Journal of Studies in Social Sciences and Humanities
http://www.jssshonline.com/
Volume 5, No. 4, 2019, 123-134
ISSN: 2413-9270

Appraisal of infrastructure capacity in Sub-Saharan Africa

Eyitayo Ogbaro
Lecturer, Department of Economics, Faculty of Business & Social Sciences,
Adeleke University, Ede, Nigeria
ogbarooye@yahoo.com

Dr. Sunday Oladeji
Professor, Department of Economics, Faculty of Social Sciences,
Obafemi Awolowo University, Ile-Ife, Nigeria

Abstract
The aim of this study is to appraise the capacity of infrastructure stocks in Sub-Saharan Africa in comparison to six other developing regions of the world over the period 1996-2015. This is with a view to ensuring that policy makers in Sub-Saharan Africa make infrastructure development choices that are concrete, efficient and growth-stimulating. To achieve this objective, the study uses a graphical approach involving line graphs as well as bar charts in appraising the infrastructure indicators. The findings reveal that a clear gap exists in the infrastructure capacity of the Sub-Saharan African region vis-à-vis the other developing regions. Hence, it is critical for countries in the region to address these shortfalls for the purpose of unlocking the region‘s productive potential so as to optimize the potentials of infrastructure in stimulating economic growth.

Keywords: Appraisal, Infrastructure, Indicators, Sub-Saharan Africa; Principal Component Analysis

Introduction

Governments in most countries of the world have prioritized infrastructure development in their policy agenda over the last two and half decades. This follows the recognition of the crucial role that adequate infrastructure development plays in the achievement of sustainable economic growth (Jerome, 2011). Sub-Saharan Africa (SSA) is not left out in the quest for generating the much needed sustainable economic growth through the scaling up of infrastructure stocks. However, in a report submitted to the G20 group of countries, which is an international forum for the governments and central bank governors from 20 major economies, the World Bank Group (2011) points out that progress on the region’s infrastructure agenda is constrained by lack of accurate data on infrastructure needs. Meanwhile, Andrés et al., (2014) argue that detecting gaps in the data on infrastructure and finding solution to the gaps are critical if governments are to make infrastructure development choices that are concrete, efficient and growth-enhancing. This paper therefore addresses this knowledge gap by appraising the stocks of infrastructure in the region.

The paper is divided into five sections. The next section contains a short literature review, followed by the methodology on which the study is based. The appraisal of the stocks of infrastructure in the SSA region is presented in section four, while the last chapter focuses on summary conclusion and recommendation.

Review of Empirical Literature

Only a handful of studies have analysed the trends of infrastructure stocks in SSA. One of such studies is the one carried out by Bogetic and Fedderke (2005), the objective of which is to investigate the performance of selected Southern African Customs Union (SACU) countries in four major infrastructure sectors over the period 1997-2003. The selected SACU countries are South Africa, Botswana, Lesotho, Namibia, and Swaziland, while the four infrastructure sectors considered are electricity, water and sanitation, information and communication technology, as well as transportation. Using a World Bank international database from over 200 countries, the authors carried out a comparison of each SACU country against the relevant group of comparator countries in terms of performance. The other geographical groupings comprise SSA, Organization for Economic Cooperation Development (OECD), South Asia, East Asia and Pacific, Middle East and North Africa, Latin America and the Caribbean, Europe and Central Asia, and the world. The results reveal that the SACU countries trail the other geographical groupings in several of the indicators of infrastructure.

Another example is the study by Calderón and Servén (2008), the objective of which is to place the experience of SSA in international context as regards infrastructure performance over the period 1960-2005. The approach adopted by the authors involves comparing the quantity as well as quality of SSA's infrastructure in three sectors to those available in other world regions and developing country groups. The three sectors are telecommunications, power and roads, while the other world regions and developing country groups include South Asia as well as East Asia and Pacific. The authors find that SSA consistently trails the other regions in terms of both quantity and quality of infrastructure.

Also, Dethier and Moore (2012) compare the stocks of infrastructure in developing regions of the world with their developed counterparts for the years 2008 and 2009. The developing regions included in the study are East Asia, Europe and Central Asia, Latin America, Middle East and North Africa, South Asia as well as SSA, while the infrastructure indicators used are electricity production, electricity consumption, average telephone mainlines, road density and access to improved water source. Their findings reveal that, with the exception of electricity consumption, SSA trails the other developing regions in all dimensions of infrastructure. The authors also find that the stock of infrastructure is between 8 to 20 times larger in richer countries than in developing countries on average.

In addition, Ianchovichina et al., (2012) conduct an appraisal of average infrastructure endowments in the developing world over the period 2005-2008. The infrastructure indicators used are density of paved road network, telephone density, electricity generating capacity, access to electricity, improved water source and improved sanitation facilities. The developing world comprises East Asia and Pacific, Europe and Central Asia, Latin America and the Caribbean, Middle East and North Africa, South Asia, as well as SSA. The appraisal showed that, with the exception of density of paved road network, SSA trails the other regions in all the dimensions of infrastructure.

Furthermore, Kodongo and Ojah (2016) use data on fixed line telephone, mobile telephone, internet density, improved sanitation, clean water, and electricity production from 2007 to 2013 in presenting a comparison of infrastructure performance for developing regions of the world. The regions included in the study are Middle East and North Africa, Latin America and the Caribbean, Developing Europe and Central Asia, East Asia and Pacific, as well as SSA. The findings reveal that SSA lags behind the other regions on every key metric.

Finally, Calderón et al., (2018) assess the performance of infrastructure in SSA in comparison with other developing regions of the world using data on telecommunications, electric power, transportation, as well as water and sanitation for 1990 and 2014 only. The other developing regions included in the study are South Asia, the Middle East and North Africa, Latin America and the Caribbean, as well as East Asia and the Pacific. The results reveal that there is a clear gap between SSA and the other regions in terms of infrastructure development.

The review above shows that all the studies, with the exception of the one by Bogetic and Fedderke (2005), failed to consider the possibility of variations within the countries in the region in terms of their infrastructure capacities. Even the scope of the study by Bogetic and Fedderke (2005) is limited to countries in the SACU sub-region without considerations for the other countries in the region. Also, the studies employed individual infrastructure indicators in their appraisal. The problem with such an appraisal is tha it may not be able to present This paper differs from the previous studies in two ways. One, it extends the appraisal to the aggregate or composite infrastructure index in addition to the individual indicators. The advantage of using the aggregate index is its ability to correct for the high degree of correlation that has been found to exist among the different indicators of infrastructure as attested to by scholars such as Calderón and Servén (2004a) as well as Calderón

(2009). Two, it updates the existing knowledge on the capacity of infrastructure stocks in the SSA region by using a more recent dataset over a longer period.

Methodology

Method of Appraisal

This paper appraises the capacity of infrastructure in Sub-Saharan Africa as a region in comparison to six other developing regions of the world in line with the previous studies. The other developing regions included in the appraisal are East Asia & Pacific (EAS), Europe & Central Asia (ECS), Latin America & the Caribbean (LCN), Middle East & North Africa (MEA), North America (NAC) as well as South Asia (SAS). The list of comparator countries comprises those countries in other parts of the developing world that fall into the same income bracket as countries in SSA. To achieve its objective, the study uses a graphical approach involving line graphs as well as bar charts in appraising the infrastructure indicators.

Data

The data employed in this study is a panel of forty-one (41) SSA countries over the period 1996-2015. Due to data availability, the study considered four out of the five infrastructure sectors (telecommunications, electric power, clean water and improved sanitation). Two infrastructure indicators are included from the telecommunication sector, namely, fixed telephone subscriptions and mobile cellular subscriptions (both per 100 people). The electricity, water and sanitation sectors are proxied by electric power consumption (kilowatt-hour (kWh) per capita), improved water source (% of population with access) and improved sanitation facilities (% of population with access), respectively. All data are sourced from the World Development Indicators (WDI) of the World Bank.

In addition to the individual indicators, the study also appraises an indicator of the overall index of infrastructure which combines the five indicators using the PCA method. The synthetic index of infrastructure is the first principal component of the individual dimensions of infrastructure. The need to include this index in the appraisal was informed by the need to correct for the high degree of correlation that has been found to exist among the different indicators of infrastructure.

Appraisal of Infrastructure Capacity

In this section, the appraisal of the adequacy of individual infrastructure indicators as well as the aggregate infrastructure index is carried out.

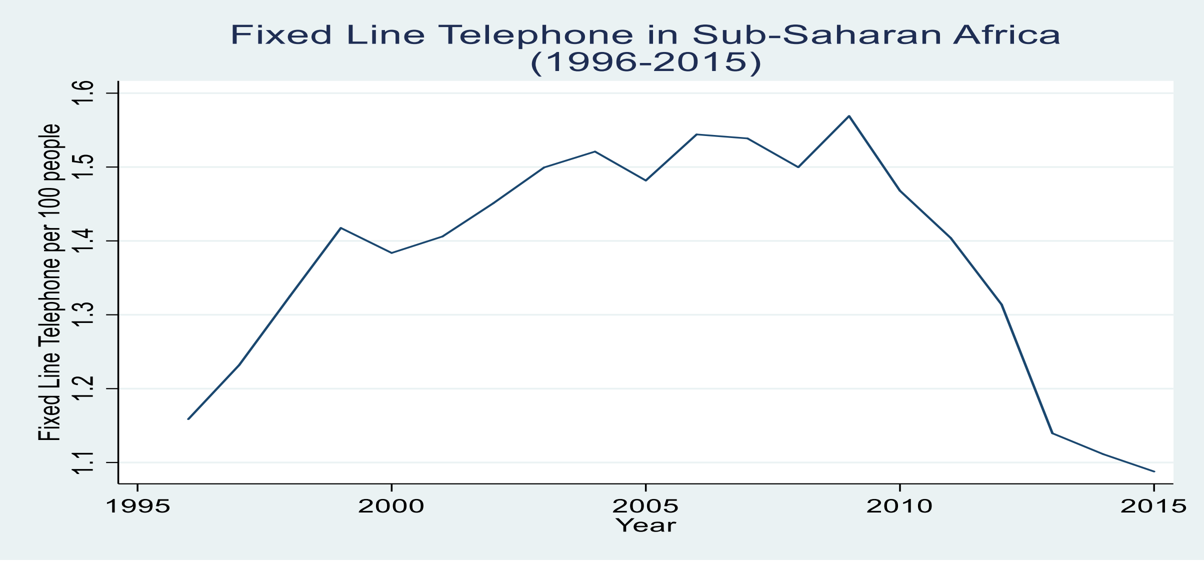
Individual Infrastructure Sectors

This sub-section presents the trends of the different dimensions of infrastructure in SSA and also appraises them vis-à-vis the global peer group of developing countries.

Telecommunication. The indicators used for the appraisal of the telecommunication sub-sector are fixed line telephone and mobile cellular telephone (both per 100 people).

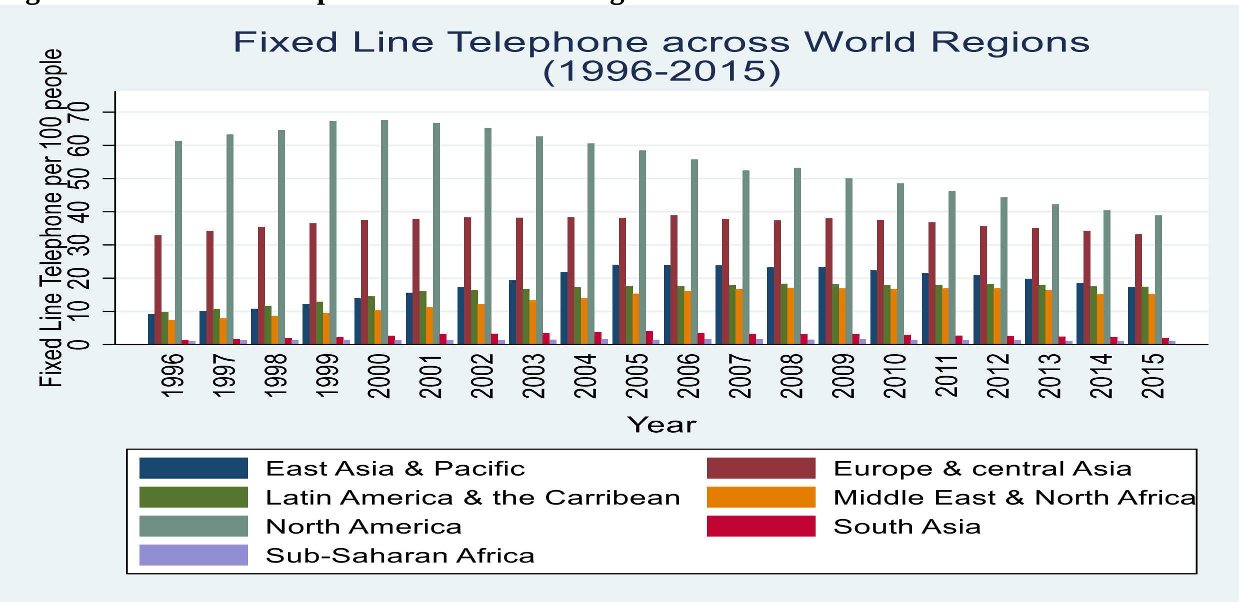
Fixed line telephone. Figure 1 show that from an initial value of 1.16 in 1996, fixed line telephone per 100 people in the whole of the SSA region reached its highest coverage of 1.57 in 2009, but fell afterwards reaching its lowest coverage of 1.09 in 2015. Compared to the comparator groups, the SSA region is well below the international standard on fixed line telephone coverage as shown in Figure 2. The figure shows that fixed line telephone coverage in SSA has remained below 1.6 lines per 100 people over time compared to other developing regions which have at least 7.4 lines per 100 people with the exception of South Asia. It can also be seen from the figure that coverages in East Asia & Pacific (with about 33% of the world population), Europe & Central Asia (with about 13% of the world population), Latin America & the Caribbean (with about 9% of the world population), Middle East & North Africa (with about 5% of the world population), North America (with about 5% of the world population) and South Asia (with about 23% of the world population) are around 13, 27, 12, 10, 41 and 2 times the level in SSA (with about 12% of the world population), respectively. Jerome (2011) claims that one of the factors responsible for SSA's low overall access is insignificant service coverage in rural areas which are the homes of a large percentage of the population.

Figure 1: Fixed Line Telephone in Sub-Saharan Africa



Source: Author's computations based on WDI of the World Bank (2020).

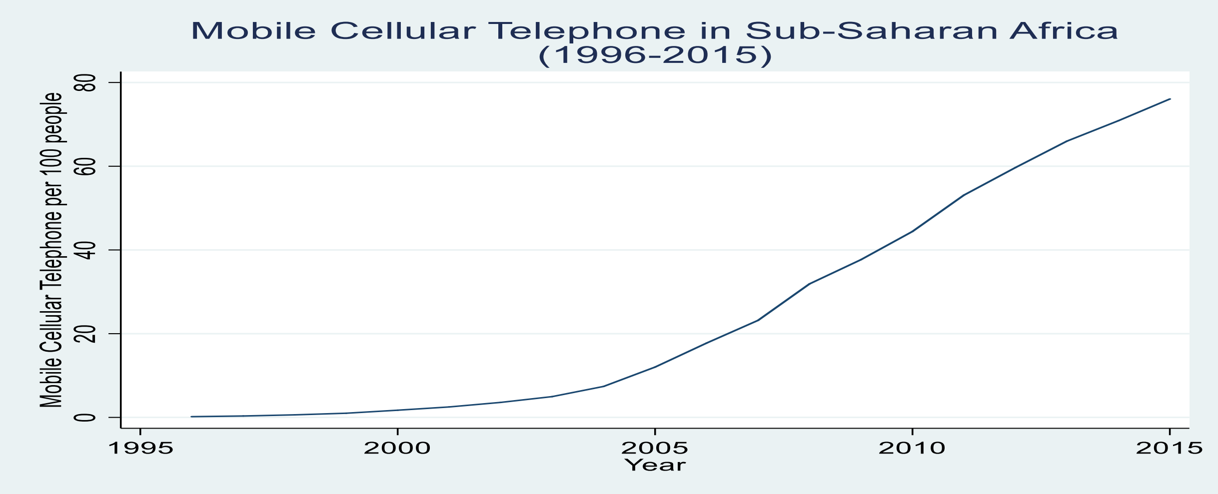
Figure 2: Fixed Line Telephone across World Regions



Source: Author's computations based on WDI of the World Bank (2020).

B. mobile cellular telephone. To some extent, the apparent low fixed line telephone reach in the region has been compensated for by the expanding mobile telephone coverage as shown in Figure 3. The figure shows that mobile cellular telephone in the SSA region increased consistently over time from an initial value of 0.18 per 100 people in 1996 to 76.06 in 2015.

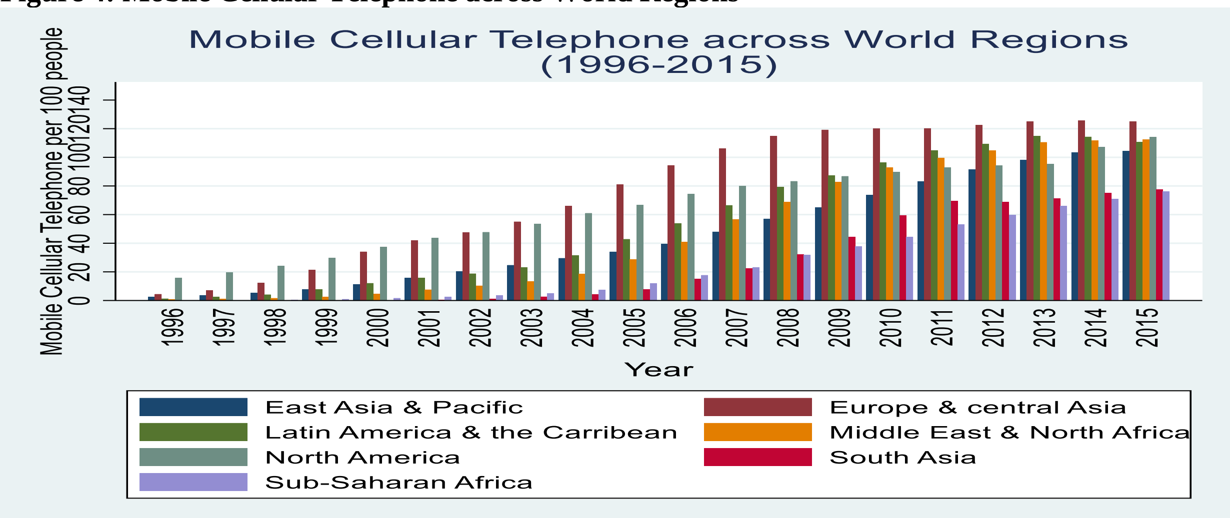
Figure 3: Mobile Cellular Telephone in Sub-Saharan Africa



Source: Author's computations based on WDI of the World Bank (2020).

When compared to other developing regions, however, SSA is still below international standard in terms of mobile telephone reach as shown in Figure 4. The figure shows that the reach in SSA was below those of the other regions throughout the period of study with the exception of South Asia. SSA was above South Asia on the mobile telephone score from the start of the period up to the year 2007, after which coverage expanded more rapidly in the latter than the former. In fact between 2007 and 2015, the region's mobile cellular telephone increased by 230.4% - from 23 lines to 76 lines per 100 people. This is opposed to South Asia where it increased by 247% - from 22.5 lines to 78 lines per 100 people over the nine-year period. On the contrary, the increase in population in the SSA region was 12% more than in South Asia over the same period.

Figure 4: Mobile Cellular Telephone across World Regions

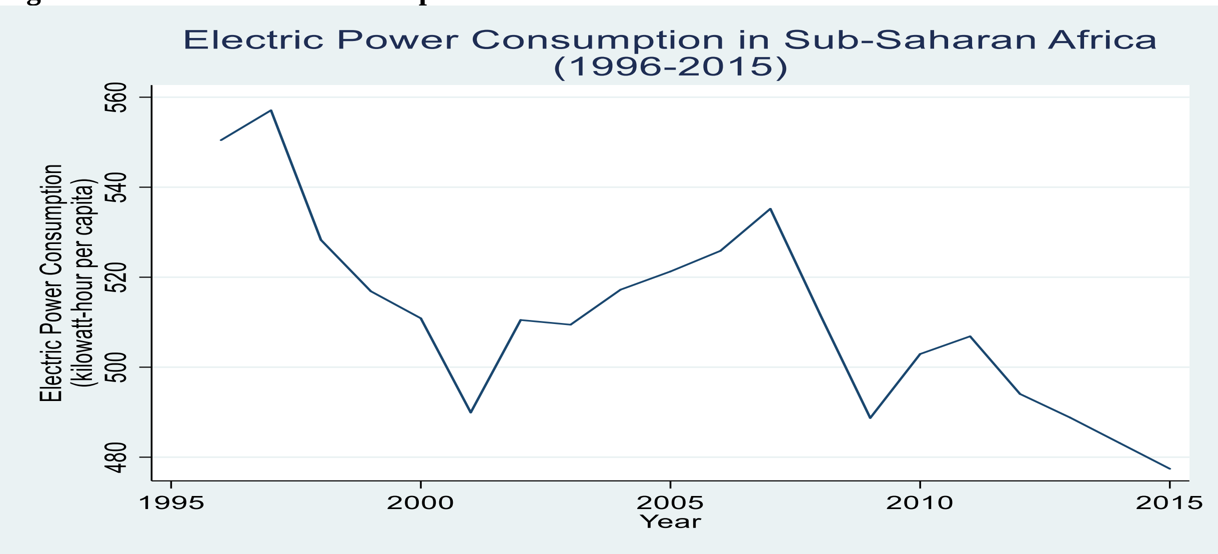


Source: Author's computations based on WDI of the World Bank (2020).

Thus, SSA ended up at the very bottom of the metric among all the developing regions of the world. It can also be seen from the figure that mobile telephone lines in East Asia & Pacific, Europe & Central Asia, Latin America & the Caribbean, Middle East & North Africa, North America and South Asia are around 4, 10, 4, 2, 16 and 0.7 times the level in SSA, respectively.

Eectric power. Two essential ways of ascertaining the contribution of electric power to the development of an economy are its accessibility and consumption (Castellano et al., 2015). Based on the consumption perspective, the power sector is the worst performing infrastructure sector for the SSA region as shown in Figures 5 and 6. Figure 5 shows that from an initial value of 550.46 kWh per capita in 1996, electricity consumption in SSA increased over the next one year to its highest value of 557.09 kWh per capita. It thereafter decreased by 12 percent over the next four years to 489.93 kWh per capita in 2001. It fluctuated over the rest of the period and finally settled at its lowest value of 477.42 kWh per capita in 2015.

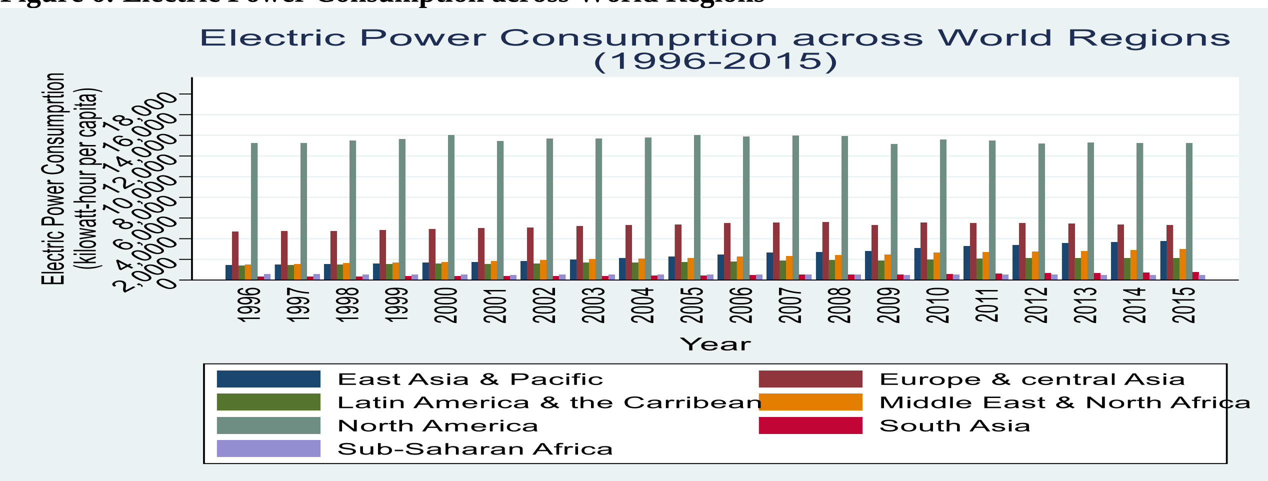
Figure 5: Electric Power Consumption in Sub-Saharan Africa



Source: Author's computations based on WDI of the World Bank (2020).

When compared to other world regions, the picture is similar to the one in mobile cellular telephone coverage as illustrated by Figure 6. The figure shows that power consumption in SSA was below those of the other regions over the period of study with the exception of South Asia. SSA was above South Asia on the electric power consumption score from the start of the period up to the year 2008, after which consumption decreased continually in the former but continued to increase to the end of the study period in the latter. In fact, the whole of the SSA region (with about 12% of the world population) actually consumed a total of 10,226.57 kWh per capita of electricity amounting to only 1.9% of the world's total electricity consumption over the entire period of the study. It also amounted to about 21%, 10%, 29%, 23%, 4% and 110% of the consumption rates in East Asia & Pacific, Europe & Central Asia, Latin America & Caribbean, Middle East & North Africa, North America and South Asia, respectively.

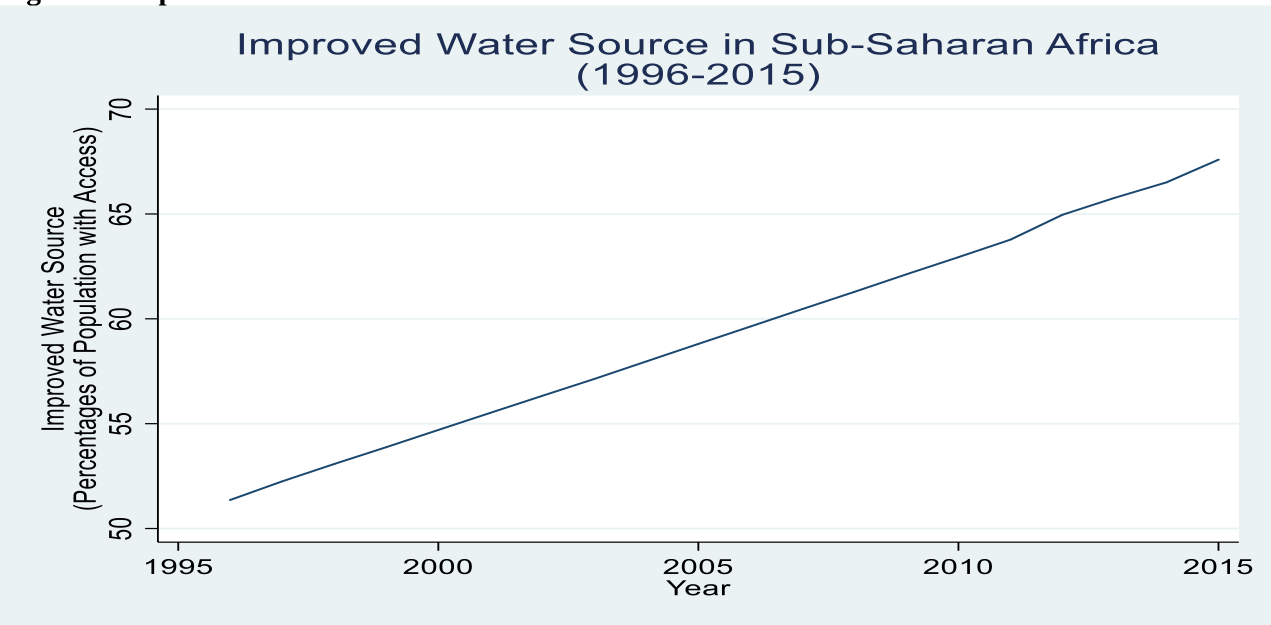
Figure 6: Electric Power Consumption across World Regions



Source: Author's computations based on WDI of the World Bank (2020).

Water. Despite making some progress in the area of water supply, there is still much to be done in SSA as shown in Figures 7 and 8. These figures illustrate improved water source (measured by percentages of population with access) in SSA and across world regions, respectively. Figure 7 shows that from an initial value of 51 percent in 1996, the proportion of people with access in SSA increased throughout and settled at its highest value of 68 percent in 2015.

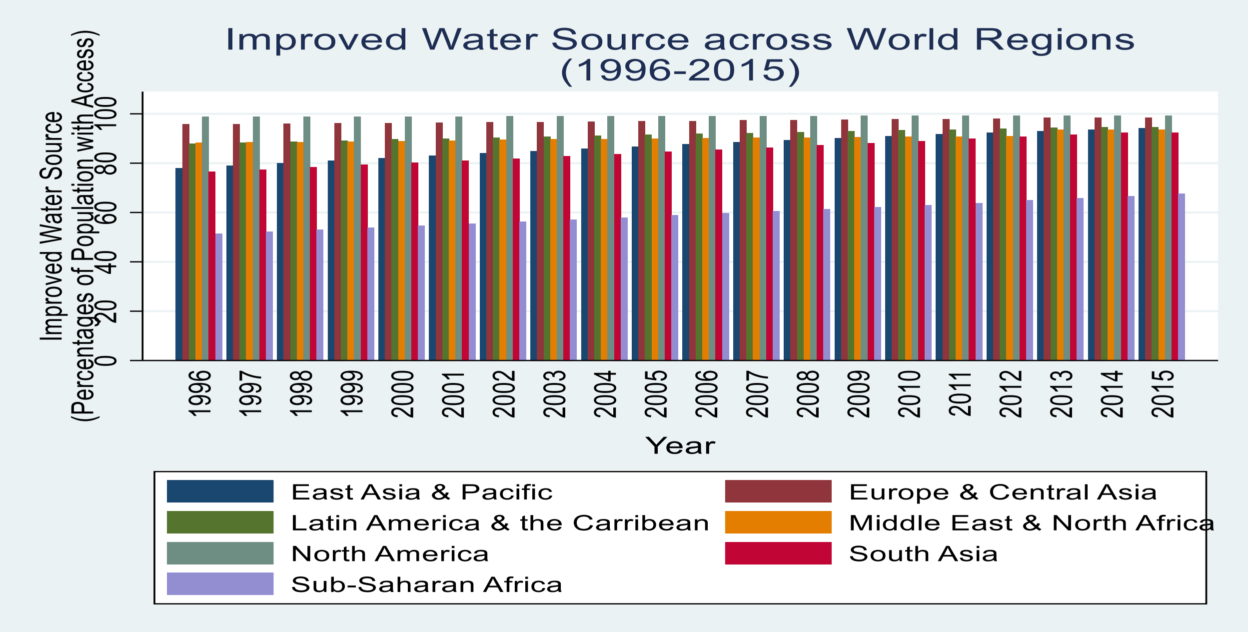
Figure 7: Improved Water Source in Sub-Saharan Africa



Source: Author's computations based on WDI of the World Bank (2020).

Figure 8, which compare access across regions, shows that the region's progress in improved sources of drinking water has been slow—access grew by only 17 percentage points between 1996 and 2015. As much as 325 million people in SSA did not have access to an improved water source in 2015. This is poor compared to 134 million in East Asia & Pacific, 14 million in Europe & Central Asia, 34 million in Latin America & the Caribbean, 28 million in Middle East & North Africa, 3 million in North America and 133 million in South Asia. These figures are similar to the ones contained in a report released by the World Health Organization (WHO) and United Nations Children's Fund (UNICEF) (2015) which put the population of people worldwide without access to improved drinking water sources in 2015 at 663 million with close to half of them residing in SSA. These figures suggest that one of every two people in the world who do not have access to improved drinking water is resident in SSA.

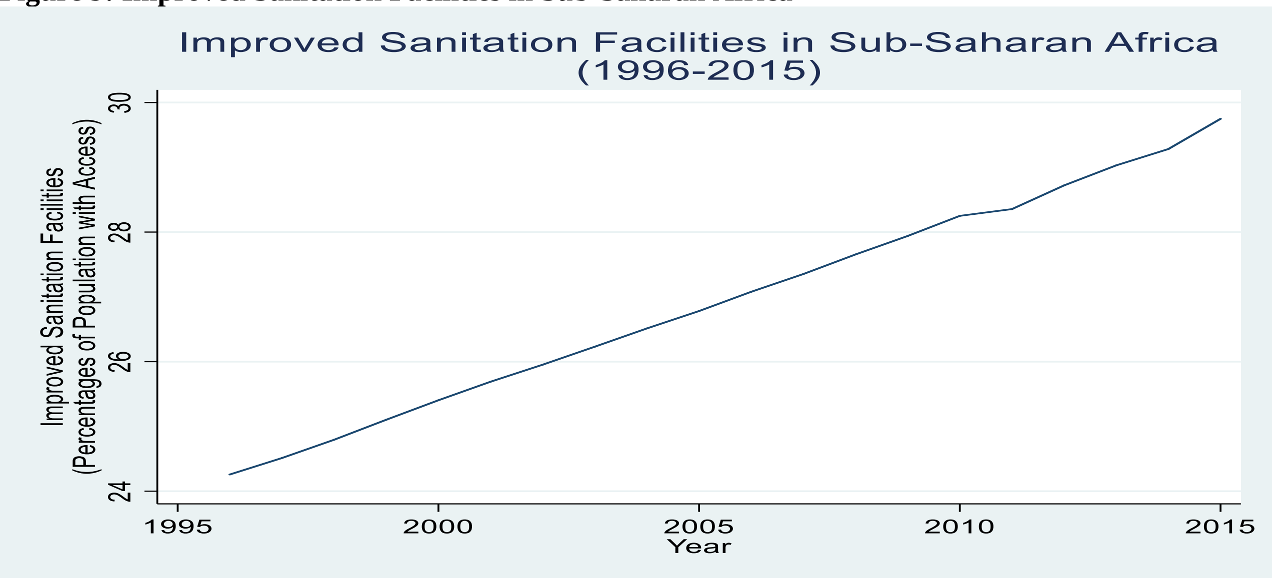
Figure 8: Improved Water Source across World Regions



Source: Author's computations based on WDI of the World Bank (2020).

Sanitation. Just like water, much still remains to be done in SSA in the area of sanitation despite the achievement recorded by the region as shown in Figures 9 and 10. These figures illustrate improved sanitation facilities (measured by percentages of population with access) in SSA and across world regions, respectively. Figure 9 shows that from an initial value of 24.3 percent in 1996, the proportion of people with access in SSA increased throughout and settled at its highest value of 29.8 percent in 2015.

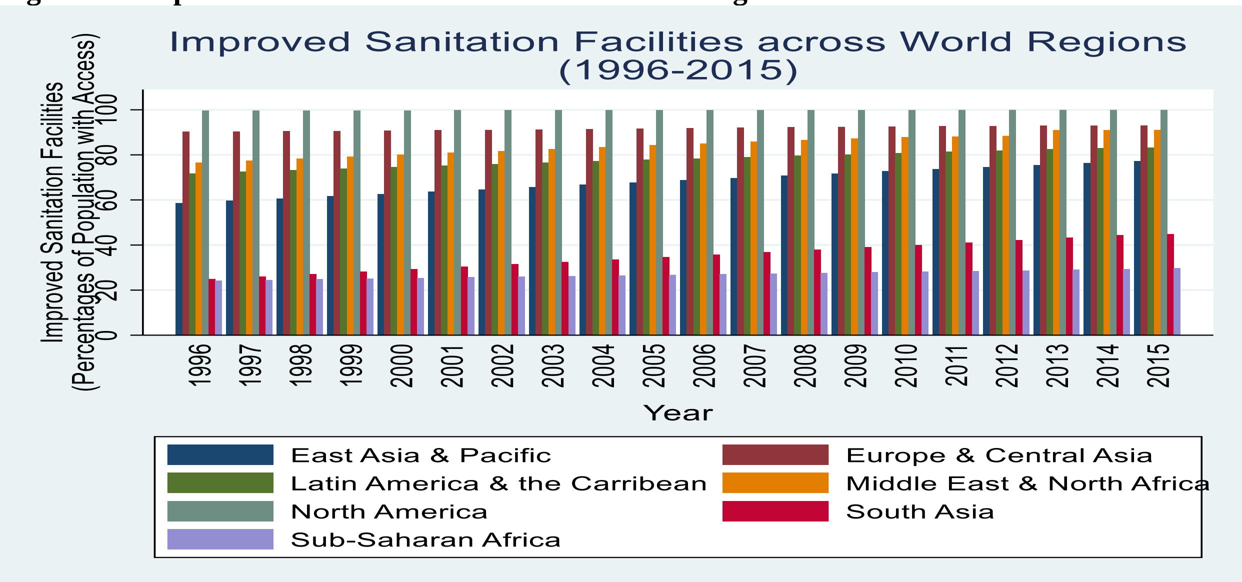
Figure 9: Improved Sanitation Facilities in Sub-Saharan Africa



Source: Author's computations based on WDI of the World Bank (2020).

Figure 10, which compares access across regions, shows that the region's progress in improving sanitation facilities has been slow—access grew by a paltry 5.5 percentage points between 1996 and 2015. This is poor compared to 18.6 percent in East Asia & Pacific, 11.4 percent in Latin America & the Caribbean, 14.5 percent in Middle East & North Africa, and 19.8 percent in South Asia. Only Europe & Central Asia as well as North America were below SSA in terms of percentage increases in the proportion of people with access to improved sanitation facilities, but were well ahead of the region in actual values. These figures are similar to the ones contained in the report released by the WHO and UNICEF (2015) which put the population of people worldwide who did not have access to improved sanitation facilities in 2015 at 2.4 billion, with 29 percent (or 695 million) of them residing in SSA. These figures suggest that of every ten people in the world who do not have access to improved sanitation facilities, about three reside in SSA.

Figure 10: Improved Sanitation Facilities across World Regions



Source: Author's computations based on WDI of the World Bank (2020).

Aggregate Infrastructure Index

This section focuses on the appraisal of the aggregate index of infrastructure stocks which is constructed from the individual indicators using the Principal Component Analysis (PCA) method. Donaubauer, Meyer and Nunnenkamp (2014) argue that the high collinearity between different infrastructure indicators would give rise to an identification problem if some or all of them were included jointly in a regression analysis. To confirm this high collinearity, the correlation between the indicators used in this study was computed and presented in Table 1 below.

Table 1. Correlation between Infrastructure Indicators

Correlation Probability	TTL	EPC	IWS	ISF
TTL	1.000000 -----			
EPC	-0.912389 0.0000	1.000000 -----		
IWS	-0.966622 0.0000	0.975605 0.0000	1.000000 -----	
ISF	-0.959714 0.0000	0.980043 0.0000	0.999435 0.0000	1.000000 ----

Notes: TTL = Total Telephone Lines (Fixed Telephone Lines plus Mobile Cellular Telephone Lines); EPC = Electric Power Consumption; IWS = Improved Water Source; and ISF = Improved Sanitation Facilities.
Source: Author's computations based on WDI of the World Bank (2020).

The results show that the correlation between total telephone lines (fixed telephone plus mobile phones) and electric power consumption exceeds 0.90. This will make disentangling the different roles of the two indicators in a regression framework difficult (Calderón & Servén, 2010a). Under such circumstance, Wooldridge (2009) suggests either dropping some of the variables or combining them. This study adopts the latter approach and employs the PCA to construct a composite infrastructure index that combines the individual infrastructure indicators which helps in addressing the multicollinearity problem. The PCA procedure is implemented in some recent contributions such as Francois and Manchin (2013), Calderón and Servén (2014) as well as Chakamera and Alagidede (2017).

Towards this end, PCA is used to aggregate electricity, telecommunication, water and sanitation infrastructures into a single index. To derive an aggregated index for infrastructure stocks, the first eigenvectors (loading matrix) from the PCA are used as the required weights and therefore the following linear combination exists:

$$IIS = a_1 TTL + a_2 EPC + a_3 IWS + a_4 ISF \quad (1)$$

where IIS is the aggregated index of infrastructure stocks; a_1, a_2, a_3 are the eigenvectors (weights) from the PCA, while TTL, EPC, IWS and ISF denote the physical measures of infrastructure in telecommunications (fixed lines plus mobile phones), electricity (electric power consumption), water (improved water source) and sanitation (improved sanitation facilities), respectively.

The infrastructure index derived for the SSA region ranges from -1.1 to +0.5. Similar studies by Calderón and Servén (2010a) and Akanbi (2015) found ranges between −1.5 and +2.0, and -1.0 and +1.0, respectively. As reported in Table 2 below, the synthetic index for SSA shows a high correlation with each of the initial individual indicators. For instance, the correlation between the synthetic indicator and total telephone lines is 0.99 and is highly significant. The correlation is 0.72 for electric power consumption, 0.99 for improved water source and 0.99 for improved sanitation facilities.

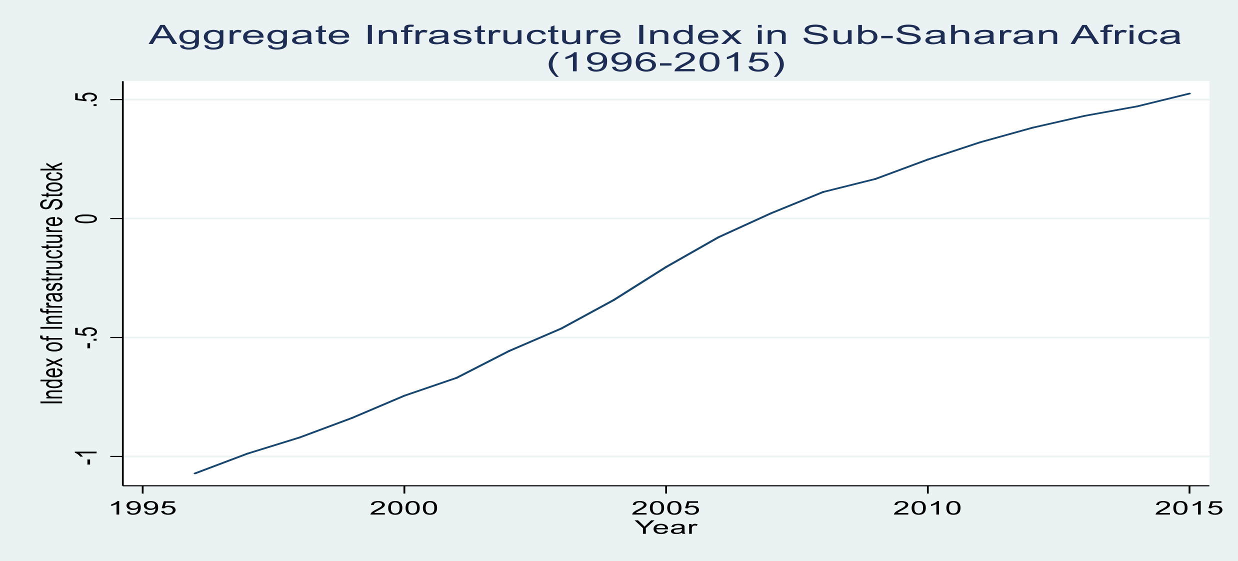
Table 2. Correlation between Aggregate Infrastructure Index and Infrastructure Indicators

	IIS	TTL	EPC	IWS	ISF
IIS	1.0000				
TTL	0.9901 0.0000	1.0000			
EPC	-0.7229 0.003	-0.6956 0.0007	1.0000		
IWS	0.9577 0.0000	0.9559 0.0000	-0.7409 0.0002	1.000000	
ISF	0.9860 0.0000	0.9531 0.0000	-0.7405 0.0002	0.9996 0.0000	1.000000

Notes: IIS = Aggregate Index of Infrastructure Stock; TTL = Total Telephone Lines (Fixed Telephone Lines plus Mobile Cellular Telephone Lines); EPC = Electric Power Consumption; IWS = Improved Water Source; and ISF = Improved Sanitation Facilities.
Source: Author's computations based on WDI of the World Bank (2020).

The trend of the computed index of infrastructure stock is presented in Figure 11. The Figure shows that starting with its lowest value of -1.1 in 1996, the aggregate infrastructure index in SSA recorded an upward trend over the period of study, although it was negative over the first eleven years.

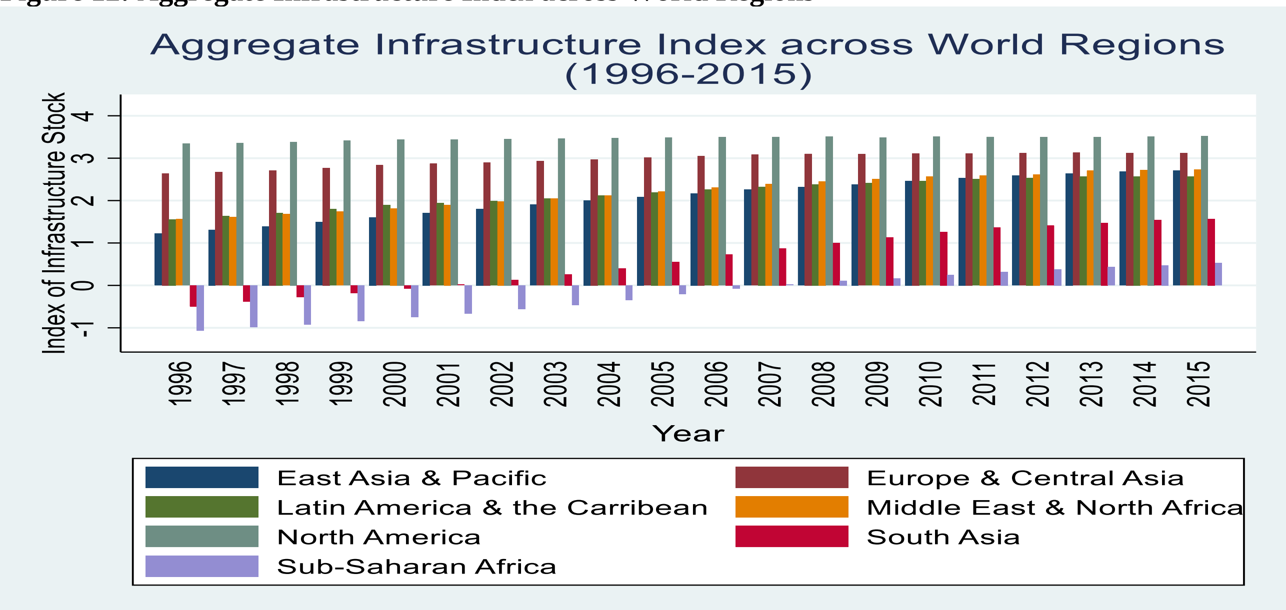
Figure 11: Aggregate Infrastructure Index in Sub-Saharan Africa



Source: Author's computations based on WDI of the World Bank (2020).

Figure 12 compares the region's infrastructure index with those of the other regions. The figure shows that overall infrastructure development in SSA has been slower than in other developing regions of the world and that the gap between SSA and others has widened.

Figure 12: Aggregate Infrastructure Index across World Regions



Source: Author's computations based on WDI of the World Bank (2017)

Summary, Conclusion and Recommendation

This study appraised the capacity of infrastructure stocks in Sub-Saharan Africa in comparison to six other developing regions of the world over the period 1996-2015. To achieve this objective, the study used a graphical approach involving line graphs as well as bar charts in appraising the infrastructure indicators. The appraisal presented in this study confirms the findings of the previous studies. It showed that despite the importance attached to it, infrastructure in the SSA region is far below the capacity in other developing regions, which are also desirous of catching up with the developed regions. It was established that in most indicators of infrastructure, SSA lag far behind all the other developing regions. The implication of this finding is that the SSA region has significant gaps to fill so as to develop its infrastructure to match otherwise similar regions.

The findings of this study show that lack of infrastructure is a fundamental constraint to economic growth in SSA. It is, therefore, necessary for countries in SSA to pursue policies that will massively boost their stocks of infrastructure. It is imperative for policy makers in the region to pursue infrastructure development through sufficient investment as well as accelerate the implementation of infrastructure projects. There is the need for more private sector participation which may take the form of public-private partnership (PPP). In order to attract private investors, there is the need to make private investment sustainable by creating an enabling environment.

Ultimately, this study has found that a clear gap still exists in the infrastructure capacity of the SSA region vis-à-vis the other developing regions. It is therefore critical to address these shortfalls for the purpose of unlocking the region‘s productive potential and thereby optimize the potentials of infrastructure in stimulating economic growth.

References

Andrés, L., Biller, D. and Dappe, M. H. (2014), "Infrastructure gap in South Asia: infrastructure needs, prioritization, and financing", working paper 7032, The World Bank, Washington DC, 1 September.

Bogetic, Z. and Fedderke, J. W. (2005), "International benchmarking of infrastructure performance in the Southern African customs union countries", working paper 7, The World Bank, Washington DC, 15 August.

Calderón, C. (2009), "Infrastructure and growth in Africa", Working Paper 4914, The World Bank, Washington DC, 8 May.

Calderón, C., Cantú, C. and Chuhan-Pole, P. (2018), "Infrastructure Development in Sub-Saharan Africa: A Scorecard", working paper 8425, The World Bank, Washington DC, 2 May.

Calderón, C. and Servén, L. (2004a), "The Effects of Infrastructure Development on Growth and Income Distribution", Working Paper 3400, World Bank, Washington DC, 2 September.

____________ (2008), "Infrastructure and Economic Development in Sub-Saharan Africa", working paper 4712, World Bank, Washington DC, 25 September.

Castellano, A., Kendall, A., Nikomarov, M. and Swemmer, T. (2015), "Brighter Africa: The growth potential of the sub-Saharan electricity sector", available at: http://www.mckinsey.com/insights/energy_resources_materials/powering_africa/ (accessed 25 July 2019).

Dethier, J. J. and Moore, A. (2012), "Infrastructure in developing countries: An overview of some economic issues", available at: https://econpapers.repec.org/RePEc:ags:ubzefd:123305/ (accessed 12 October 2019).

Ianchovichina, E., Estache, A., Foucart, R., Garsous, G. and Yepes, T. (2012), "Job creation through infrastructure investment in the Middle East and North Africa", working paper 6164, World Bank, Washington DC, 1 August.

Jerome, A. (2011), "Infrastructure, Economic Growth and Poverty Reduction in Africa", *Journal of Infrastructure Development,* Vol. 3 No. 2, pp. 127-151.

Kodongo, O. and Ojah, K. (2016), "Does infrastructure really explain economic growth in Sub Saharan Africa?", *Review of Development Finance,* Vol. 6 No. 2, 105-125.

World Bank Group (2011), "Infrastructure needs in developing countries", available at: www.g20dwg.org/documents/pdf/view/14/ (accessed 17 May 2019).

World Health Organization and United Nations Children's Fund (2015), "Progress on Sanitation and Drinking Water: 2015 Update and MDG Assessment. Switzerland: WHO and UNICEF", available at: https://www.unicef.org/publications/index_82419.html/ (accessed 17 May 2019).