tools because they need this new way of learning (Di et al., 2016). However, these tools are often discouraged since there are no supporting policies or master plans. For this reason, many countries in the world, developed or developing, are making Educational Technology Policies (ETPs) to enable the application of ICT in classrooms and to improve their ETI. Consequently, the educational quality of any country in the 21st century can be measured by the extent to which its ETI has been developed and the extent to which its ETP has been formulated.

Globally, ETP has also been successfully developed in several nations. For instance, the US developed the first National Educational Technology Plan (NETP, 1996), in which ETI was confirmed to be one of the main educational interventions of the federal government. This plan was followed by revised versions, including NETP 2000, NETP 2005, and NETP 2010. Similarly, the UK, China, and other countries have formulated national policies to promote ETI. Several case studies in different African countries have been conducted by UNESCO researchers (e.g., Kozma and Shafika, 2011). These studies focus on ETI, ETP, digital resources, and educational quality (Alamin, 2015; BECTA, 2002; 2005; 2008; Tairab & Huang, 2016).

Sudan is considered one of the countries interested in ICT intervention and integration into its educational system. From the state's perspective, however, Sudan faces several challenges to conduct such intervention (Alamin, 2015; Federal Ministry of GE, 2008; 2014; Tairab et al., 2016). In view of this, it is argued that policymakers and educational planners in Sudan need to identify the current situation of ETI, which is crucial for any educational reform based on technology, and to identify the current situation of ICT, which is fundamental for the development of ETI. Furthermore, approximately 2.3 million (24%) children in Sudan are not on campus (Stubbe et al., 2016; World Bank, 2021). Nomadic children account for 9% of total children in Sudan (UNICEF, 2015). Neither displaced nor nomadic children reside in fixed places and there is no school for them. Distance learning enabled by available ETI seems to be the only solution. Therefore, technological reform in Sudanese education is decisive.

This study also argues that frameworks that have been used to measure international experiences of ETI can also be used to measure Sudan's current situation of ETI. Section 2 will address this measurement with a review of the current situation of ETI and the important factors of ETP across a range of countries.

2. Literature Review

The US Office of Educational Technology (OET) has developed a series of four National Educational Technology Plans (NETPs) since the first plan was published in 1996 (that is, NETP 1996) followed by NETP 2000, NETP 2005, and the latest NETP 2010-2020. Similarly, China has developed more than four core plans and specified four stages of development (1996 and 1999, 2003, 2006, 2010, and 2012) (Alamin, 2015; Alamin, Guo and Zhang, 2015; Di et al., 2016; Yumin and Ellen, 2010). However, China needs to confront several challenges such as its large population, large geographic land area, and economic conditions. These challenges have imposed an enormous impact on China's development of ETPs since it made its first step at the end of the last century. In the early 2000s, policies were formulated to support underdeveloped areas. In association with the US NETP 2000, for example, China developed specific policies to promote the advancement of educational technology for the western poor provinces in 2003. Since then, integrated policies for educational technology have been reinforced throughout the whole country (Yumin and Ellen, 2010; Zhang, 2005). During the period 1980 to 2000, only 26 colleges and departments in total fulfilled China's ETP. This number

increased by almost 7-fold between 2000 and 2005 (Alamin, 2015). This reflects the efforts that have been made to improve ETI as one of the main steps to promote China's educational quality.

According to the NETPs (NETP, 1996; 2000; 2005), ETI was described in terms of digital resources, research and education networks, schools and classrooms connected to the internet, the ratio of students to computers, the ratio of teachers to computer, and relevant policies. These policies, including educational loans and the bring-your-own-device (BYOD) policy, encourage teachers, students, or schools to be equipped with ETI devices. In addition, the US government also implemented a policy to reduce internet connectivity prices in public schools, that is, 'the E. rate policy'. It helps the schools in getting supportive resources provided by the US educational research networks. By 2005, nearly 100% of schools were connected to the internet. In 2008, 98% of classrooms in public schools had Internet access. In terms of connectivity, the ratio of students to computers with internet access in public schools was 3.8: 1 in 2005 (Alamin, 2015). Former President Barack Obama launched the ConnectED Initiative, setting a goal of connecting 99% of students to the Internet in their schools. The program mandated that schools and libraries should have access to the internet with speeds no less than 100 megabits per second (Mbps) per 1000 students and aim at a target speed of 1 gigabit per second (Gbps) by 2018 (OET, 2014). Unlike traditional dial-up access, broadband internet access enables high-speed connectivity.

According to China's Ministry of Education (MOE) in 2011, the ratio of students per computer was 13:1. MOE has implemented a policy of compulsory technology education. Nearly 15,000 hours of video educational resources and free courses are provided for 160 million students in primary and secondary schools in rural areas (Alamin, Guo, and Zhang, 2015; Di, 2014).

European countries have established a project called "Europe's Digital Agenda 2010–2020". This project seeks to create an environment in which experiments are carried out to take advantage of ICT and enable sustainable applications of technology in education (Toporkoff, 2013). A survey conducted by European Commission reported some of the European efforts to establish ETI (Wastiau et al., 2013). Four groups of indicators are included in this survey to measure the development of ETI. The first group is related to terminal devices such as desktop computers, laptops, notebooks, tablets, and smartphones. The second group relates to the network conditions such as school websites, email addresses, virtual learning environments, and the utilization and maintenance of equipment in computer labs, classrooms, and libraries. The third group is related to the accessibility of ICT, including teachers' and students' accessibility of ICT, teacher and student performance, strategies, and policies implemented by schools to support the use of ICT in teaching and learning. The fourth group concerns attitudes to ICT such as opinions and viewpoints at the school level, teacher and student opinion on the use of ICT in learning, and the impact of ICT on achievement and motivation.

According to a guide published by UNESCO (2009), several factors are used to measure the use of ITC in education, including schools with electricity supply, radios for educational purposes, televisions for educational purposes, telephone communication facilities, the ratio of student to computer, schools with Internet access, kinds and speeds of internet access, numbers of computers per school, available online resources, digital libraries, computers connected to the internet, computers per teacher and administrator, and school websites.

The World Bank (2012) examined the use of ICT in education sectors in three African countries, namely, South Africa, Uganda, and Senegal. Factors developed by the World Bank (2012) to assess ETI in general education include digital learning resources, affordable technologies, and education management information systems (EMIS). A policy framework (SABER-ICT) has been developed to keep policymakers informed of ICT so that they are able to make better decisions on the use of ICT in

education sectors. SABER-ICT confirms those factors suggested by UNESCO (2009). It provides a framework in which ETI is described in these three aspects: electricity supply, ICT facilities, and technical support and maintenance. ICT facilities include access to available online resources at schools (classrooms, labs, and libraries), mobile phones, wireless and wired networks, and the policy of BYOD which enables on-demand access for teachers and students alike. ETI has attracted policymakers and educational planners in various developing countries. In 2015, for example, Peru implemented the policy of “one laptop per child”. The cost was 188 USD for each laptop, and the target students were Grade two pupils in public schools in Lima. Relevant packages are also provided to promote the application of ICT in schools (Daniel, 2020). In Pakistan, the program “E-Learn” delivers courses on math and science through short videos with multimedia presentations (Beg, 2019). The curricula are tailored for 8 grades, including multiple-choice review questions, a small tablet for teachers to project their materials, and an LED screen installed in each classroom. In collaboration with Sudan’s Ministry of Education, Ahfad University for Women in Khartoum, and War Child Holland in 2015, a custom-built computer/tablet game called “E-Learning Sudan”, provides alternative learning opportunities to Sudanese children who are excluded from education.

However, based on the literature reviewed for the core reports of ETP and its implementations in the US and China in terms of assessing the implementation of ETI in USA and China, as well as the advisories given by UNESCO (2009) and the World Bank (2012; 2016), there seems to be an improvement in ETI implementation.

ETI is a prerequisite for successful ICT-based education reforms. In this study, the framework provided by SABER-ICT is adopted to explore the current situation of ETI in Sudan. Major factors include electricity supply, internet access (schools and classroom connection to the internet and speed of connectivity), and facilities (ratio of student to computer, EMIS, and digital educational resources).

3. Materials and Methods

Three types of source materials are used in the present study: Arabic, Chinese and English. All the Chinese and English sources are published documents, including publications by the US Office of Educational Technology (Department of Education), the UK Government online archive and BECTA publications, and the website of China’s Ministry of Education. Publications by United Nations Educational and Scientific Cultural Organization UNESCO and the World Bank are also included.

Information about China’s ETI is available in Chinese at <http://www.moe.cn>. Related links are appended to the references. British data comes from publications on UK’s ICT educational policies UK by the British Educational Communication Technology Association (BECTA, 2002; 2005), including the National Grid for Learning and Harnessing Technology Strategies (2005-2008 and 2008-2014). Information about the US is mainly based on the websites of the US Department of Education and the Office of Educational Technology. This includes the National Educational Technology Plans NETPs (1996; 2000; 2005 and 2010). International information includes publications by the World Bank and UNESCO: Education in Africa, Sudan Country Report, SABER-ICT Framework Paper for Policy Analysis, and UNESCO’s indicators on analyzing ICT in education (2009). Sudanese data comes from study reviews, internal reports, and publications by the Federal Ministry of General Education (FMGE), including Education Plans (2007-2011; 2012-2016), FMGE (2008) National Report about the Development of Education in Sudan (presented in the International Conference for Education in Geneva), and an interview with the federal educational planning director at FMGE Headquarters in Khartoum 2014. Most of the Sudanese sources are in Arabic. In addition, several articles cited in this paper are also included. Content analysis as a qualitative method has been adopted to explore the situation of ETI implementation in Sudan.

Polit and Hungler (1995) defined reliability as ‘the consistency or constancy of a measuring instrument’, and they defined validity as ‘the determination of whether a measurement instrument actually measures what it is purported to measure’. See also (Long & Johnson, 2000). There is an ongoing debate about whether reliability and validity are appropriate to evaluate qualitative studies. Noble and Smith (2015) suggested truth value instead of validity and consistency instead of reliability. In terms of truth value, they required qualitative researchers to recognize that multiple realities exist; how their personal experiences affect the study methodology; clearly and accurately present participants’ perspectives. In terms of consistency, they suggested that an independent researcher should be able to reach the same findings if he gets similar data.

Generally, qualitative researchers have to include techniques to increase the validity and reliability of their research design. This study used content analysis to measure the situation of ETI in Sudan. Qualitative analysis refers to “any kind of research that produces findings not arrived at by means of statistical procedures or other means of quantification” (Strauss et al., 1990 as cited in Bray, 2007). Specifically, content analysis refers to “a flexible method for analyzing textual data” (Hsieh and Shannon, 2005). Content analysis is also “[a form of] analysis of documents and texts that seek to quantify content in terms of predetermined categories” (Bryman & Bell, 2015). The present research is conducted based on international experiences to explain the situation of Sudan’s ETP implementation. With regards to content analysis, based on a review of the literature, common factors are identified and highlighted to assess the situation of ETI in Sudan.

The progression indicators of the SABER-ICT policy framework are also used to assess the situation of ETI in Sudan. The SABER progression indicators are classified into four types, that is, the latent: lack of the factor; the emerging: some efforts toward the factor and availability of the opportunities for an improvement; the established: many and effective efforts already done toward the factor; and the advanced: the factor is not an issue for the policy maker. Based on the literature, the common factors include ICT policy towards the ETI, electricity supply, connectivity (schools and classrooms connected to the internet and internet speed), the ratio of students to computers, educational management information system (EMIS), and availability of digital resources. In short, the findings aim to describe the overall situation of Sudan’s ETI based on SABER indicators and common factors as identified in the literature. An adapted table of the SABER framework to assess the ETI in Sudan has been suggested in Table 1 below.

Table 1. An Adapted table of the SABER framework to assess the ETI in Sudan

ICT Infrastructure				
Stage	Latent	Emerging	Established	Advanced
Policy Situation	No policies on ICT in Education	Draft on policy in ICT in education	The policy on ICT in Education has been approved	Explicit policy guidance related to ICT/education topics; ICT in education the policy is fully operationalized and seeks to transform learning environments, teaching practices, and administrative processes with the aid of ICTs
Electricity Coverage in Sudan	School electrification is an acute issue across the system	School electrification is an issue only in rural areas	School electrification is an issue only at the margins	School electrification is not an issue
Internet in Sudanese Education	Internet is an acute issue across the country	Internet is an issue only in rural areas	Internet is an issue only at the margins	Internet is not an issue

Computer per Students	No computers in the schools, and the students do not have them at home.	Some of the students have computers in some schools and homes.	Most students have computers in schools and their homes.	All the students have their own computers and have computers in the schools.
ICT use in Management Information System (EMIS)	Little/no mention of EMIS	EMIS use coordinated centrally by the ministry, minimal exchange of data with individual schools	EMIS in widespread use for a limited number of data points, primarily to feed the central education system database.	National EMIS uses ICT to collect, process, and store information produced by various levels of the education system and disseminate data to various levels of the education systems as a key decision tool, accessible via multiple channels (e.g., Internet, mobile devices), with some access to EMIS data available to the general public and with robust security and data privacy safeguards in place
Digital tools and educational resources	No digital content/there is no use in teaching	Some digital content is available Digital content is available in some classrooms	Digital learning Resources DLR are widely available, some explicit linkages to curricular objectives in online education portals are available •Digital content is available in most classrooms •Some attention is paid to intellectual property issues (e.g., around OER issues) •Some access to DLR outside of school	Teachers and students access digital content/DLR resources linked to specific curricular and learning objectives, anytime anywhere, using a range of devices and platforms •Teachers and students regularly use, develop- re- use and re-mix develop digital teaching and learning resources • Advanced' digital learning resources (e.g., robotics, simulations, games) are used in teaching •Intellectual property issues are well considered •Users involved in evaluating and assessing the quality of digital learning resources

Source: adapted from Trucano (2016)

4. Findings and Discussion

4.1. Policy situation

Sudan is a developing country interested in educational reforms and interventions by means of ICT. In June 1999, the Sudanese national ICT strategy was formulated, and a high-level ministerial committee was formed to oversee its implementation (Hamdy, 2007). This strategy focused on five major areas, that is, technology (infrastructure), human resource development, software industry development, content (Arabic reservoir), and geo-information. As part of Sudan's national ICT policy, the government introduced ICT in high school curricula in 2002. However, although Sudan has some initiatives to apply ICT in education, Sudan's ETI is not well developed to fully implement relevant ETP (Hamdy, 2007).

The Federal Ministry of General Education of Sudan (FMGE) and its affiliated institutions are the main body who has the legitimacy to formulate educational policy. At present, although some policymakers have expressed their desire to intervene in education with ICT, the vision for ICT or ETI has not yet been integrated into general education. For example, FMGE (2008) recognizes that "there is a lack of an integrated national vision for educational technology, but the lack of action with educational technology plan does not mean there is a lack of solutions" (FMGE, 2008). That is confirmed by The head directorate of Federal Educational Planning (FMGE, 2014) E-government is

a student's policy and international commitment. He also confirms that Sudan has previously formulated some policies to support the application of ICT. For instance, the first Five-Year Plan 2007-2011 aimed to increase the students' enrollment ratio for both boys and girls, improve the environment of schools, and strengthen the capacity of teachers and school principals. In addition, this plan also sought to achieve software-based education, encourage students to use ICT, and engage them in some innovative activities. The Five-Year Plan 2007-2011 shows that FMGE has worked to offer basic ETI and directed efforts to find a suitable solution to the application of ICT in Sudan's general education. In the second Five-Year Plan 2012-2016, FMGE gave priority to the implementation of this policy. Communities are encouraged to participate, and public resources are constructed. These sources are not only used for educational purposes in schools but also used as relevant data for implemented-government activities. That e-Learning is part of e-Government, but still, there is no policy for ICT or integrated vision of educational technology in Sudan. Alamin(2015) also demonstrated that and suggested an educational technology policy framework based on international experiences. Nevertheless, our analysis concludes that Sudan's ETI and ETP are still in an "emerging state". The government should try to take lessons from developing or developed countries that have more than 10 or even 20 years of experience in their construction of ETI. In addition, some international journals and non-governmental organizations also provide suitable solutions.

4.2. Electricity Coverage in Sudan

The Sudanese National Electricity Corporation (SNEC) and World Bank (2021) reported that 39.3% of Sudan's rural population areas and about 81.4% of Sudanese in urban population areas were connected to electricity in 2019. These general data have been used to assess the availability of electricity in education. Schools are supposed to have been connected to electricity in areas where electricity is available. For example, electricity is available in Khartoum; all the schools in Khartoum are supposed to have an electricity connection. Schools that have an electricity supply are likely to have the ability to connect to the Internet and use ICT.

According to the SABER-ICT framework (2016), three levels can be identified in Sudan's electricity-based ETI for urban areas the situation is between emergence and the established levels in the areas of electricity availability.

Almost 32% of total rural lands are in a situation between latent and emergence levels. It is worth noting that the urban population accounts for about 34% of the total population.

The state of electricity services in Sudan is a nationwide problem. It is challenged by wide lands that are sparsely populated. This imposes a real challenge for the construction of electricity infrastructure. See also (CIA, 2017). Figure 1 is a 2021 map of the electricity supply in Sudan by (Website of Sudan National Electricity Corporation (SNEC), 2021).

The lack of access to electricity is an international problem for technology-based educational reforms. According to World Bank (2021), by 2015 there is more than one billion people without an electricity supply and another one billion with an inadequate supply of electricity. In 2016, Renewals Global Status reported that some countries in Africa started to install solar home lighting systems, including Kenya, Uganda, and Tanzania. Solar systems provide a clean and reliable supply of electricity (Sengar et al., 2017). As a result, education has been improved. According to a questionnaire in Zambia, 75% of the respondents said that their children had changed their study routines after they had access to solar services; 69% said that their children spent more time studying in the evenings; 71% said that their children had improved their marks in school. (Gustavsson, 2006).

From the perspective of equity, the intervention should support both urban and rural areas. However, lack of the electricity supply in many rural areas in Sudan does not display any nationwide

educational policy intervention. We believe that solar energy is a solution to electricity-related problems in the construction of ETI in areas that lack an electricity supply.

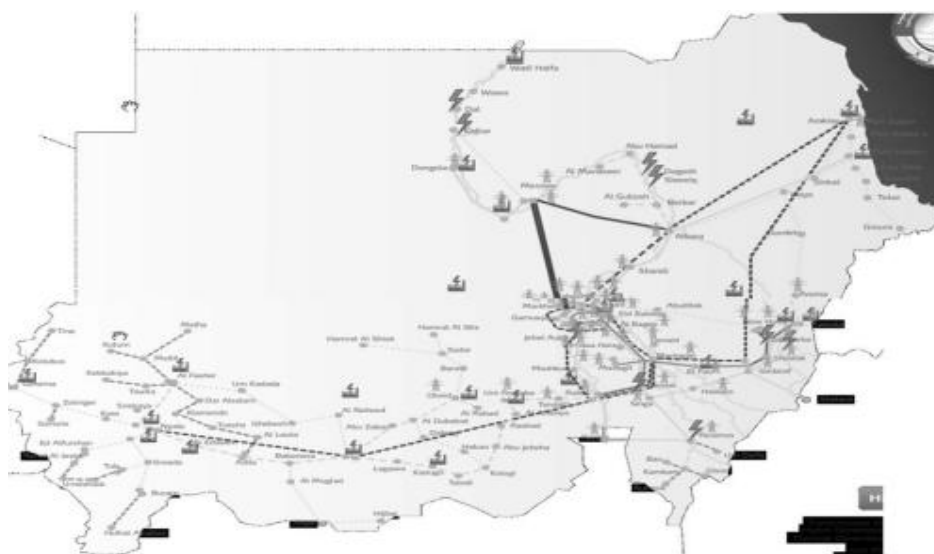


Figure 1: Electricity coverage area in Sudan (SNEC, 2021)

4.3. Internet in Sudanese Education

Sudan telecommunication Sudatel is a national company that owns internet cables in Sudan. In 2003 Sudatel in collaboration with Saudi telecom owned their cable Saudi-Sudan cable (SAS1) with a length of 330 Km and the highest capacity speed of 1.28 Terabit per second and in 2011 owned the second one (SAS2) with the same standard. **Sudatel** Submarine Cables Station has been built on an area of 2,400 square meters in Port-Sudan, the coastal town on the Red Sea (Alyaum, 2003; Sudatel, 2021; Submarine cables map, 2021)

The Internet in Sudan is managed by Sudan's National Telecommunication Corporation (NTC), a national governing body affiliated with the Federal Ministry of Information and Communication (MIC). NTC manages four Internet Service Providers (ISPs) or telecommunication companies, namely, Kanar, MTN, Sudani, and Zain. Currently, two types of connections are available in Sudan wired and wireless. Asymmetric Digital Subscriber Line (ADSL) provides the wired connection. This is a leased line that involves the leasing under a contract of the cable by a wired network operator to a company for the purpose of connecting to the Internet (Akue-Kpakpo, 2013). A wired connection provides good quality internet services. In Sudan, however, there is little ADSL coverage in some cities. In addition, a lack of governmental support or insufficient support impedes the development of ADSL. Therefore, Sudan's ISPs mainly provide mobile-wireless internet connections. For schools' education, this is a poorer alternative to a wired connection. Regarding Sudan's large surface area, developing economy and lower middle-income level (World Bank, 2021) the internet connection will grow in favor of wireless internet or mobile internet rather than ADSL connection. According to data collected from the formal government website of NTC, the current situation of internet penetration is as follows: the percentage of ADSL internet users is only 0.27% and that of mobile internet users is 99.73%. This contrast is understandable if we know that people who use mobile phones account for 74.1% of the total population and those who use fixed telephones account for about 0.31%.

According to Table 2, the number of internet users has increased significantly. Thabit is a sub-company of Sudani, and Kanar is also ISP, both of them provide ADSL internet services, while others provide mobile internet only. Table 2 also shows that nearly 50% of the internet users are using Zain's services, the oldest company; MTN was the next most utilized company. Sudani is the newest mobile internet service company. Thabit and Kanar have a much smaller number of users in comparison with other ISPs. According to Sudan Telecommunication and Post Regulatory Authority TPRA (2020), the total number of citizens who are able to use internet services reached 34,344,769 by the end of 2020, accounting for 78.4% of the total population. By November 2013, the AKAMAI Ranking of internet speed identified the average speed of internet in Sudan as 2.0 Mbps. It is worth noting that all the ISPs support 4G, that is, a generation of mobile telecommunication technology which provides mobile broadband access of tens of Mbit/s to smartphones and mobile modems in laptop computers.

Table 2. Internet Services Providers (ISPs) and the increase of internet users per years

ISPs	Increasing internet users per year		
	2011	2015	2020
Zain	1,325,491	5,363,096	16,099,159
MTN	734,910	3,835,958	9,603,105
Sudani	300,000	2,350,000	8,549,426
Kanar	10,000	14,854	53,445
Thabit	9,752	12,829	39,634
Total	2,380,153	11,661,883	34,344,769

Source: NTC Annual Report, 2016; Telecommunication and Post Regulatory Authority TPRA, 2020

Generally, Sudan is challenged by some obstacles in terms of the provision of ICT services. For example, the CIA (2017) indicated that “the sizeable areas of population are found around the capital city –Khartoum, southeast between the Blue and White Nile Rivers, and throughout South Darfur”. Nevertheless, the distribution of ICT services including electricity, mobile networks, and internet coverage with low quality and accessibility is shown in Figure 2 using data provided by AKAMAI (2013).

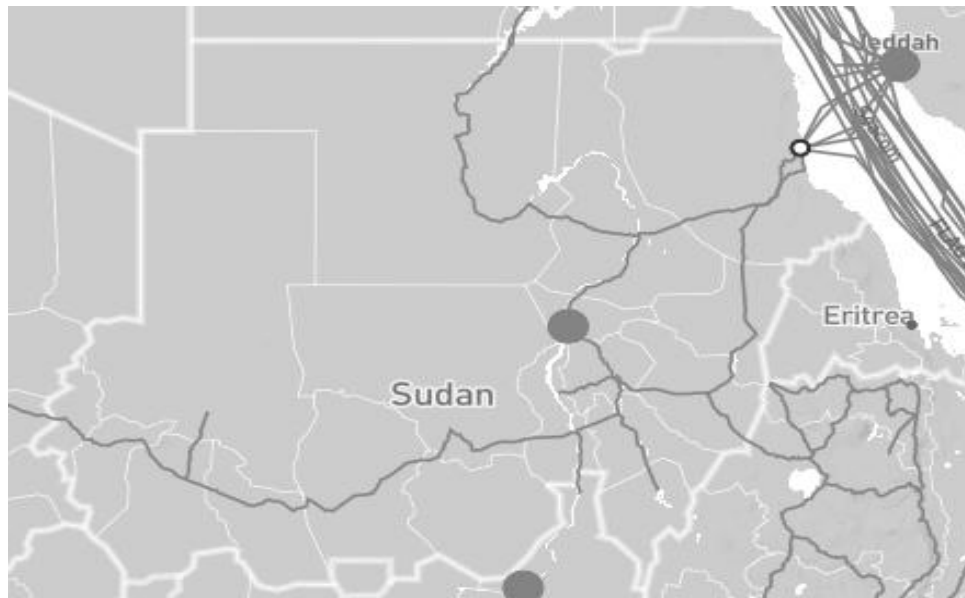


Figure 2. The optic fiber network in Sudan **Source:** Infrapedia (2022)

Figure 3 shows the population distribution in 2022. According to Knoema (2020), the population density in Sudan is about 22.7 per km². However, considerably wider areas are controlled by nomadic

tribes who are constantly on the move with their livestock, lands, routes, and farms. In addition, many tribes settle down around cities, villages, or rural remote areas. These tribes account for 9% of the total population and travel around 50% of Sudan's total land mass. The situation of density in Sudan is relatively associated with limited networks (Alamin & Abdelgabar, 2014). For instance, rural citizens account for 66% of the total population and most of them live in remote areas. Obviously, the fact that the Sudanese people live in considerably expansive lands of the country is a real challenge for ETI. This challenge can be demonstrated in a comparison with Egypt. According to World Bank Ranking, nearly 95% of Egyptians live in 5% of Egypt's total land area. Egypt's total land area is about 50% of Sudan's area. For this reason, the mobile connection is suitable for Sudan. Notably, by 2016 the NTC announced that mobile internet coverage reached around 84% of the total population and 43.5% of the total surface area.

Regarding the readiness of ETI in Sudan, there are no statistics about the connectivity of schools in Sudan, and no preferential policies toward accessing the internet from schools (FMGE, 2014). This also shows that policymakers do not have an integrated vision towards supporting schools' internet connectivity and there is a lack of policies towards ETI in general. Some countries suggested an "e-rate" policy. For example, the US supports discount rates for the schools' connectivity, while the connectivity is completely subsidized for the schools in China and the UK (Alamin, 2015). The collaboration with ISPs for adopting an e-rate policy could make a breakthrough in the situation of school's internet connectivity. According to policies recommended by the SABER-ICT framework (2016), internet connectivity in schools or even the whole country can be evaluated on two levels; that is, the established level and the latent level. The first level is related to mobile internet coverage and the second level is related to the connectivity in Sudan's schools or the availability of internet lines based on ADSL or fixed telephones. The data discussed in this section show that efforts have been made by the ISPs to cover Sudan's major population so that students from remote areas may have internet access. However, it is also shown that ETI is challenged by poor electricity supply and internet coverage in terms of ADSL. Even mobile internet fails to cover all the population areas. In addition, internet speed is also a challenge for any attempt to integrate ICT in education.

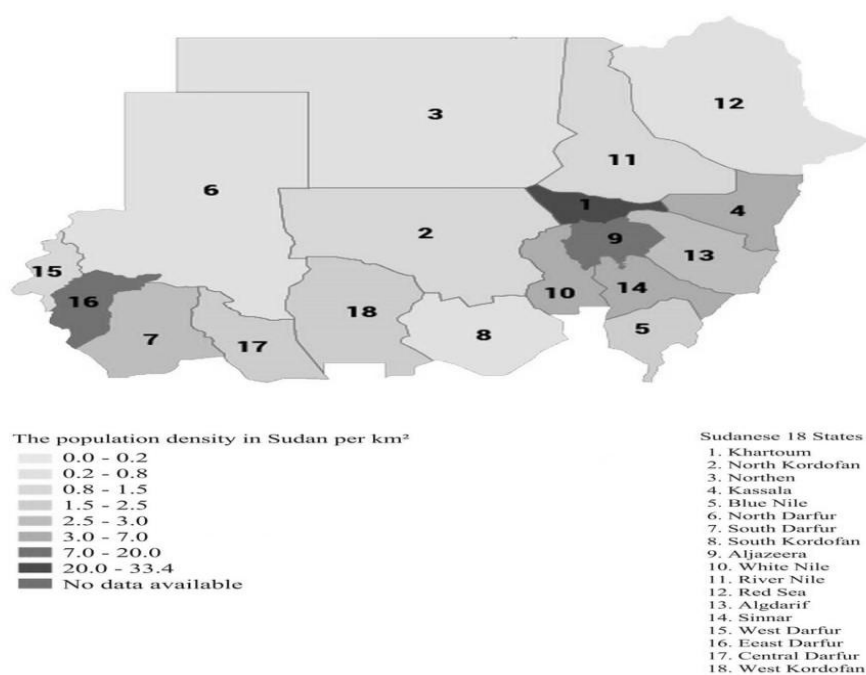


Figure 3. The distribution of the population (Fanack, 2020)

4.4. Computers per student

It has been shown that simply putting computers into schools does not impact students' learning. It is special ICT applications that reform teaching and learning practices, enable education innovation, and even improve conditions in the community (Kozma, 2008). According to NTC (2013), the government imported 68,008 computers: 50,000 computers for families under a project named "Computer for Every Family", 16,650 computers for schools, and 1,358 computers for labs. Tairab et al. (2016) finds that the Federal FMGE equipped secondary schools with 21,860 computers in 2014, and 92 schools among 21,235 schools have been connected to the internet. In addition, 103 e-classrooms have been established across the country, distributed in seven states.

Table 3. Shows that the total number of students was 82,765, while the computers distributed among high school students were 27,826. Consequently, the ratio of students per computer in high schools is 28:1. This ratio, however, does not serve as an indicator because there are no records to show if the computers are still working or not in the schools (Alamin, 2015). Different schools have different numbers of students: some schools have more than 1000 students, but others have less than 100. Though no accurate numbers of computers in basic and high schools have been collected, governmental efforts have provided high schools with a given number of computers (Alnuaman, 2015; FMGE, 2014). As indicated by Assamany and Rayan (2011), the government has distributed 14 computers per school in 1,987 public high schools, according to the statistics of Table3 that about 55% of high schools in Sudan have computers. This indicates that the government is making an effort to improve ETI. According to SABER standards, the situation in secondary education is at the "emerging level" but the situation in basic education is still at the "latent level". In view of this, the FMGE should measure the current status of the connectivity in the schools, and take advantage of the relevant policies, including E-rate policies, student loans, bring-your-own-devices (BYOD), and adopt economic methods for supporting ETI. This will galvanize the desire of students to own smart devices and stay connected to the internet with a positive response to ETI. Given these policies, work should also be done by teachers and students to enhance the process of teaching and learning with ICT.

Table 3. Sudanese education

2017 Data	Total Number
Number of Basic schools	18,052
Number of High schools	3644
Total school	216916
Number of Basic school students	5800829
Number of High school students	782765
Total number of students	7580484
Number of Basic school teachers	161345
Number of High school teachers	44943
Total number of teachers	206297
Total number of computers in high schools	27826

Source: FMGE (2013, 2017); See also (Alamin, 2015).

4.5. Educational management information system (EMIS)

The Education Management Information System (EMIS) refers mainly to a statistical project that helps policymakers make decisions based on appropriate information. In some poorer countries, the

EMIS is manual (UNESCO, 2003). Sudan's EMIS covers the statistics of 18 states. EMIS supports decentralized decision-making and helps with educational planning and budgeting. Provincial ministries are supported by computers, training manuals, and resource guides. The project developed its first report in 2013 after signing an agreement between partners/donors in collaboration with UNICEF, the EU, and the Education Planning Directorate.

The EMIS Project commenced in September 2008 and following a ten-month extension from March 2010, ended in December 2010. Consultants funded by the EU and through UNICEF provided technical support for projects at the Federal and the state level. As indicated in the first report of EMIS (FMGE, 2013), the project is only partially successful. According to the educational planning director (2014), efforts have been taken to train educational managers in all the Sudanese States, particularly statistical specialists who are responsible for educational planning and reporting. She also points out that EMIS supports decentralized policymaking. Since the first publication of EMIS in 2013, the FMGE has not published any further EMIS reports for the audience. The situation of EMIS is still at the "emergence level" according to SABER standards. Nevertheless, to upgrade the level of Sudan's EMIS, systematic or periodical data should be collected in conformity with EMIS indicators and published to the audience. Various aspects of ICT could be adopted to improve the FMGE internal data collection, including supporting EMIS with new tools like Android Apps, websites, and social media groups for EMIS managers in the whole country. These can speed up and adjust the procedures of data collection and analysis. Furthermore, software tools and open-access data of EMIS provide researchers and policymakers with a platform of ubiquitous educational data and information.

4.6. Digital tools and educational resources

Open educational resources (OER) are conducive to teaching and learning, including videos, audio, animations, texts, electronic books, games, and courses, as well as various educational tools (Alamin, 2015). The UNESCO Qingdao declaration (2015) recognizes these digital educational resources. This is an important step to reduce the technology gaps between developed and under-developed countries and supports the equality of education. UNESCO is committed to developing sector-wide strategies and building projects of OERs to expand educational access and achieve quality by 2030.

In 2004, Sudan's FMGE introduced ICT as part of the national curricula in secondary education, and in response to the requirements of the 21st century, NCCER is now planning to introduce computer science for basic education. In association with these efforts, NCCER started to introduce computers into the general education curriculum. As explained by the head directorate of federal educational planning (2014), good achievements have been made in this project. According to her, the idea of this project was suggested before 2012. The official curriculum is covered, and texts are designed based on instructional theories. On this basis, a new national curriculum will be developed and then introduced gradually nationwide by 2015 (FMGE, 2014). Due to the lack of applications and digital resources in Sudan's public education, no governmental e-learning platform has been established in Sudan for public education.

E-learning platforms are very important to achieve the quality of 21st-century education in Sudan (Alamin, 2015). The private sector, national organizations, and international organizations support digital resources. The private sector and international organizations had initiated projects to build virtual schools and digital resources. International organizations have provided offline games and digital resources for children who are excluded from formal education. Notably, the number of children out of formal, basic education in Sudan is the highest in the Middle East and North Africa (MENA) (UNICEF, 2015). In 2013, UNICEF announced its two-phase project. In the first phase, 67 children in

3 villages attended the alternative game-based mathematics course for 45 minutes per working day. The course lasted for 45 days. In the second phase, a similar course is open to 591 children in 19 villages for six months in remote villages (Stubbé et al., 2016). Except for the current work conducted by NCCER, the Sudanese government should make a greater effort to support the development of digital educational resources.

The work of UNICEF or NCCER is insufficient to deal with the real situation. These resources are needed for formal education and for those students who are out of basic education. According to the SABER guide for assessing ICT in education, digital educational resources are still at the “emergence level”. The government needs to discover the experiences of other countries in the same socio-economic status with similar ETPs to work collaboratively with the private sector and non-governmental organizations, especially ISPs and UNICEF, to boost digital educational resources. These are considered official efforts to provide digital resources for general education students in Sudan. In practice, the efforts made informally by teachers to make digital resources available, especially books and lessons in PDF and Word formats, have become popular among students and teachers and are shared in social groups between teachers and their students, especially in urban areas where the electricity supply is almost stable. While, videos, tutorials, and experiments are still relatively few, most of them are available for a fee and cannot be obtained for free.

5. Conclusions and Recommendations

The present study highlights the importance of ETI in the core ETPs of the US, the UK, and China. According to related literature and publications of UNESCO and the World Bank, major factors for assessing ETI in Sudan are identified, including ETPs, electricity supply, internet connectivity, and speed, the ratio of students to computers, the Educational Management Information System (EMIS), and digital resources. This study helps the policymakers in Sudan in identifying the current status of ETI in Sudan. The study was challenged by the lack of official data on the ETI and the lack of updated educational data after the year 2018 because Sudan witnessed the start of the December revolution at the end of 2018. This was followed by an unstable-political situation and the succession of governments with different political views, and these conditions are still continuing. Consequently, this situation affected the collection of educational data, which has not been updated so far.

The findings of the study report on (1) the lack of comprehensive vision for ICT in Sudan's education; (2) Sudan's lack of ETI discourages technology-based intervention; (3) the electricity shortage, hindering the development of in urban areas; and (4) the ratio of student to the computer in high schools 1:28, indicating lack of computers in basic education. The equipment of computers in primary schools is rated as “latent level” and that in secondary schools is rated as “emergence level”. In addition, mobile internet connectivity is rated as “established level” and fixed internet connectivity is rated as “latent level”. EMIS and digital educational resources are rated as “emergence level”.

The study recommends the following: (1) the Sudanese government needs to learn from global lessons to implement ETPs; (2) solar energy works as a solution to the shortage of electricity supply; (3) FMGE should identify the current status of connectivity in schools, take advantage of various policies, including the e-rate policy, student loans, BYOD policy, and take economic measures to provide schools with computers; (4) the government should collaborate with ISPs and NTC to extend mobile internet coverage, improve ETI, and enact relevant ETPs; and (5) EMIS should be supported with new tools like Android apps, websites or social media groups for EMIS managers. Furthermore, software tools and open-access data of EMIS provide a platform of ubiquitous educational data and information. The experiences of other countries and collaboration with the private sector and non-governmental organizations are decisive for Sudan's future development of ETI.

Finally, we suggest that educational researchers can conduct studies on the effectiveness of Digital Educational Resources (DER) or Open Educational Resources (OER) in Sudanese general education or for nomadic students specifically, and improve the currently used of DER and OER in a manner consistent with global trends, the government should adopt serious studies in determining the current situation of education technology policies and infrastructure from an international perspective in order to develop its first educational technology plan.

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