THE LINKAGE BETWEEN ACCESS TO INFRASTRUCTURE SERVICES AND INCOME INEQUALITY IN AFRICA

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ABSTRACT

The importance of infrastructure services for Africa is emphasised in the United Nations Sustainable Development Goals and the African Union Agenda 2063. However, limited research has been conducted on the impact of access to infrastructure services on income inequality in Africa. The study investigated the linkage between access to infrastructure services (such as electricity, the Internet, transport, water, and sanitation) and income inequality in sub-Saharan Africa. The study employed random effects, fixed effects, and sub-set regression analyses using panel data from the 2002 to 2020 World Development Indicators for 48 African countries. The results showed that, during that period, access to electricity, the Internet, transport, and water services negatively and significantly correlated with income inequality. The study therefore provided insight into which infrastructure services should be targeted for investment by government and private funders to ensure a significant reduction in income inequality. The study recommended that African countries' private and government sectors could substantially contribute to reducing income inequality by channeling investments into improving access to electricity, the Internet, transport, and water services. In addition, regional disparities in infrastructure access should be considered when designing inclusive investment strategies, as rural and underserved areas often experience the highest levels of inequality. Multilateral development institutions and regional bodies such as the African Development Bank and the African Union could play a catalytic role in mobilising resources and coordinating efforts to scale up infrastructure development. By aligning infrastructure investments with equity-focused policies, African countries can accelerate progress toward inclusive and sustainable development.

Keywords: Inclusivity, income inequality, infrastructure services, sustainable development.

INTRODUCTION

Access to infrastructure is the ability of users to obtain and utilise essential physical and institutional facilities and services that enable service delivery, economic development, and climate adaptation. This includes infrastructure related to energy, water, sanitation, transport, and digital systems (Steckel et al., 2017). However, income inequality in Africa is a multifaceted issue driven by various factors, including historical legacies, economic structures, governance challenges, and global market dynamics. Among the many solutions, access to infrastructure services—such as electricity, clean water, transportation, and digital connectivity—is critical in reducing disparities. In the context of South Africa, Maluleke (2019: 4) asserts that reducing income inequality requires changes to the structure of the economy and improvement in the quality of services the government provides to ensure equal access and, most importantly, equal positive outcomes in health and education across the population. According to the World Bank, seven out of the top ten countries with the highest Gini coefficients are in Africa, with South Africa being the most unequal country in the world (World Bank, 2024). No African country is among the top ten countries with the lowest Gini coefficients.

The importance of infrastructure services for Africa is emphasised in the United Nations Sustainable Development Goals (SDGs) and the African Union Agenda 2063.

Goal 9 of the SDGs focuses on quality, reliable, sustainable, and resilient infrastructure (United Nations, 2025). Furthermore, Goal 10 focuses on reducing inequality within and amongst countries, while inclusive growth and sustainable development are the foundation of Agenda 2063 (African Union, 2015).

Sen's capability theory reinforces the argument that infrastructure is central to addressing inequality. The theory asserts that well-being is directly linked to individuals' capabilities—their ability to function and participate meaningfully in society (Sen, 2005). Infrastructure is crucial in expanding these capabilities, enabling individuals to access education, healthcare, and employment opportunities. Without equitable infrastructure development, individuals and communities remain restricted in improving their socio-economic conditions, perpetuating existing inequalities. In this way, Sen's framework provides a theoretical basis for understanding why infrastructure investment is not only about economic growth but also about expanding freedoms and opportunities, aligning with the objectives of the SDGs and Agenda 2063.

Empirical studies have found that infrastructure development is positively linked to economic growth and equality (Calderón & Servén, 2010; Hooper et al., 2017) and that better quality and quantity of infrastructure promote income equality (Chotia & Rao, 2017; Seneviratne & Sun, 2013). Empirical studies have also linked specific infrastructure and income inequality across various jurisdictions. Examples include social infrastructure development with a focus on education and health in South Africa (More & Aye, 2017), electricity access in South Africa (Sarkodie & Adams, 2020), power infrastructure in Brazil (Medeiros & Ribeiro, 2020), and energy access globally (Acheampong et al., 2020). However, little research has been done on the impact of access to key infrastructure services on income inequality in African countries. Therefore, the study aimed to investigate the impact of access to infrastructure services on income inequality in Africa. Furthermore, the research objectives were to examine the relationship between access to infrastructure services and income inequality in Africa, to identify which infrastructure services—such as electricity, water, sanitation, Internet connectivity, and transport—were most effective in reducing income inequality, and to analyse how infrastructure development contributed to achieving SDG 9 (Industry, Innovation, and Infrastructure) and SDG 10 (Reduced Inequalities) while fostering inclusive growth and sustainable development as outlined in the African Union Agenda 2063.

The primary research question that guided this study was: To what extent does access to infrastructure services impact income inequality in Africa? The secondary research questions were: Which infrastructure services most effectively reduce income inequality in Africa? And how does infrastructure development contribute to achieving SDGs 9 and 10 while fostering inclusive growth and sustainable development as outlined in the African Union Agenda 2063? The study employed random effects (RE), fixed effects (FE), and sub-set regression analyses using panel data from the 2002 to 2020 World Development Indicators for 48 African countries to achieve these objectives. The results indicated that access to electricity, the Internet, transport, and water services negatively correlated with income inequality. These results suggested that private and government sectors in African countries could contribute significantly to reducing income inequality by channelling investments into improving access to electricity, the Internet, transport, and water services. However, in the study, access to sanitation was statistically insignificant.

THEORETICAL FRAMEWORK

Sen's (2005) capabilities approach provided the theoretical foundation for the study, explaining the relationship between access to infrastructure services and income inequality. This framework emphasises that access to essential services, such as sanitation, water, road infrastructure, electricity, and information and communications technology (ICT), enhances individuals' capabilities, enabling social and economic integration (Chotia & Rao, 2017). Literature has developed this perspective, with recent studies reinforcing the link between infrastructure access and income inequality. Sen's capability theory, which has contributed significantly to understanding the impact of infrastructure on income inequality, claims that a person's well-being is linked to their capabilities and ability to function effectively, thereby avoiding social exclusion (Sen, 2005). According to this perspective, well-being depends not only on the availability of goods and services but also on individuals' ability to utilise these to enhance their livelihoods. Sen (2005) refers to these abilities as "functionings," encompassing the various activities and states that people can achieve. Functionings are directly tied to people's capacity to engage in economic and social activities rather than merely the presence of infrastructure. Consequently, inequality persists when individuals do not have equal capabilities to function owing to disparities in access to essential services. Unequal access to basic infrastructure, such as sanitation and piped water, constrains individuals' ability to participate fully in society.

Furthermore, the availability and location of infrastructure shape opportunities for development and well-being. Access to fundamental infrastructure services determines individuals' capabilities, influencing their livelihoods, overall well-being, and susceptibility to poverty (Vink et al., 2019).

Sen's (2005) capability theory facilitates understanding of how infrastructure services impact income inequality. According to this theory, infrastructure would enable low-income earners in underdeveloped areas to connect to economic activities, access productive opportunities (Calderón & Servén, 2004), increase the value of their assets, and rise out of poverty (Chotia & Rao, 2017). Moreover, infrastructure development reduces trade, and transaction costs and enhances competitiveness (Sahoo & Dash, 2009). Kuznets theory (Kuznets, 1955) explores the theoretical relationship between growth, poverty, and inequality. The theory is that as an economy develops, income inequality first increases, then later peaks before a decrease is seen (Kuznets, 1955) (see Figure 1):

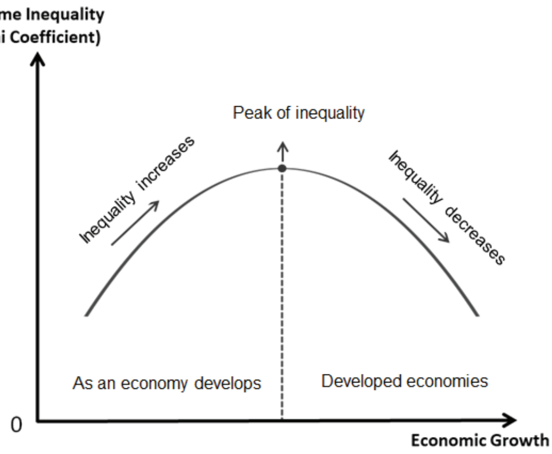

Figure 1: Kuznets Curve

As most African economies are past the initial stages of development, they should see significantly reduced inequality. However, in South Africa, for example, the apartheid era created inequality and required interventions, infrastructure development, the promotion of access to essential services (Government of South Africa, 2021), and "pro-poor" growth strategies to increase equity and the incomes of people experiencing poverty (Bluhm et al., 2016). The poverty-growth-inequality triangle by Bourguignon (2005) provides an understanding of the link between poverty, inequality, and growth. Bourguignon (2005) explains that while poverty is directly impacted by inequality and growth, inequality and growth also interact with each other and indirectly affect poverty. The theory indicates that if growth in revenues occurs in firms which employ few low-skilled people but more high-earning individuals, income inequality will increase. However, if the growth occurs in labour-intensive sectors, income inequality will decrease (Bourguignon, 2004).

The literature review relating to the link between income inequality and access to infrastructure services leads to the following hypotheses: (i) H1. Access to electricity services reduces income inequality; (ii) H2. Access to Internet services reduces income inequality; (iii) H3. Access to transport services reduces income inequality; (iv) H4. Access to water services reduces income inequality; and (v) H5. Access to sanitation services reduces income inequality.

REVIEW OF THE EMPIRICAL LITERATURE

Several studies have been reviewed to understand the access element of infrastructure services, the impact of those infrastructure services on income inequality across different economies, and the comparison between the various infrastructure services in terms of their effect on income inequality.

The relationship between infrastructure access and inequality across different economies

While empirical studies have been conducted on the relationship between multiple infrastructure services and income inequality, only Calderón and Servén (2010) focused specifically on sub-Saharan Africa (SSA), with few studies focusing on the access element of infrastructure services. This gap shows the limited research on the link between access to infrastructure services and income inequality in Africa. Calderón and Servén (2004) initially conducted an empirical study on the impact of infrastructure development on growth and income distribution in 100 countries between 1960 and 2000. They found that the stock of infrastructure assets positively affects growth, and that higher infrastructure quantity and quality reduce income inequality (Calderón & Servén, 2004). These results were corroborated further when Calderón and Servén (2010) conducted another panel regression study on SSA and other regions. They assessed the impact of infrastructure development on growth and inequality and found that infrastructure development positively impacts growth and reduces inequality. A key conclusion of the study was that countries in SSA need to expedite poverty reduction through infrastructure development, as it leads to increased growth and lower inequality. In addition, the study revealed that this relationship exists worldwide, especially in Asia.

Seneviratne and Sun (2013) studied the link between infrastructure investment and income distribution in the Association of Southeast Asian Nations (ASEAN)-5 using regressions covering advanced and emerging market economies and Calderón and Servén's (2004) methodology of using infrastructure indices for quality and quantity. They found that better infrastructure quality and quantity improved income distribution, but that investment alone had an insignificant impact. The authors attributed this to "a weak link between investment and infrastructure buildup" (Seneviratne & Sun, 2013: 3). Another essential conclusion was that different infrastructure services impact inequality differently, which requires further research. Using a mixed-methods approach and regression modelling, Parikh et al. (2015) conducted a study on five slums in India. They found that water, sanitation, drainage, road, and energy infrastructure positively changed socio-economic conditions in the slums, particularly for women. The study found that infrastructure development needs to be focused on and directed at those areas most subject to poverty to have an impact and reduce inequality. Another result was that infrastructure increased education among females by 66%, providing essential services enhanced income by 36% and reduced health costs by 26% (Parikh et al., 2015).

These results were, however, due to poverty, as slums usually do not have any basic infrastructure. Thus, the results might differ in urban or developed areas. In China, to assess how specific types of infrastructure influence inequality, Mendoza (2017) used ordinary least squares (OLS) and found a negative correlation (with a lag of two or three years) between wastewater treatment, domestic waste management, public green spaces, water efficiency, and residential power efficiency infrastructure and income inequality (Mendoza, 2017). The study also used access and coverage as infrastructure development measures for the various infrastructure types. The study found that investment in these infrastructures may be associated with reduced inequality, ranging from 4% to 49% (Mendoza, 2017). Through Pedroni's panel co-integration test and panel dynamic OLS, Chotia and Rao (2017) found that across the BRICS nations, infrastructure development is linked to a reduction in poverty and rural-urban inequality. The study used principal component analysis (PCA) to construct an index using variables representing a country's infrastructure development. Using structural equation modelling (SEM) in South Africa, More and Aye (2017) focused on social infrastructure (specifically health and education) and its relationship with economic growth and inequality. The study found a negative but insignificant relationship between education and inequality. Health and inequality, however, had a significant negative relationship (More & Aye, 2017).
Although this study contributed to the literature, it focused on social infrastructure and was limited to only one African country.

Information and Communication Technology:

Richmond and Triplett (2018) assessed the often-overlooked topic of the impact of information and communication technology (ICT) on income inequality using panel regression for 109 countries at all levels of development. The study's premise was that while growth in ICT is expected to impact economic growth and development positively, it may negatively impact income inequality owing to the differences in individuals' skill sets and access to ICT. Richmond and Triplett's (2018) empirical analysis found that the impact of ICT on income inequality depended on the type of ICT, other economic/political factors, and the measure of income inequality. Thus, their analysis showed that increased mobile subscriptions and Internet usage decrease income inequality. In contrast, an increase in fixed broadband subscriptions increases income inequality, possibly owing to affordability challenges leading to limited access.

In Australia, through bivariate correlation analysis, Park (2015) found that rural areas have a disadvantage because of a lack of broadband connectivity and access to the Internet. The study further recommended that when addressing the problem of digital inclusion, institutions should also consider socio-demographics, employment and education. In addition, Molini and Wan's (2008) assessment of the causes of rural inequality in Vietnam concluded that even though infrastructure was found to decrease income inequality, its impact was closely linked to the community's level of education (Molini & Wan, 2008). Therefore, efforts to increase infrastructure access need to be matched with an increase in education to maximise the effect of infrastructure. Confirming the relationship between ICT and income inequality in the context of SSA through more empirical studies would be a valuable addition to the literature on this topic.

Transport:
Transport infrastructure can be expected to impact income inequality by improving the accessibility of rural areas to urban centres where income can be generated (Banerjee et al., 2018). Although not specific to inequality, Banerjee et al.'s (2018) study showed that access to transportation in China (focusing on proximity) positively correlated to per capita GDP levels across sectors. Additionally, the study found that transporting capital and skilled labour from rural to urban areas may increase the impoverishment of those left behind in rural areas (Banerjee et al., 2018). Nevertheless, with no access, the productivity of labour would be boosted in rural areas, and its labourers would still be able to participate in the benefits of globalisation by contributing to exports. Furthermore, the cost of travelling might reduce the profitability of accessing urban areas. Bajar and Rajeev's (2015) study of 17 states in India found a negative correlation between infrastructure services and inequality. However, transport had a positive correlation with inequality. The possible reasons cited were that as mobility increases owing to transport, productive opportunities arise, however, their benefits are felt by the non-poor, leading to the rise in inequality. This result is similar to those of Banerjee et al. (2018), although a deeper look into the link between access to transport and income inequality is required.

Electricity:
Assessing the relationship between access to electricity and income inequality at a global level using GMM, Acheampong et al. (2020) found that access to electricity reduces income inequality globally, except for access to green/clean energy, which increases global income inequality. Clean energy increases global income inequality, possibly owing to the high cost of implementing green solutions, which means people experiencing poverty cannot afford them. Nevertheless, Acheampong et al. (2020) found that conventional rural and urban electrification decreased income inequality, although urban electrification had a more significant impact. Factors such as education, gender empowerment, industrialisation, and health are possible channels through which access to electricity impacts income inequality (Acheampong et al., 2020). Using panel and GMM estimation techniques, Medeiros and Ribeiro (2020) investigated the impact of access to electricity in Brazil on inequality and found a negative correlation. However, the results showed that as the power supply grows, the effect of electricity on inequality lessens, showing that high-income earners benefit from improvements in power quality.

Sarkodie and Adams (2020) tested the effect of access to electricity on income level, income inequality and corruption in South Africa using the Bayesian linear and NARDL regression models. They found a positive correlation between income level and access to electricity and that access to electricity increases income inequality. Sarkodie and Adams (2020) maintain that access to electricity benefits the wealthy by increasing income-producing ventures and high returns, which lead to a higher income and a more significant gap between the rich and the poor.

However, Sarkodie and Adams (2020) acknowledge that other studies have reported an insignificant impact of electricity access on income inequality. Therefore, further research is justified to understand this relationship in South Africa and SSA.

Water and sanitation:
According to Local Burden of Disease WaSH Collaborators (2020), access to piped and treated water is lowest in SSA, where access is concentrated in urban areas. Understanding the impact of this on income generation and income inequality is an essential step towards addressing the issue. Studies cited earlier in the paper found that water and sanitation negatively correlated to the Gini coefficient (Calderón & Servén, 2010; Chotia & Rao, 2017; Mendoza, 2017). Additionally, Saroj et al. (2020) found that in India, there was a higher level of inequality in cities with poor access to water and sanitation than in those with better access.

Summary of the literature review

In summary, some empirical studies have confirmed the importance of accessibility to infrastructure services in reducing income inequality (Estache et al., 2001; Estache et al., 2002; Fay & Straub, 2017) and in various countries (Calderón & Servén, 2004; Calderón & Servén, 2010; Hooper et al., 2017; Mendoza, 2017). Other studies have found that the quality and quantity of infrastructure services reduce income inequality (Chotia & Rao, 2017; Seneviratne & Sun, 2013). Additionally, empirical studies have found a link between specific infrastructure services, such as ICT, transport, electricity, water and sanitation, and income inequality in different countries (Acheampong et al., 2020; Medeiros & Ribeiro, 2020; Richmond & Triplett, 2018; Sarkodie & Adams, 2020; Saroj et al., 2020; Zhang et al., 2017). Despite all the above-mentioned studies, there is a lack of research on the impact of access to key infrastructure services (electricity, water and sanitation, the Internet, and transport) on income inequality in African countries. In addition, several studies focused on the impact of the availability of infrastructure services, as opposed to the accessibility of those infrastructure services. Therefore, the current study aims to fill that gap by focusing on the impact of access to key infrastructure services on income inequality in Africa.

RESEARCH METHOD

The study used quantitative research methods to achieve the research objectives. Panel data on 48 countries in SSA from 2002 to 2020 from the World Bank's World Development Indicators (WDI) was used, which is considered an appropriate source, as it provided consistent measures of the countries under study (World Bank Group, 2024). The WDI is produced by a combination of bodies that vet global data before the indicators are published (World Bank Group, 2024). Global data, such as statistics on drinking water, sanitation and hygiene, are obtained from organisations such as the Joint Monitoring Programme of the World Health Organisation (WHO) and the United Nations Children's Fund (UNICEF) based on administrative sources, national censuses and nationally representative household surveys (World Bank Group, 2024). Table 1 below presents the data gathered from the WDI:

Table 1: Dependent, independent and control variables

Dependent variable	Definition	Measure	Data source
Gini coefficient (Gini index)	The extent to which income distribution amongst individuals within an economy deviates from a perfectly equal distribution.	Index	WDI
Independent variable	**Definition**	**Measure**	**Data source**
Electricity	The proportion of people with access to electricity	%	WDI
Sanitation	The proportion of people using safely- managed sanitation services	%	WDI
Water	The proportion of people using safely- managed drinking water services	%	WDI
Internet (ICT)	The proportion of people with access to an Internet connection	%	WDI
Transport	Transport services (% of service imports and exports, BoP)	%	WDI
Control variable	**Definition**	**Measure**	**Data source**
GDP per capita	Real output per capita	number	WDI
Education	School enrolment, secondary (% gross)	%	WDI
Inflation	Inflation as measured by the consumer price index	%	WDI
Trade openness	Exports and imports as a% of GDP	%	WDI

Source: WDI (World Bank Group, 2024)

The Gini coefficient (dependent variable) was specified as a function of accessibility to electricity, transport, the Internet, water, and sanitation (independent/explanatory variables). The study included several control variables to mitigate the risk of biased estimates owing to omitted variables. Income per capita was included as a standard control variable primarily because income and growth have been linked directly and indirectly to inequality and poverty (Bourguignon, 2004). Education (measured by the secondary enrolment in the study) and trade (indicated by trade openness) are said to be key contributors to technology development (Calderón & Servén, 2010). Inflation (representing price instability) impacts investment in the economy and, thus, the infrastructure conditions of a country (Calderón & Servén, 2004).

Descriptive statistical data analysis and diagnostic tests were performed to achieve the research objectives. The software used for the analysis was Statistica version 14 and EViews 11. Based on the discussion on the estimation methods below and the literature review, the statistical data analysis was performed on the following relationship:

$$yit = \delta + \phi yi,\ t + \alpha(\text{infrastructure services access})it + \beta xit + vi + eit \qquad \text{(Equation 1)}$$

where yit is income inequality; δ is the intercept of the equation; ϕ is the parameter to be estimated for income inequality (yi,t); α represents the marginal impact of an increase in infrastructure service on income inequality; x is a vector of the control variables; β is a vector of the parameters to be estimated for the control variables; i = 1,2, …, 48 represents the countries; t = 2002, 2005, …, 2020 represents the period; vi captures the unobserved effects of the countries; and eit is the random residuals.

The study applied Mendoza's (2017) estimation model to determine the linkage between access to infrastructure services and income inequality in SSA, although Mendoza's (2017) study was on the People's Republic of China. As indicated earlier, other empirical studies assessing this relationship have used various methods, including FE, RE and all-subsets. Other tests include the Jarque-Bera test to determine normality, the Durbin-Watson test to determine autocorrelation, and the Breusch-Pagan heteroskedasticity test to ensure that the variance of the residual is constant across all the values.

RESEARCH RESULTS

Descriptive statistics and diagnostic analysis

Table 2 below presents the descriptive statistical analysis results of the data gathered in 48 African countries for the Gini coefficient, and the users of electricity, the Internet, sanitation, water, and transport.

Table 2: Descriptive statistics

Variable	N	Mean	Median	Max	Min	Std. Dev.	Skewness	Kurtosis	Jarque-Bera
Gini coefficient	133	43,3	42,4	64,8	29,6	7,9	0,88	3,469	18,533
Electricity	903	38,9	35,4	100,0	0,7	25,8	0,611	2,536	64,314
Internet	858	11,6	5,0	79,0	0,0	14,7	1,845	6,199	852,751
Sanitation	380	17,1	15,7	47,6	2,7	9,3	0,655	2,789	27,844
Transport (exports)	733	19,0	15,1	79,5	0,0	16,0	1,141	4,078	194,517
Transport (imports)	747	42,1	41,2	83,9	7,4	17,1	0,110	2,308	16,394
Water	342	19,4	17,0	45,9	3,4	11,4	0,508	2,062	27,255

Source: Authors' construction, EViews 11; World Bank Group (2024)

The mean of the Gini coefficient was 43, showing high income inequality in African countries. The means of the independent variables reflect the low levels of access to infrastructure services in African countries. The Jarque-Bera test indicated that the distribution of all the variables is not normal. Therefore, the panel methods used were appropriate for this dataset, as they did not require normality. In addition, non-parametric tests were used, as they did not require normality. Furthermore, Table 3 shows a correlation matrix.

Table 3: Correlation matrix

	GC	IT	EL	SA	WA	TE	TI
Gini coefficient (GC)	1						
Internet (IT)	0,003	1					
Electricity (EL)	-0,029	0,664	1				
Sanitation (SA)	0,193	0,594***	0,448**	1			
Water (WA)	0,23	0,628***	0,704	0,684	1		
Transport exports (TE)	-0,099	-0,136	0,002	-0,225	-0,261	1	
Transport imports (TI)	-0,367**	-0,288	0,061	-0,11	0,008	0,436*	1

***p value<0.001, **p value<0.05, *p value <0.10 **Source:** Authors' construction, EViews 11

A range of diagnostic tests was run on the data to determine autocorrelation, multicollinearity and heteroscedasticity, as shown in Table 4. Considering the diagnostic test results, particularly multicollinearity, an all-subsets regression employing a principal component factor analysis (PCA) was carried out using Statistica version 14. The PCA resulted in the best five covariates, those resulting in the highest R-square with no collinearity and no autocorrelation as shown in Table 4.

The results of the regression analysis are presented as Model 8 in Table 5, as well as the other statistical analysis results.

Table 4: Diagnostic tests summary

Diagnostic test	Results	Conclusion
Variance inflation factor (VIF) test	High VIFs above 10, reduced to below 3 post PCA	Indication of multicollinearity, corrected through all-subsets regression
Durbin-Watson test	Initial value of 3.1 prior to PCA, and 1.92 post PCA	Initial autocorrelation detected, corrected by all – subsets regression
Breusch-Pagan test	A p-value of 0.20, therefore no heteroskedasticity	No heteroskedasticity detected
Hausman test	Chi-Sq= 6.098, p-value = 0.1919	RE model appropriate is for this data set
VAR Granger Causality/Block Exogeneity Wald tests	GDP per capita, electricity and transport imports p values <0.05	Some variables are not exogenous.
The redundant fixed effects tests	Cross section chi-square = 1, p value= 0.0004	Cross-section effects had to be accounted for

Source: Authors' construction using EViews 11 and Statistica 14

Empirical results and interpretations

Based on the descriptive analysis and the results of the diagnostic tests, the study employed the RE as the primary basis of analysis, with the FE as an additional technique for robustness and the all-subsets regression/ best fit (Model 8 in Table 5 below) to deal with multicollinearity and autocorrelation. In the FE, both the cross-sections and period effects were fixed, as per the redundant fixed effects test results. The RE, FE, and all subsets regression results in Table 5 below confirmed the hypothesis that access to infrastructure services reduces the Gini coefficient. Table 5 presents a negative correlation between the Gini coefficient and all the variables representing access to infrastructure services except sanitation. Access to electricity, the Internet, and transport as a percentage of import services were negatively correlated with the Gini coefficient, with statistical significance, based on the RE technique, as seen in Models 1, 2, 7 and 8.

The impact of access to transport services was only significant when all the controls were dropped except for GDP, as in Model 7 and Model 8, which excluded several variables based on the best-fit model. Access to transport services showed statistical significance negatively correlated with the Gini coefficient in the RE models and the FE Model 9. While access to water services initially showed statistical insignificance, removing all control variables except for GDP per capita resulted in statistical significance for both FE and RE, with a negative correlation to the Gini coefficient, as expected from the literature results. These results revealed that for access to water services to reduce the Gini coefficient significantly, there were other dependencies/factors, such as the control variables, to address, as they may have an impact on the influence of water services on income generation and the reduction of income inequality. Access to sanitation services was also negatively correlated with the Gini coefficient; however, this was not statistically significant across the different variations of models. The results showed the significant impact of the control variable, education, regarding secondary enrolment. Secondary enrolment significantly reduced the Gini coefficient in all the models except Model 3 and Model 4. In summary, the results suggested that four of the five independent variables reduced the Gini coefficient sufficiently and thus supported the hypotheses H1, H2, H3, and H4. However, the relationship between access to sanitation services and income inequality in the context of SSA countries requires further research.

Table 5: Empirical results

Access to Infrastructure Services	Random Effects								Fixed Effects	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
Electricity	-0,161**									
	(0,066)									
Internet		-0,251***								
		(0,068)								
Water			0,253					0,540*		-0,040**
			(0,228)					(0,280)		(0,220)
Sanitation				0,031				-0,070		
				(0,110)				(0,230)		
Transport (exports)					0,027					
					(0,063)					
Transport (imports)						-0,004	-0,109**	-0,50*	-0,149**	
						(0,062)	(0.039)	(0,19)	(0,000)	
GDP per capita	0,000	0,000	-0,003	-0,001	-0,001	-0,001	5,830	-0,470***	-002	0,002
	(0,001)	(0,000)	(0,003)	(0,002)	(0,001)	(0,000)	(0,000)	(0,250)	(0,000)	(0,002)
Secondary enrolment	0,256***	0,261***	-0,064	0,059	0,195***	0,200***				
	(0,063)	(0,054)	(0,134)	(0,084)	(0,057)	(0,058)				
Inflation	0,018	0,053	-0,057	0,122	-0,042	-0,044		0,280*		
	(0,125)	(0,164)	(0,207)	(0,179)	(0,135)	(0,135)		(0,170)		
Trade	-0,010	-0,033	0,026	0,051	0,011	0,009				
	(0,033)	(0,034)	(0,052)	(0,040)	(0,036)	(0,036)				
Constant	38,206***	36,030***	40,272***	33,888***	34,219***	34,926***	47,580***	44,979*	51,718***	47,613***
	(3,103)	(2,999)	(4,955)	(2,837)	(3,697)	(5,156)	(2,236)	(3,352)	(3,094)	(2,948)
Observations	69	67	22	26	62	62	118	31	118	53

Standard errors in brackets; ***p value<0.001, **p value<0.05, *p value <0.10. Source: Authors' construction using EViews 11 and Statistica 14

DISCUSSION

The research results illustrated that accessibility to infrastructure services was one of the tools to reduce income inequality, consequently contributing to the achievement of SDG 10 (Reduced Inequalities). Moreover, the results highlighted that the achievement of SDG 9 (Industry, Innovation, and Infrastructure) positively impacts SDG 10, while promoting inclusive growth and sustainable development in line with Agenda 2063 (African Union, 2015). Several techniques were used to analyse the linkage between income inequality and access to infrastructure services in SSA from 2002 to 2020. The infrastructure services were broken down into electricity, the Internet, water, transport, and sanitation, each being shown to have a specific impact on the Gini coefficient. Firstly, the research results indicated that access to Internet services had a statistically significant negative correlation with income inequality. A 1% increase in access to Internet services will cause a 0.25 index point improvement in the Gini index, indicating a reduction in income inequality. This result was corroborated by Richmond and Triplett (2018), who used panel regression for 109 countries across all development levels, and Odhiambo (2022), who used GMM in SSA. These results demonstrated that investments in ICT services could significantly benefit Africa, as households and businesses would be connected to income-earning opportunities as well as ways of conducting business and accessing education cost-effectively and efficiently.

Secondly, the results showed that access to electricity services significantly reduced income inequality. For every 1% increase in access to electricity services, the inequality was reduced by 16 index points. This result implied that SSA could reduce the income inequality gap by making electricity accessible to all, as Mendoza (2017) and Acheampong et al. (2020) also found. While SSA countries have been progressively investing in access to electricity, the average access to electricity was still relatively low at 48% in 2020 compared with a global average of 90% (World Bank Group, 2024). Thirdly, when all controls were included, access to water services was positively correlated with the Gini coefficient, as reflected in Models 3 and 8 in Table 5 above, which were both results of RE. This result contradicted some of the empirical studies reviewed (Calderón & Servén, 2010; Chotia & Rao, 2017; Mendoza, 2017). FE was then employed to test the accuracy of the analysis, and access to water services showed a 4 index point reduction in the Gini coefficient when all the control variables were dropped except for GDP per capita. This result aligned with the studies of Saroj et al. (2020) and Mendoza (2017), revealing that water negatively correlated with the Gini coefficient in several countries. This result therefore indicates that the impact of the control variables on the statistical significance of the correlation between water and the Gini coefficient requires further study.

Fourthly, the negative correlation between transport services as a percentage of import services and the Gini coefficient found in the study aligned with the expected outcome. This result was due to the reliance of economic activity, small businesses, health, and education on transportation services, which impacted inequality, as indicated by various studies, including that of Banerjee et al. (2018). Further studies on individual countries might lead to a deeper understanding of the relationship between transport as a percentage of import/export services and the Gini coefficient. Depending on the availability of data, future research in studying the link between access to transport and income inequality could consider factors such as the length of tarred roads and railways and their quality (Calderon & Serven, 2010). Lastly, access to sanitation was statistically insignificant in the RE and all-subsets regression models, as presented in Table 5. According to the RE (Model 4), access to sanitation was positively correlated with the Gini coefficient. Nevertheless, the all-subset regression/best fit per Model 8 revealed a negative correlation, albeit by a small percentage. Previous studies proved statistical significance. Therefore, an investigation into the reasons for these results in the context of SSA is required. Potential reasons may be the inclusion of the controls, showing the dependency of the impact of access to sanitation on other macro and micro economic factors because the main difference between Models 4 and 8 was the variables included. In addition, further studies are required to determine whether access to sanitation has more impact when a lag is introduced to reflect the time it takes to see better health conditions due to sanitation infrastructure. However, the data analysis revealed that not all countries invested significantly in sanitation infrastructure. For example, in 2020, only 12% of the population of Guinea-Bissau had access to sanitation services, Ghana had 13%, Ethiopia 6%, and Chad 10%. These levels were very low compared to the world average of 54%, including urban and rural areas, and 87% for urban only (World Bank Group, 2024).

Owing to limited data for the study period, the current study focused on access to infrastructure services and not their quality or quantity. Future studies could focus on these aspects. In addition, there was limited data on some of the variables post-2020, particularly the Gini coefficient.

Future studies could incorporate post-2020 data to examine the Gini's trend in relation to the countries' infrastructure investment efforts to improve access to infrastructure services.

CONCLUSION

This paper investigated the linkage between access to infrastructure services and income inequality in Africa as the primary research objective. As a secondary objective, the paper determined which infrastructure services were the most effective in reducing income inequality in Africa during the period under study, as well as how infrastructure development can serve as a key tool in reducing income inequality while contributing to broader development goals.

- The main research objective was achieved by proving the hypotheses that access to electricity, Internet, transport, and water services reduce income inequality. However, the impact of access to sanitation services requires further research because the results were mixed.
- The first secondary research objective was achieved by the results indicating that access to the Internet has the most significant impact on income inequality reduction. In addition, access to electricity has a significant impact, while there is a link between access to transport and water and a reduction in income inequality. As indicated in the previous paragraph, the link between access to sanitation and reducing income inequality does not appear strong.
- The second secondary research objective was achieved by the results demonstrating that by addressing the accessibility of quality, reliable, sustainable, and resilient infrastructure (United Nations, 2025), governments and the private sector can contribute to the reduction of income inequality. In doing so, they also contribute to the achievement of SDG 9 (Industry, Innovation, and Infrastructure) and SDG 10 (Reduced Inequalities), as well as inclusive growth and sustainable development per the African Union Agenda 2063.

The results of the empirical study provide insight into which infrastructure services should be targeted for investment by governments and private funders of infrastructure to ensure a significant reduction in income inequality. This insight will contribute to effective investment decisions for reducing income inequality in targeted countries, as well as policies supporting spending on a mix of infrastructure services, which contribute to an expedited reduction of income inequality, along with other government priorities.

RECOMMENDATIONS

The theoretical framework underpinning this study, the empirical literature reviewed, and the results of this empirical study demonstrate that the multifaceted nature of income inequality in Africa requires an all-inclusive solution which improves individuals' abilities to function and participate meaningfully in society. It is within this context, and as guided by the outcomes of the empirical study, that the paper makes the following recommendations for reducing income inequality in Africa:

- Firstly, the study revealed that access to the Internet reduced income inequality the most compared to other infrastructure services. Therefore, efforts should ensure wider access to Internet services to bring SSA's average access closer to global Internet access.
- The second infrastructure service which significantly reduced income inequality in the study was electricity. African countries have realised the importance of electrifying households and ensuring a reliable electricity supply to households and businesses. These initiatives should continue and be adopted in those countries that are lagging behind in providing access to electricity.
- Thirdly, countries should improve the quality and accessibility of transport infrastructure to ensure maximum impact of transport infrastructure in reducing income inequality.
- Since the empirical investigation into the link between access to sanitation and income inequality gave mixed results, further studies on sanitation services are recommended. Furthermore, studying the impact of the quality and consistency of water services, in addition to access to these, may lead to a deeper understanding of the impact of water services on income inequality and the relationship of this infrastructure service with others.

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