Elevating Sub-Saharan Africa: The Effect of Infrastructure Investment in Alleviating Poverty

A Minor Dissertation

Submitted to

The **Development Finance Centre (DEFIC)**

Graduate School of Business

University of Cape Town

In partial fulfilment

of the requirements for the Degree of

Master of Commerce in Development Finance

By

Joshua, Magolie

MGLJOS003

Supervisor: Prof. Latif Alhassan

PLAGIRISM DECLARATION

I, Joshua Magolie, hereby declare that the work on which this Minor Dissertation is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university. I authorise the University to reproduce for the purpose of research either the whole or any portion of the contents in any manner whatsoever.

Signature:

Signed by candidate

Date: 14 May 2023

ABSTRACT

This study investigates the effect of infrastructure development on poverty reduction in 35 Sub-Saharan African countries from 2005 to 2015. This timeframe was chosen as it encapsulates the final 11 years of the United Nations' Millennium Development Goals era, recognised as one of the most significant anti-poverty initiatives in history. Notably, Sub-Saharan Africa was the only region to fall short of its poverty reduction target under Goal 1: Eradicate extreme poverty and hunger. This study is thus underpinned by Sub-Saharan Africa's failure to meet its poverty reduction goal, coupled with the recognised imperative that infrastructure is indispensable for economic and social development. Assessing the results from the battery of panel data estimation techniques, the study unequivocally demonstrates that investment in infrastructure led to poverty reduction. Specifically, transport infrastructure had the most significant impact, followed by water and sanitation, and electricity infrastructure. The robustness of the findings was verified through Wald, Hausman, and Heteroskedasticity tests. The study provides valuable insights for policymakers, recommending increased investment in transport, water and sanitation, and electricity infrastructure across Sub-Saharan Africa. It advocates for the promotion of Public-Private Partnerships to mobilise private capital and alleviate the fiscal burden on governments. Furthermore, it suggests leveraging funds from local pension funds to finance infrastructure development. Additionally, policymakers are urged to create an environment conducive to infrastructure investment by ensuring stability in macroeconomic policies and strengthening and enforcing anti-corruption laws.

ACKNOWLEDGMENTS

Embarking on the journey to pursue a Master of Commerce Degree in Development Finance stemmed from my fervent desire to contribute to Africa's advancement. I firmly believe that Africa has a compelling narrative, and I am dedicated to contributing to it.

I extend my heartfelt gratitude to my life partner, Nicole Green, whose unconditional support and understanding were truly exceptional. Your words of motivation and unwavering belief in my abilities have been a constant source of strength.

To my parents, Keith and Elaine Magolie, I am deeply grateful for your firm support throughout my academic journey. Your encouragement and guidance have been instrumental in my success.

To my brother, Zachary Magolie, your concern for my well-being during my time as a Master's student did not go unnoticed. Your support has meant the world to me.

I would also like to express my sincere appreciation to Professor Latif Alhassan. Your mentorship and guidance were invaluable in navigating through the challenges of completing this Minor Dissertation. Thank you for your tireless support.

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

Abbreviation	
ADB	Asian Development Bank
AfDB	African Development Bank
AIDI	Africa Infrastructure Development Index
AIHSRN	African Integrated High-Speed Railway Network
AIKP	Africa Infrastructure Knowledge Programme
AU	African Union
AUDA-NEPAD	African Union Development Agency-NEPAD
BRICS	Brazil, Russia, India, China, and South Africa
COVID-19	Coronavirus Disease 2019
CPI	Consumer Price Index
DFI	Development Finance Institutions
ELEindex	Electricity index
FEM	Fixed Effects Model
GDP	Gross Domestic Product
GNIPC	Gross National Income per capita
HDI	Human Development Index
ICA	Infrastructure Consortium for Africa
ICT	Information and Communications Technology
LIC	Low Income Country
MDG	Millennium Development Goals

Abbreviation	
MIC	Middle Income Country
OECD	The Organization for Economic Cooperation and Development
PDOLS	Panel Dynamic Ordinary Least Squares
PIDA	Programme for Infrastructure Development in Africa
PPP	Purchasing Power Parity
PPPs	Public Private Partnerships
PVT	Poverty
REM	Random Effects Model
SDG	Sustainable Development Goal
SSA	Sub-Sahara Africa
Std. dev.	Standard deviation
SVAR	Structured Vector Autoregressive
TOP	Trade openness
TRAindex	Transport index
UN	United Nations
UN-HABITAT	The United Nations Human Settlements Programme
UNECA	United Nations Economic Commission for Africa
UNICEF	United Nations Children's Fund
USA	United States of America
VAR	Vector Autoregressive
WDI	World Development Indicators
WHO	World Health Organization
WSSindex	Water and sanitation index

TABLE OF CONTENTS

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND TO THE STUDY

As the world welcomed the new millennium, world leaders joined forces at the United Nations (UN) to develop a vision that would shape the way in which poverty was to be fought for the next 15 years. Out of this was born, eight Millennium Development Goals (MDGs). And, while it is thought to be the most successful anti-poverty movement in history – bringing roughly a billion people out of extreme poverty (humans living off less than $1 per day) from 2000 to 2015 – Sub-Saharan Africa (SSA) is the only developing region that had failed to meet its MDG 1 target, which sought to halve the proportion of those living in extreme poverty within the region (Beegle et al., 2016; United Nations, 2015a).

Literature tells us that several factors influence the levels of poverty experienced by a country's citizens. Factors including but not limited to – education levels, the employment, and the marital status of the those at the helm of the household – have an impact on the level of poverty within the homestead under investigation (Biyase & Zwane, 2018). On the other hand, Kates & Dasgupta (2007) found that geopolitics, governance, and geography were contributing factors to poverty within Africa. Merit can be found in both views, even so, one cannot deny that they are vastly different.

There are, however, a couple of facts where consensus has been reached. Firstly, Africa is largely underdeveloped from an infrastructure perspective when compared to the rest of the world. Not only does it trail its counterparts in this regard, but even more so, it is found wanting in core infrastructure areas such as energy, water, and road and rail transportation (Lakmeeharan et al., 2020). Second, Africa, globally currently holds the number one spot regarding population growth. By 2050 it is projected that Africa's population will quadruple totalling 4 billion, with half a billion of which are expected to be added as soon as 2030.

It has also been acknowledged that the population growth will not be evenly distributed between rural and urban areas as urbanisation becomes increasingly popular within Africa. Estimations indicate that by the late 2030s most of the continent's population will be living in cities or towns (UNICEF, 2014).

Despite robust economic growth, averaging 4 percent annually between 2000 and 2020 according to World Bank Group and OECD data, sustaining Africa's trajectory as the continent

of the future demands an intensified focus on infrastructure development. This emphasis on infrastructure investment is deemed pivotal for the continued economic development of the continent, as articulated by Kodongo & Ojah (2016); Prinsloo (2019); and Sanchez-Robles (1998).

Africa thus finds itself in a state of weighty infrastructure need, brought on by prolonged underinvestment. Intense urbanisation will certainly place additional pressure on inner city infrastructure needs. However, if the continent is to be resilient through the urbanisation push, provide a prosperous future for its inhabitants, avoiding slum ridden megacities going forward – significant infrastructure investment will need to continue into the foreseeable future.

1.2 PROBLEM STATEMENT

The significance of infrastructure investment is widely recognised, and it is not surprising that it has secured a position within the Sustainable Development Goals (SDGs) of the United Nations Agenda 2030. Adopted in September 2015, these goals build upon the MDGs, which concluded in the same year. SDG number 9 of 17 reads – "Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation" (United Nations, 2015b). A little closer to home, the African Union (AU), as part of its five-decade vision for the continent, included as Goal 10 – "World class infrastructure criss-cross Africa" (African Union, 2013) . The aim of this study is to investigate whether core infrastructure investment has impacted poverty reduction across SSA through the MDG period.

Common among developing nations the world over is the challenge of economic growth, poverty, and inequality. Africa is no exception. Moreover, SSA was found to be the only region, globally, that over a twenty-year period ending in 2010 may have increased the proportion of its population living in poverty (UN-HABITAT, 2011). The African Development Bank (AfDB) (AfDB, 2018) in its report titled, *African Economic Outlook 2018*, noted that for the continent to bring an end to poverty it needs to industrialise.

Several researchers have also found that infrastructure investment does in fact contribute positively toward productivity, national output, and social development (AfDB, 2018; Lübbe, 2015; Calderón & Servén, 2008; Esfahani & Ramírez, 2003). The Brookings Institution (2017) even went as far as stating, "Infrastructure is the cornerstone of a country's economic activity, and infrastructure bottlenecks stunt economic growth and increase poverty and inequality".

Urbanisation is among the most extreme alterations the African continent will face in the 21st century. African cities are also the fastest growing in the world (OECD et al., 2022). It thus

appears that the urbanisation trend within the continent is unavoidable as those across Africa seek improved economic opportunity and higher living standards often associated with cities. It may thus be said that the current infrastructure within these expanding cities will come under pressure going forward. To this note, Saghir & Santoro (2018) found that presently a significant number of urban areas within SSA do not possess the infrastructure needed to appropriately support the migration to the area and are therefore ill-equipped to overcome the risks associated with urbanisation.

The following points have been established: Firstly, the swiftly growing population of Africa is projected to predominantly inhabit densely populated megacities. Secondly, there is a recognised need for infrastructure investment to accommodate this expanding population. Lastly, such investment, when combined with robust economic policies, has historically resulted in economic growth. However, there has been relatively limited research on whether investment in core infrastructure, which is utilised by all inhabitants of a city, effectively contributes to poverty reduction among the population.

This study, therefore, sought to answer the following question:

1. Has the investment in core infrastructure resulted in a reduction in poverty among SSA countries?

1.3 OBJECTIVES OF THE SUDY

The purpose of this study is to:

1. Examine the effect of infrastructure investment on poverty reduction in SSA.

1.4 SIGNIFICANCE OF THE STUDY

The study's objective is to examine the influence of hard infrastructure on poverty reduction throughout SSA, spanning the final 11 years of the MDG period. This research is significant for several reasons:

- Poverty alleviation consistently takes centre stage on the agendas of leaders in developing nations. Investigating the specific actions undertaken by governments, development finance institutions (DFIs), and other private stakeholders that contribute to the tangible improvement and reduction of poverty is crucial.
- A significant infrastructure deficit exists in Africa, and this study endeavours to illuminate this issue, paving the way for further exploration of financing mechanisms

for bridging the infrastructure gap. Recognising that infrastructure plays a pivotal role in poverty alleviation, this research aims to contribute insights into addressing the existing challenges.

1.5 ORGANISATION OF THE STUDY

This study is structured into five chapters as follows:

- Chapter 1 serves as the research proposal, setting the stage for the study by outlining the research problem, objectives and scope.
- Chapter 2 comprises the literature review, which delves into the theoretical and empirical literature surrounding infrastructure and poverty reduction. Readers are also provided with insight into the state of poverty and infrastructure in SSA.
- Chapter 3 delineates the research methodology, providing detailed information on the collection, analysis, and measurement of data concerning infrastructure investment and poverty as applied in this study.
- Chapter 4 presents and discusses the results obtained through the model.
- Chapter 5 serves as the conclusion, offering a summary of key findings, recommendations, and suggesting potential avenues for future research.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

There is extensive literature exploring the link between infrastructure investment and economic growth (Calderón & Servén, 2008; Easterly & Levine, 1997; Escribano et al., 2010; Esfahani & Ramírez, 2003). Furthermore, there is growing acknowledgment that the discourse has evolved beyond economic growth. Jerome (2011) acknowledges that the conversation has also started shifting, with more recent literature drawing the nexus between infrastructure investment and poverty. In light of this, the current chapter aims to assess studies relevant to the subject at hand.

The literature review is organised, firstly, to furnish the reader with the key definitions and concepts pertaining to infrastructure and poverty. Following this, an overview of infrastructure and poverty in SSA is provided. A theoretical framework is subsequently introduced. Lastly, preceding the conclusion, the empirical literature analysis endeavours to provide a comprehensive examination of the actual impact that infrastructure investment has had on poverty reduction.

2.2 DEFINITIONS AND CONCEPTS

Before delving deeper, it is imperative to establish a clear understanding of what constitutes infrastructure and similarly poverty in the context of this study.

2.2.1 Infrastructure

The term 'infrastructure' has evolved, encompassing several definitions, with no singular one being universally accepted. As the discourse on advancing the developing world gains momentum, so does the interest in infrastructure, leading to multiple interpretations of the term as the body of knowledge expands.

Infrastructure is frequently delineated based on its inherent characteristics, often defined as public goods accessible to all and fixed investments with extended payback periods, as observed by Jerome et al. (2011). Fourie (2006) distinguishes between two types of infrastructure. The first being economic or otherwise hard infrastructure – that which serves as a catalyst for economic activity, such as roads, railways, airports, seaports, energy, telecommunications, and water and sanitation supply. Secondly, social (or soft) infrastructure

is defined as infrastructure which promotes education, health, and cultural standards of a society. Furthermore, within hard infrastructure as a sub-category, Stupak (2018) introduces the concept of "core infrastructure", which refers to infrastructure investments expected to generate greater gains in economic output compared to more general infrastructure types. These high impact areas include energy, water, road, and rail infrastructure (Stupak, 2018).

For the purposes of this study, where infrastructure is used it refers to core infrastructure.

2.2.2 Poverty

Despite the extensive body of work regarding poverty, its causes and how it may be alleviated, it has proven to be a challenging concept to define. Dagume (2021) states that an individual may perceive themselves poor if they find they live below a poverty line and incapable of meeting their basic needs which include – food, shelter, and healthcare. Victims of poverty endure malnutrition, illness, crime, family disintegration, indignities, and at times death was noted by Kammerman & Kahn (1997) as a measure of poverty.

Kates & Dasgupta (2007) characterise poverty as a condition in which individuals lack access to essential elements of well-being. In this context – the impoverished are often without food security, lack ownership of assets, experience shortened lifespans, face illiteracy, encounter barriers to credit and savings, and suffer from disempowerment. Additionally, they may find themselves vulnerable in the face of crop failures or household calamities, excluded from global trade participation, inhabitants of unhealthy environments, and grappling with a pervasive lack of control over their own lives (Kates & Dasgupta, 2007).

Inaugurated in 1990 and based on the 1985 Purchasing Power Parity (PPP) (a measure which accounts for the discrepancies in price levels among nations), Ravallion and his colleagues at the World Bank conducted a study that would later form the basis of what would be coined the "dollar-a-day" poverty line. A consumption threshold of $31 per month – equivalent to roughly $1 per day – was established as an equitable base for the poverty line applicable across developing countries (Ravallion et al., 1991). This pivotal study, an integral component of the World Bank's *World Development Report 1990*, aimed to ascertain a universal standard for measuring absolute poverty (defined as extreme poverty, where an individual is unable to achieve consumption levels considered adequate, solely in the most impoverished nations) across the developing world (Ravallion et al., 1991).

Currently, the methodology introduced by Ravallion, Datt, and Van De Walle during their time at the World Bank remains in place, with the extreme poverty line now measuring $2.15 per day based on the 2017 PPPs (World Bank, 2022c).

Despite the extreme poverty line as defined in 1990 prevailing as the preferred indicator of welfare measurement, it is not without its limitations. Firstly, when assessing the poverty within a country, this proxy is inadequate as it may not reflect the social and economic nuances unique to that nation. Where one draws comparison between urban and rural poverty, access and prices to goods may differ and adjustments to the poverty line may thus be required. Secondly, for a more nuanced and sophisticated measure of poverty – the distance of poor people from the poverty line and the degree of income inequality among poor persons, the poverty gap squared, and the poverty gap should be employed respectively (World Bank, 2000).

2.3 OVERVIEW OF INFRASTRUCTURE AND POVERTY IN SSA

2.3.1 Infrastructure

Scholarly consensus emphasizes the compelling case for fostering economic growth and alleviating poverty through strategic infrastructure investment, especially when coupled with effective governance. (AfDB, 2010) argues that while higher returns are being achieved across Africa for infrastructure investment, particularly in the telecommunications sector; the continent remains underserved compared to the rest of the world. This disparity underscores the urgent need for increased and improved infrastructure investment to unlock the full potential of economic development and poverty alleviation in the region.

In response to this imperative, a collaborative effort involving the African Union Commission (AUC), African Union Development Agency-NEPAD, the AfDB, and the United Nations Economic Commission for Africa (UNECA), the African Union (AU) Heads of State and Government developed the Programme for Infrastructure Development in Africa (PIDA). The programme is widely regarded as the master plan for advancing infrastructure in Africa from 2012 to 2040. With a targeted focus on the transport, energy, transboundary water, and information and communications technology (ICT) sectors, PIDA aims to address the pressing infrastructure challenges and catalyse sustained development across the continent.

While it is well established that infrastructure will serve as the foundation upon which Africa is developed, it is equally well acknowledged that the continent faces a substantial infrastructure deficit. As of 2018, the latest estimates by the AfDB indicate that continental infrastructure needs range between $130 billion and $170 billion annually.

As outlined in a report by Heathcote & Mulheim (2018) for the Global Infrastructure Hub and Oxford Economics, the global infrastructure investment gap is anticipated to reach a staggering $15 trillion by 2040, signalling a sixteen percent deficit. This underscores that an infrastructure deficit, characterised by the misalignment between the supply and demand for infrastructure services, extends beyond the borders of Africa. However, the distinctive concern for Africa and more so SSA lies in the realm of core infrastructure. This is evidenced by the fact that energy remains the number one concern for Africa according to the AfDB (2018). With 640 million people, translating to roughly 60 percent of the population without access to energy. This represents a very weak improvement from AfDB estimates in 2008, which placed the continental population with access to electricity at 38 percent. Of even more concern is the dampened access for SSA – which the AfDB puts at 26 percent, compared to access rates of 53 percent and between 80 and 90 percent for Latin America and South Asia respectively (AfDB, 2010).

The marked disparity in access rates between SSA and the rest of the continent can be attributed primarily to the concentration of energy sector dominance in the northern and southern regions. In Southern Africa, the sector is overwhelmingly led by South Africa, while in North Africa, Egypt, and Morocco, located outside the geographic boundaries of SSA, lead the charge. According to UN-HABITAT (2011), a significant three-quarters of Africa's total energy output is generated by 5 countries: South Africa, Algeria, Libya, Egypt, and Morocco.

A critical contention arises from the rural-urban energy dynamic within SSA. The supply of energy is predominantly restricted to urban areas, leaving rural regions with a severe lack of access. This pronounced urban-rural divide exacerbates the challenges faced by rural communities, further underscoring the need for targeted efforts to address and bridge this energy gap. Governments will need to lead the way regarding rural infrastructure investment, ensuring growth is experienced alongside urban areas which will more easily attract private investment due to the heightened commercial viability of inner-city development (AfDB 2010)

While energy may be Africa’s most pressing infrastructure need due to the crucial role that it plays in a country’s productive activity; water supply and sanitation is the sector with the largest infrastructure gap. The AfDB, who by 2025 intends to have a 100 percent access rate for rural and urban areas where water and sanitation is concerned, places the Africa wide water supply and sanitation gap at between $56 and $66 billion (AfDB, 2018). This is particularly worrying due to the high human development challenges arising from poor access to water. With inadequate access to water and sanitation, individuals often find themselves confronted with

numerous difficulties such as – additional time spent on water collection, higher medical costs related to the consumption of unsanitary water, and higher costs associated with the purchase of water. UN-HABITAT (2011) conveys that all the above contributes to people remaining in a poverty trap.

There is a notable contrast in access to improved water sources in SSA compared to other regions, with only 60 percent of the population having access, in stark contrast to the higher percentages in East Asia and Pacific (87 percent) and Latin America and the Caribbean (91 percent). SSA faces the greatest challenges in this regard, as approximately 330 million of the global 884 million people without access to improved water sources reside within the region. This represents 36 percent of the global population lacking such access (AfDB, 2010).

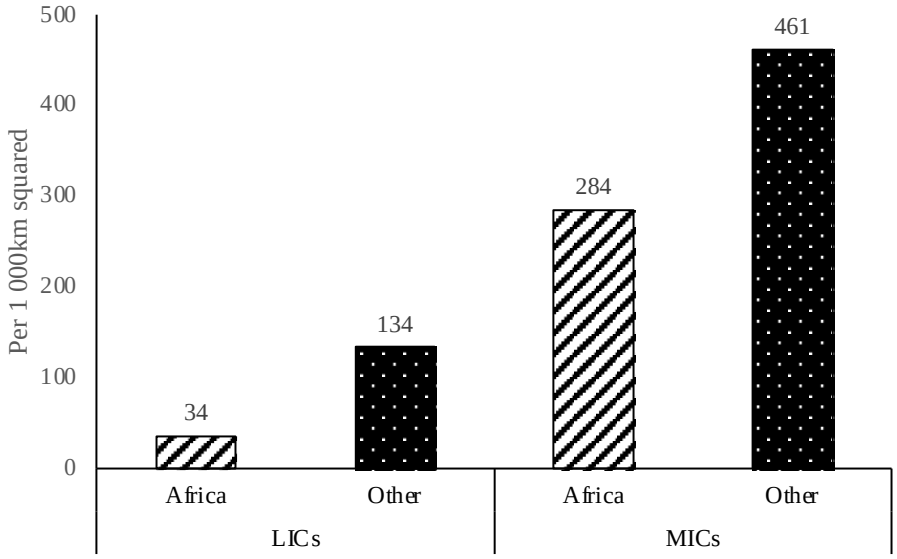
Countries with the least access to improved water sources, all falling below a 50 percent access rate, include Ethiopia, Mozambique, and Mauritania, each located in SSA, as reported by WHO and UNICEF (2010). Noteworthy progress has, however, been achieved in SSA, with Burkina Faso, Ghana, Namibia, Malawi, and South Africa reaching the Millennium Development Goal target for safe drinking water by 2006, according to the AfDB (2010). Despite these advancements, the region as a whole faces substantial challenges in ensuring universal access to improved water sources, highlighting the need for continued efforts and targeted interventions.

Accounting for the third largest sector by infrastructure deficit terms, transportation infrastructure remains a challenge across Africa. According to the AfDB (2018), the transport infrastructure gap in Africa amounts to between $35 billion and $47 billion. This is worrisome as the continent could vastly benefit from an improved transportation system, particularly on an economic front. A modernised transportation system tends to increase the manufacturing competitiveness in a cheap and efficient manner by allowing raw materials to be moved around with ease. This underinvestment has also been costly, hindering the ability of the continent to trade globally with ease, transportation and insurance costs account for 30 percent of total export value, compared to a mere 9 percent in other developing regions UN-HABITAT (2011).

A more expansive transport network also contributes to the labour market, affording more people access to job opportunities. On a human development front, these transport networks could provide people with better access to basic education and health services. Additionally, paved, and well-maintained roads could also reduce road traffic injuries and fatalities. This is of concern, as in Africa the paved road density is significantly lower than elsewhere (AfDB,

2018). According to the AfDB (2010), SSA has a total road network of 204 kilometres per 1000 kilometres squared, compared to a global average of 944 per 1000 kilometres squared. Moreover, added to the low road density in SSA, only about 25 percent of the road network across SSA is paved. The chart below, Figure 1, illustrates that paved road density in African states lags that of other countries globally. Low-Income Countries (LICs) in Africa have a road density four times lower than LICs outside the continent. While Middle-Income Countries (MICs) in Africa show some improvement relative to their global peers, they still have only half the road density. Notably, there is a stark contrast in road development between LICs and MICs within Africa, highlighting the significant disparities within the continent itself.

Figure 1: Paved road density across Africa versus other countries



Source: Adapted from (AfDB, 2010)

Note: As at 2024, the World Bank defines LICs as those with a Gross National Income per capita (GNIPC) of $1,1135 or less, while Middle Income Countries have a GNIPC of between $1,136 and $13,845.

The rail sector emerges as the most underdeveloped infrastructure segment across Africa, a poignant circumstance given the continent's primary reliance on bulk commodity exports that could be transported more efficiently and cost-effectively through rail transportation compared to road. This setback, however, presents a compelling investment opportunity for both local and foreign investors keen on developing the African rail network or financing essential assets such as locomotives for use once the network is established.

In terms of rail development, North Africa stands out as the most advanced, notably with Morocco hosting the sole high-speed railway in Africa. The Al-Boraq train, connecting the port city of Tangier to Casablanca, achieves speeds of up to 320 kilometres per hour, significantly

reducing travel time from nearly five hours to just over two hours (Jones, 2023). Despite these success stories, such advancements are scarce when examining rail transportation across the continent. Unfortunately, SSA bears the brunt of these challenges, with the AfDB (2010) reporting that thirteen countries in SSA lack an operational rail network.

Notably, Gabon, Botswana, and South Africa are the exceptions with a network density exceeding four hundred, while the rest of the African countries exhibit a network density ranging between 30 and 50. To put this into perspective, European countries boast rail densities ranging between 200 and 1000 (AfDB, 2010). This stark contrast underscores the urgent need for comprehensive efforts to revitalise and expand rail infrastructure across Africa, presenting significant opportunities for transformative investments.

Promisingly, there is a sense of optimism as African leaders demonstrate a collective understanding of the challenge and unite their efforts to address the pressing need for rail infrastructure across the continent. A pivotal initiative in this regard is the African Integrated High-Speed Railway Network (AIHSRN), established as a flagship project under the broader Agenda 2063. This ambitious project envisions connecting cities, commercial and industrial hubs, economic zones, and tourist destinations across Africa through an extensive high-speed rail network that spans the entire continent.

Adopting a strategic and phased approach, the AIHSRN is currently in the development stage, with the first phase set to be completed within the period from 2013 to 2023, as outlined by the African Union Development Agency-NEPAD (AUDA-NEPAD, 2023). This concerted effort signifies a significant step toward transforming the rail infrastructure landscape in Africa, reflecting a shared commitment to fostering connectivity, economic growth, and development across the continent.

While the infrastructure gap in Africa is widely acknowledged, an equally significant reality persists – the substantial cost and funding challenges associated with infrastructure development. Securing adequate funding has been a longstanding issue on the continent. As of 2020, the infrastructure financing gap across four key sectors – transport, water, energy, and ICT – reached approximately $96 billion, according to the Infrastructure Consortium for Africa (ICA, 2020). A substantial portion of this gap, totalling $59 billion, was attributed to water infrastructure alone.

This financial shortfall underscores the pressing need for comprehensive and sustained efforts to bridge the funding gap and enable robust infrastructure development. Addressing this

challenge requires innovative financing mechanisms, strategic partnerships, and a concerted commitment from both domestic and international stakeholders to ensure that infrastructure projects vital for Africa's sustainable development receive the necessary financial support.

2.3.2 Poverty

Recognising the significant strides in mitigating global poverty is paramount. Seipel (2003) asserts that in the last 50 years, the world has witnessed a decline in poverty at an unprecedented rate compared to the previous 500 years. This underscores the feasibility of overcoming poverty. Despite such progress, poverty has persistently and detrimentally impacted human well-being over an extended period, standing as a formidable global challenge.

As a response to this challenge, global attention has been keenly directed towards poverty alleviation, emphasizing its status as a top priority. This commitment is reflected in the formulation of the MDGs in 2000 and, subsequently, the establishment of the SDGs 15 years later. However, it becomes apparent that the battle against poverty is progressing at a pace slower than desired. The goal of eradicating poverty by 2030 appears elusive. This as the COVID-19 pandemic arrived at a less than ideal time, considering the world's slower progress in poverty reduction between 2014 and 2019 (World Bank, 2022a).

The progress towards bringing people out of poverty and living without the deprivation of basic services has been largely uneven. At the close of the MDG period, those living below the global poverty line reside almost solely in two regions, Southern Asia, and SSA. Together these regions accounted for as much as 80 percent of extremely poor persons globally (UN, 2015).

At the start of the SDG era in 2015, SSA alone had a population of more than 40 percent living in poverty as reported by the UN (2015), a rate that has since declined. However, a large contributor to this was the fact that less individuals now lives below the poverty line since the shift from the 2011 to the 2017 PPPs. According to Jolliffe et. al (2022), SSA also showed the largest decline in poverty levels post the adoption of the 2017 PPPs.

Nonetheless, the reality remains that global poverty is very much condensed to SSA, with a poverty rate approximately 4 times that of South Asia, the region with the second highest poverty rate behind SSA. Estimates from 2019 reflect an SSA poverty rate of 37 percent, while South Asia is below 20 percent (World Bank, 2022a). Indicating that, although these two regions are the two poorest globally, significant disparities are present.

Another factor also plaguing Africa is the rapid population growth, so while the poverty rate may be declining the number of people living in poverty on the continent and specifically in

the SSA region is increasing. Latest estimates indicate that 389 million persons in Africa live off less than $2.15 per day.

This bleak reality is precisely what is driving the poverty discourse, which has shed light on several matters. Most interestingly – what is the cause of Africa's poverty and why has it so stubbornly persistent? Kates & Dasgupta (2007) notes numerous reasons including, geopolitics and the heritage that has been left by colonialism specifically focusing on the state of the infrastructure, economy, health, and education of subject nations. Adding that these factors have often driven countries to conflict further delaying the journey to economic and social prosperity of Africa.

Tackling global poverty necessitates nuanced strategies that account for the unique economic, social, and cultural differences across various regions. SSA stands at the forefront of this challenge, grappling with high poverty rates that demand targeted interventions. By understanding the evolution of poverty and making regional comparisons, policymakers and stakeholders can better tailor initiatives to address the specific needs of SSA and contribute to the global goal of eradicating poverty.

2.4 THEORETICAL FRAMEWORK

Infrastructure is widely acknowledged as a fundamental prerequisite for a nation's prosperity. It is, therefore, unsurprising that it has become a focal point for governments, development practitioners, and the broader private sector. The Asian Development Bank (ADB) (1999) underscores the critical link between poverty reduction and economic growth. They put forward that when economic growth is coupled with robust macroeconomic management and effective governance, it not only facilitates sustainable development but also promotes social inclusivity.

The report titled "World Development Report, Infrastructure for Development" (World Bank, 1994) has played a pivotal role in advancing the discourse on infrastructure development and its impact on economic progress and poverty alleviation. By fostering diversified production, facilitating expanded trade, accommodating population growth, mitigating poverty, and enhancing environmental conditions, infrastructure emerges as a key determinant of a nation's success or failure.

A notable contribution of the report is its emphasis on the timing of infrastructure investment. According to the World Bank (1994), for optimal results, infrastructure development should align with the pace of economic growth. This insight underscores the importance of

synchronising the expansion of infrastructure with the broader economic context, highlighting the nuanced relationship between the two.

According to Dissou & Didic (2013), although exceptional economic growth does not guarantee a reduction in inequality or poverty, there is a consensus among researchers and policymakers that rapid and consistent growth is imperative for poverty alleviation efforts.

A nation reaps significant advantages from its infrastructure investments, as articulated by the United Kingdom Department of International Development (2002). These investments contribute to economic development by reducing transaction costs and facilitating cross-border trade, enabling economic players to respond dynamically to diverse demands in different locations. Additionally, infrastructure development lowers input costs associated with the production of goods and services, fosters the creation of new business opportunities, thereby increasing profitability, and plays a pivotal role in employment generation. In essence, a well-directed focus on infrastructure not only enhances a country's physical foundation but also serves as a powerful driver for comprehensive economic growth and prosperity.

Corroborating the aforementioned perspective, a report by UN-HABITAT (2011) asserts that Africa's comprehensive infrastructure challenges have led to suppressed competitiveness on the global stage. The report highlights the burdensome task of conveying goods and services produced in Africa to the world marketplace, emphasizing the toll these infrastructure limitations have taken on the continent's global economic participation.

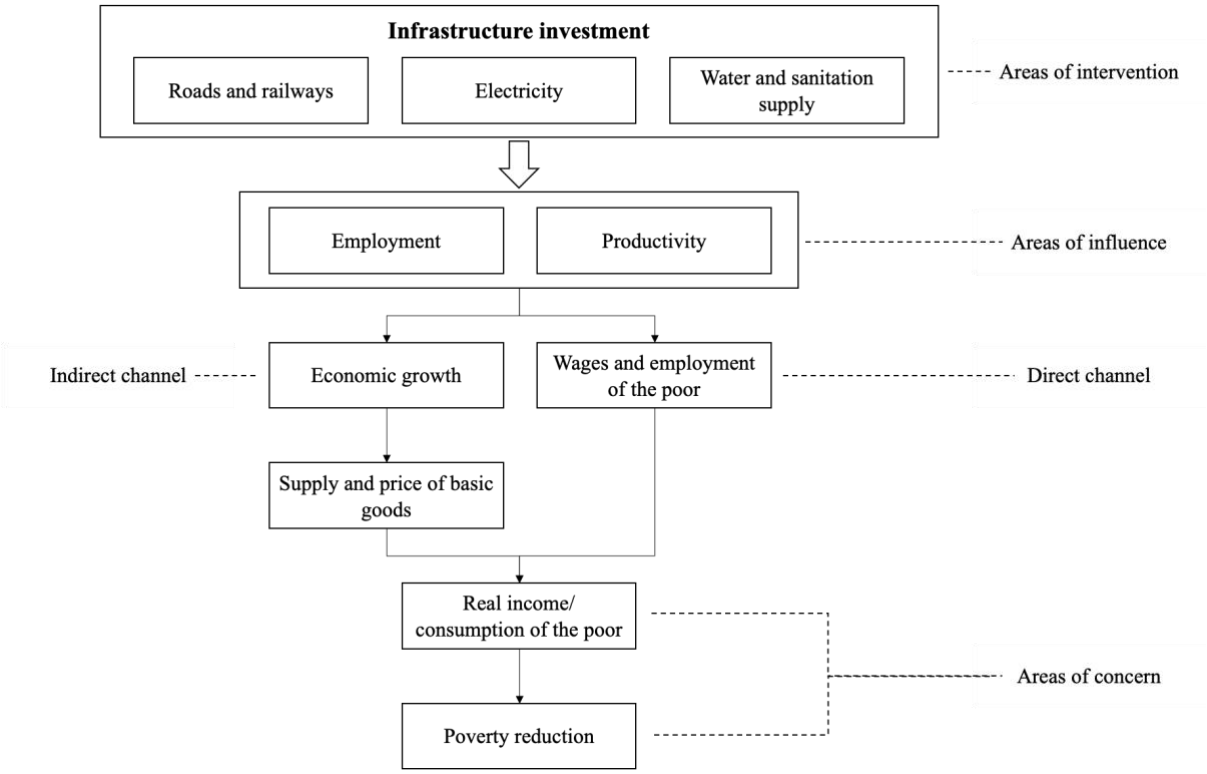
Straub (2011) in a report appraising literature on infrastructure and development adds that infrastructure can make a vital contribution to the improvement of a nation’s quality of life especially for the poor. Hence, it becomes evident why infrastructure development stands out as a global priority, especially among developing nations that grapple with a substantial gap in both the quantity and quality of infrastructure.

Weiss (1999) highlights the critical importance of assessing the benefits of infrastructure investment by considering the opportunity costs associated with neglecting such investments. This is particularly evident in the business sector, where enterprises may find it necessary to invest in generators as a response to the unreliability of electricity supply. Weiss (1999) specifically underscores the challenges posed by an unstable electricity supply in SSA, emphasizing the real-world implications of inadequate infrastructure investment in this region.

Figure 2 illustrates the theoretical dynamics of infrastructure investment and its impact on poverty, recognising that such investment can contribute to poverty reduction through either

direct or indirect channels. In the direct channel, infrastructure investment is envisioned to lead to an increase in wages and employment opportunities. Conversely, through the indirect channel, economic growth is expected to enhance a country's capacity to acquire goods and services or distribute more income to its citizens. The goal of both channels is to collectively reduce the number of individuals living in poverty.

Figure 2: Framework illustrating the link between infrastructure investment and poverty reduction.



Source: Adapted from Ali & Pernia (2003)

According to Mujumder (2012), there has been a departure from the conventional perspective on infrastructure investment and its presumed "trickle-down" effects towards a new paradigm known as pro-poor growth. Pro-poor growth is characterised as "growth that enables the poor to actively participate in, and significantly benefit from economic activity." This shift reflects a deliberate emphasis on poverty reduction, wherein infrastructure development serves as the tool. This marks a departure from the previous approach, where investment was primarily aimed at economic growth, with poverty reduction considered a by-product resulting from increased per-capita income emanating from economic growth. This study aims to build on this, by assessing the direct impact that infrastructure investment has had on poverty alleviation.

2.5 EMPIRICAL LITERATURE

The empirical research conducted by Aschauer (1989) is considered seminal for its focus on the relationship between productivity and government spending stock. Analysing the period from 1949 to 1985 using the United States of America (USA) as a subject country, the study found that core infrastructure (highways, streets, water systems and sewers) investment has the most significant impact on productivity.

Building upon Aschauer's study, early contributors to the body of work, employing different methodologies and datasets, include Easterly& Rebelo (1993), Canning & Pedroni (1999), and Esfahani & Ramírez (2003). These studies collectively demonstrate that infrastructure has a lasting impact on production and income levels.

In the earliest of the mentioned studies, Easterly & Rebelo (1993) assert that "investment in transport and communication is consistently correlated with growth." Utilising a cross-section regression approach akin to Barro (1990), they analysed a dataset spanning 100 countries over the period 1970 to 1988.

Canning & Pedroni (1999) delved into the long-term effects of infrastructure on per capita income across a panel of countries from 1952 to 1992. Their findings indicate that investment in electricity-generating capacity positively influenced per capita income in 60 percent of the countries, followed by telephone infrastructure with a positive impact in 54 percent of the countries. Roads, in turn, yielded positive outcomes in 52 percent of the countries.

Esfahani & Ramírez (2003) tell us that the contribution made by infrastructure to the growth of an economy is sizeable, often surpassing costs associated with the provision of this infrastructure. The analysis comprised a cross country model consisting of 75 countries that focused on the impact that power and telecommunications infrastructure has on per capita GDP growth rates.

Encompassing four pivotal sectors – energy, water and sanitation, transport, and telecommunications, Chotia & Rao (2017a) devised a comprehensive infrastructure development proxy. Their study aimed to scrutinise the enduring and causal dynamics between infrastructure development and poverty reduction in India over the period of 1991 to 2015. Utilising per capita consumption as a surrogate for poverty reduction, the research uncovered a compelling nexus. The findings robustly affirmed a long-term co-integrating relationship, clarifying a causal link flowing from both infrastructure development and economic growth to the reduction of poverty. Notably, the study identified a positive unidirectional causality

specifically emanating from infrastructure development towards poverty reduction. This underscores the pivotal role of infrastructure in fostering economic prosperity and alleviating poverty, thus emphasizing the need for strategic investments in key sectors to drive sustainable development.

Broadening the scope beyond India to encompass the BRICS nations (Brazil, Russia, India, China, and South Africa), Chotia & Rao (2017b) conducted an investigation into the relationships among infrastructure development, economic growth, poverty, and, notably, introduced a novel variable – inequality. While both studies by Chotia & Rao (2017a, 2017b) share similarities, relying on an infrastructure index comprising only hard components such as energy, transport, water and sanitation, and telecommunications, and utilising per capita consumption as a proxy for poverty reduction, there are discernible distinctions. In the BRICS study, a notable addition was the incorporation of rural-urban inequality as a variable. This inclusion stemmed from findings in studies such as Ravallion (2005), which suggested that while infrastructure investment could serve as a catalyst for economic growth, it can give rise to subsequent inequality. Methodologically, the study across BRICS nations employed a Panel Dynamic Ordinary Least Squares (PDOLS) approach and Pedroni's panel co-integration test. In contrast, the study pertaining to India's infrastructure development and poverty reduction deployed the Autoregressive Distributed Lag (ARDL) methodology (Chotia & Rao, 2017a, 2017b).

In spite of these methodological differences, both studies converge on a shared conclusion: a clear long-run relationship exists between infrastructure investment, economic growth, and, ultimately, poverty reduction. Additionally, the BRICS study identified a short-run causality from economic growth to rural-urban inequality. These findings collectively underscore the importance of considering varied factors, including inequality, when assessing the impact of infrastructure on broader economic and social outcomes.

Turning our attention closer to home, Calderón & Servén (2008) in their examination of SSA, discovered a positive direct correlation between infrastructure development and long-term economic growth, along with a simultaneous negative impact on inequality.

Akinbobola & Saibu (2004) conducted a study delving into the economic landscape of Nigeria. Collecting quarterly data spanning the period 1986 to 2000, they employed a Vector Autoregressive (VAR) model to investigate the interplay among income, government expenditure, and the Human Development Index (HDI) as a representative measure for poverty.

The study's findings revealed a noteworthy correlation: as capital expenditure increased, unemployment concurrently subsided. This dynamic led to an enhancement in the HDI, culminating in a reduction in poverty levels. Consequently, the authors advocated for a strategic shift in Nigeria's macroeconomic policies, emphasizing the importance of prioritising infrastructure development. They argued that such a focus would not only result in expanded job opportunities but also lead to an uptick in per capita income, ultimately contributing to a decline in poverty rates. The implications of their research underscore the potential transformative impact of targeted economic policies on a nation's overall well-being and socioeconomic progress.

Subsequently, a study investigating the impact of infrastructural development and poverty reduction using Nigeria as a subject was conducted by Ogun in 2010. Diverging from the study published by Akinbobola & Saibu in 2004, Ogun's research introduced notable distinctions on two principal fronts. Firstly, Ogun's investigation delved into the impacts of both physical and social infrastructure investments. This expanded scope provides a more comprehensive understanding of the multifaceted contributions of different forms of infrastructure to poverty alleviation. Secondly, Ogun adopted a Structured Vector Autoregressive (SVAR) model, utilising quarterly data spanning from 1970 to 2005. This analytical approach is characterised by its consideration of the structural dynamics inherent in the subject economy. Interestingly, despite these methodological differences, Ogun's findings resonated with Akinbobola & Saibu's conclusions. Both studies affirmed the poverty-reducing effects of infrastructure investment. However, Ogun's contribution went beyond, revealing a nuanced insight – the impact of soft infrastructure on poverty reduction surpassed that of physical infrastructure. This nuanced perspective offers valuable insights for policymakers, emphasizing the need for a holistic approach that considers both physical and social infrastructure to address poverty effectively (Ogun, 2010).

Ruch & Geyer (2017) conclude on a municipal level that significant infrastructure investment yields rather subdued levels of poverty reduction. Focusing on local and district municipalities within South Africa; their study found that between 2001 and 2011 a 1 percent increase in economic growth attributable to infrastructure development resulted in 1.2 to 1.5 percent decrease in poverty.

In their examination specifically of road infrastructure with paved roads as a proportion of total roads, Anyanwu & Erhijakpor (2009) discovered a noteworthy correlation. Specifically, a 10 percent increase in road infrastructure investment resulted in a 5.2 percent reduction in the

poverty headcount across 33 African countries. This investigation utilised datasets spanning the years 1990 to 2005. Notably, the study illuminated that the extent of poverty alleviation is contingent on the chosen poverty measurement metric. When employing more nuanced indicators such as poverty depth and severity, the outcomes revealed a more substantial impact, with a 6.1 and 6.9 percent decrease respectively in poverty observed for a commensurate increase in road infrastructure investment.

2.6 CONCLUSION

As previously noted, an extensive body of work has been done drawing the connection between infrastructure investment and economic growth with key contributors including (Aschauer, 1989; Canning & Pedroni, 1999; World Bank, 1994). Developing nations have more frequently found themselves to be the subject of these studies, with works done by (Fedderke et al., 2006; Kodongo & Ojah, 2016; Kumo, 2012), amongst others. This is as governments of underdeveloped nations are particularly aware of the need to narrow their infrastructure gap in the effort to foster and facilitate growth. While at the same time, the nexus between infrastructure and poverty gains traction as a subject of interest, SSA has emerged as a focal point in numerous studies. However, to the best of the Author's knowledge, there remains a gap in the literature specifically examining this connection on a regional level in SSA, with a dedicated emphasis on the MDG period spanning from 2000 to 2015. It is precisely this void in the literature that the present study aims to address.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter outlines the methodological processes used to address the research question of this study. It begins by explaining the research approach and design, followed by a description of the data and an explanation of the relevant variables. The chapter then presents the model specification and details the chosen estimation approach.

3.2 RESEARCH APPROACH AND DESIGN

In academia, there are three widely accepted research approaches for conducting studies, qualitative research, quantitative, and a mixed approach. This study employed a quantitative research approach to address the research question outlined in Chapter 1. This approach was adopted as it best fits the objective of this study which sought to determine a causal relationship between investment in core infrastructure and poverty reduction, which can be effectively analysed using quantitative data and statistical methods. Research indicates that a similar approach was adopted in numerous studies that sought to determine causal relationships between infrastructure and economic growth and/ or poverty, these include (Calderón & Servén, 2008; Kumo, 2012; Seneviratne & Sun, 2013).

3.2.1 Sample size, data period and source

The dataset utilised in this study consists of annual national data from a panel of 35 nations within the SSA region, as depicted in Table 1. The research spans the timeframe from 2005 to 2015, covering the final 11 years of the MDG era. While acknowledging the significant passage of time since the conclusion of the investigation period, a couple of factors guided the decision to examine this specific timeframe. Firstly, the study aims to align with the MDG period. The MDGs provided a global framework for addressing key development challenges which included poverty (MDG1: Eradicate extreme poverty and hunger). The study thus sought to assess progress towards this goal, particularly in the context of infrastructure development and its impact on poverty.

Secondly, and possibly more importantly, the availability of reliable and comprehensive data for analysis was a key consideration. Complete infrastructure data was only available from 2005 onwards. Therefore, the chosen investigation period aligned with the availability of good quality data sources.

Secondary data for this study was sourced from the databases of both the World Bank and the AfDB. This robust dataset allows for a thorough examination of the relationship between infrastructure development and poverty reduction in the SSA region.

To ensure a focused analysis, countries within SSA that have undergone significant conflicts during the period under examination were intentionally excluded from the dataset. For the purpose of this study, significant conflict adopts the definition of Non-International Armed Conflicts (NIAC). The International Committee of Red Cross (ICRC) adopting Article 3 of the Geneva Convention define NIAC as armed conflicts involving one or more non-governmental armed groups. The ICRC further distinguishes armed conflict from lessor conflicts by applying two criteria. Firstly, hostilities must reach a minimum level of intensity. An example would be when the government is obliged to use military force against the insurgents, as opposed to police forces. Secondly, non-governmental groups involved in the conflict need to be recognised as 'parties to the conflict.' This recognition requires that these groups possess organised armed forces, which implies having a defined command structure and the capability to sustain military operations (ICRC, 2008). Based on the aforementioned definition, the nations to be excluded from the study are – Cote d'Ivoire, Central African Republic, Cameroon, Congo, Democratic Republic, Somalia, and South Sudan. Subsequently, data was collected for the remaining 41 countries, with each country contributing a maximum total of 99 datapoints. If a country had less than 80 percent of the total datapoints, it was excluded from the analysis. As a result, the following countries were excluded from the study – Liberia, Malawi, Mozambique, Nigeria, São Tomé and Príncipe, and Zambia.

Table 1: List of countries that comprised the panel for SSA.

No.	Country	No.	Country
1	Angola	19	Lesotho
2	Benin	20	Madagascar
3	Botswana	21	Mali
4	Burkina Faso	22	Mauritania
5	Burundi	23	Mauritius
6	Cabo Verde	24	Namibia
7	Chad	25	Niger
8	Comoros	26	Rwanda
9	Congo, Republic	27	Senegal
10	Equatorial Guinea	28	Seychelles
11	Eswatini	29	Sierra Leone
12	Ethiopia	30	South Africa
13	Gabon	31	Sudan
14	Gambia, The	32	Tanzania
15	Ghana	33	Togo
16	Guinea	34	Uganda
17	Guinea-Bissau	35	Zimbabwe
18	Kenya		

Source: Author

3.2.2 Model specification

The study employs the following empirical model specification to examine the relationship between infrastructure development and poverty:

$$PVT = f(TRAindex, ELEindex, WSSindex, CPI, TOP, GNIPC) \quad (1)$$

$$PVT_{CY} = \beta_0 + \beta_1 TRAindex_{CY} + \beta_2 ELEindex_{CY} + \beta_3 WSSindex_{CY} + \beta_4 CPI_{CY} + \beta_5 TOP_{CY} + \beta_6 GNIPC_{CY} + e_{CY} \quad (2)$$

Here, $TRAindex, ELECindex, and\ WSSindex$ represent three of the four components of the Africa AIDI – transport, electricity, and water and sanitation, respectively. The indices are on

an annual basis specific to each country in the study denoted as *CY*, where $C = 1$ represents the country and $Y = 1$ each annual period under investigation.

3.2.3 Measurement and definition of variables

Infrastructure development

In assessing a nation's infrastructure development, this study utilised components of the Africa Infrastructure Development Index (AIDI). Developed by the AfDB as part of its Africa Infrastructure Knowledge Programme (AIKP), the AIDI serves as a dedicated portal for infrastructure-related data across the continent.

The AIDI encompasses four infrastructure sub-sectors: transport, electricity, water and sanitation, and ICT. However, given the specific focus on core infrastructure in this study, only three sub-sectors were adopted. These include:

- Transport (TRAindex): Total paved roads (kilometres (km) per 10 000 inhabitants), Total road network (per km² of exploitable land area);
- Electricity (ELEindex): Net generation (kWh per inhabitant); and
- Water and sanitation (WSSindex): Improved water source (% of population with access), Improved sanitation facilities (% of population with access).

Expanding on the insights presented by Ogun (2010), it is crucial to note that despite a sustained increase in infrastructure investment spending in Nigeria, its impact has been subdued by the pervasive influence of inflation. The study emphasized that, when adjusted for inflation, the genuine value of infrastructure investment has declined. The adoption of non-monetary metrics as an evaluative tool for infrastructure development in this study aims to alleviate the distortions introduced by inflation, offering a more precise and authentic portrayal of the actual infrastructure advancements over time.

Poverty

Ideally the study would employ as the measure of poverty, the percentage of persons within a country living below the global poverty line which is set, based on 2017 PPPs, at $2.15 per day. This definition aligns well with the World Bank's definition of poverty, which identifies individuals living in poverty as those whose expenditures fall below socially acceptable minimum living standards (World Bank n.d.). However, poverty time series data for developing countries and specifically African states remains largely sporadic over the time period under investigation in this study. The World Development Indicators (WDI) database, developed by

the World Bank, only provided 84 datapoints out of a potential 528 for the number of persons living below the international poverty line across the 48 countries in SSA. Due to this substantial gap in the dataset, adopting the international poverty line as a measure was deemed impractical for this study.

Keho (2017) tells us that due to the inability to source sufficient poverty time series data, household final consumption per capita was adopted as a proxy. Their study investigated the relationship between financial development, economic growth and poverty reduction on a panel of African countries.

Consumption expenditure is dependably reported and notably stable as opposed to income for poor person according to Kheir (2018), whose study employed a similar measure to that of Keho (2017), however, this time, household final expenditure annual growth was adopted. The study investigated the connection between financial development and poverty reduction in Egypt.

Odhiambo (2009) who examined the inter-temporal causal relationship between financial sector development and poverty reduction within Zambia, faced a similar challenge of sourcing adequate data on poverty. The study used per capita consumption as a proxy for poverty, noting that is a better measure than per capita income as the latter does not account for the relationship between poverty and growth.

For the purpose of this study, we measure the poverty (PVT) of countries in SSA using Household final consumption expenditure per capita. Household final consumption expenditure per capita has become the indicator of choice for the World Bank when measuring poverty. An estimated level of consumption per household is derived at after interviewing several households where they are asked to specify purchases of goods against a list of market products over a set period. This data combined with a poverty line can then identify those living in poverty. The World Bank Acknowledges that income may also be used as a measure of poverty, however, this should only be used where it is the only possible indicator of well-being within a country (Jolliffe et al., 2015). For this study, the household final consumption expenditure, utilising the 2015 constant prices is U.S. dollars has been applied.

It is essential to acknowledge that the above metrics may not encompass all dimensions of poverty as measured by the World Bank and UNDP. However, applying a more basic measure such as the global poverty line is not without its flaws in this study. Firstly, during the period under investigation, the definition of the poverty line underwent changes. Until 2014, the

poverty line was established at $1.25, utilising the 2005 PPPs, and subsequently adjusted to $1.90 in 2015, applying the 2011 PPPs. This evolution in the poverty line standards poses a challenge in maintaining consistency over the study duration. Second, applying a global poverty line might not fully account for the nuances that each country may face from a poverty perspective.

Control variables

This study incorporates three control variables:

- **Consumer Price Index (CPI)** is employed as a metric to assess inflation. Several factors underlie this choice. Firstly, inflation progressively erodes the purchasing power of individuals over time, a phenomenon underscored by Chotia & Rao (2017b). Notably, the adverse effects of inflation are more pronounced on the poor and middle class compared to affluent members of society. Secondly, given the extensive 11-year duration of the investigation, it becomes nearly unavoidable for individuals not to experience the impact of price adjustments. Consequently, given the study's primary focus on the impoverished population, who are likely to be disproportionately affected by inflation, and considering the prolonged study duration, the inclusion of CPI as a variable is deemed pertinent.
- **Trade openness (TOP)**, quantified by trade as a percentage of GDP, is introduced as a control variable. The work of Malefane & Odhiambo (2018) highlights the substantial impact of TOP on economic growth, particularly when total trade relative to GDP is used as an indicator. The inclusion of TOP serves to mitigate the potential influence of trade on GDP per capita, aligning with the study's specific goal of examining the exclusive effects of infrastructure development on poverty. By incorporating TOP, the study seeks to enhance the precision of its analysis and provide a clearer understanding of the nuanced relationship between infrastructure development and poverty within the context of the selected variables.
- **GNI per capita growth (GNIPC)** is defined as the sum of value added by all resident producers plus product taxes, less subsidies not included in the valuation of output plus net receipts of primary income (compensation of employees and property income) from abroad. The value is then divided by the midyear population (World Bank, 2022b).

The control variable data was sourced from the World Development Indicators (WDI) database, developed by the World Bank. All the variables are taken in their natural logarithm.

3.3 ESTIMATION APPROACH

Three distinct panel data estimation techniques are available for consideration in the current study: the fixed effects model, the random effects model, and/ or a mixed effects model can be applied to the panel of data. Each of these approaches offers unique insights into the sources of variation within the dataset, influencing the choice of the most suitable model for the analysis.

The fixed-effects model posits that the sole origin of uncertainty arises from within the study itself, implying that the only errors considered are those associated with sampling or estimation. The model assumes that individual countries contribute to the observed variation solely through time-invariant characteristics, thereby isolating within-country variations.

Conversely, the random-effects model introduces an additional source of uncertainty into the analysis. In this model, variations across individual countries are acknowledged to have an impact on the dependent variable, supplementing the uncertainties related to sampling or estimation. The random-effects model accommodates both within-country and between-country variations, recognising that the characteristics of individual countries may evolve over time.

To determine the most appropriate model for the analysis, a Hausman test is required. This statistical test is crucial for assessing the choice between fixed and random effects models. The null hypothesis of the Hausman test puts forward that the random effects model is preferable, implying that the observed variations across individual countries are not systematically related to the dependent variable. In contrast, the alternative hypothesis suggests that the fixed effects model is more suitable, indicating that country-specific characteristics significantly contribute to the observed variations in the dependent variable.

The theoretical foundations of the fixed and random effects models, as well as the application of the Hausman test, draw from seminal works in econometrics. Notably, Wooldridge (2002) provides comprehensive insights into fixed and random effects models, offering a rigorous foundation for understanding their applications and implications. Additionally, Hausman (1978) introduced the Hausman test, which has become a standard tool for model selection in panel data analysis.

To summarise, the choice between fixed and random effects models is a critical decision in panel data analysis. Drawing on the theoretical underpinnings presented by Wooldridge (2002) and the statistical methodology introduced by Hausman (1978) , the application of a Hausman

test in the current study aims to robustly determine the most appropriate model for capturing the underlying dynamics of the dataset.

3.3.1 Heteroskedasticity

Heteroskedasticity arises when the standard error of a variable fluctuates over time, indicating a non-constant variance of error terms. Conversely, with homoskedasticity, error terms maintain a consistent level of variability. In the context of regression analysis, heteroskedasticity introduces a lack of constancy in the standard error of a variable, potentially impacting the reliability of statistical inferences. It is noteworthy that while heteroskedasticity does not inherently introduce bias into coefficient estimates, its presence raises the likelihood of these estimates deviating further from the true population values.

Empirical research underscores the significance of addressing heteroskedasticity to enhance the precision of regression analysis. White (1980) argues that heteroskedasticity can lead to inefficient estimators and, consequently, incorrect standard errors, affecting the accuracy of hypothesis tests and confidence intervals. Additionally, Greene (2003) emphasizes the importance of robust standard errors in the presence of heteroskedasticity, highlighting that failure to account for varying variances may result in unreliable statistical inferences.

To assess the potential presence of heteroskedasticity, the current study employed the Breusch-Pagan/Cook-Weisberg test using the statistical software application, Stata. The test assumed a null hypothesis that the error terms are constant.

In conclusion, the recognition and mitigation of heteroskedasticity are pivotal in ensuring the reliability of regression analysis. The insights from White (1980) and Greene (2003) contribute to the rationale for addressing heteroskedasticity within the dissertation's methodology, offering a firm foundation for the subsequent interpretation of results and the formulation of valid conclusions.

3.3.2 Multicollinearity

Multicollinearity, a phenomenon arising from strong correlations among two or more independent variables, can pose challenges in regression analysis, potentially inflating the variability in the predicted variable – in this context, poverty. The assessment of multicollinearity was conducted utilising Stata, allowing us by means of a correlation matrix to assess the interrelationships among the independent variables

Empirical studies emphasize the detrimental impact of multicollinearity on the reliability and interpretability of regression models. Notably, Aiken & West (1991) caution that high correlations between explanatory variables can lead to inflated standard errors and unstable coefficient estimates, hindering the accurate identification of the individual contributions of each variable. Furthermore, the seminal work of Belsley et al. (1980) underscores the importance of diagnosing multicollinearity, as its presence can compromise the efficiency of parameter estimates and pose challenges in discerning the true relationships between variables.

In summary, the careful examination of multicollinearity underscores the significance of statistical diagnostics in regression analysis. The results, supported by insights from Aiken & West (1991), Belsley et al. (1980) , and Johnston (1984), affirm the reliability of the regression model, providing confidence in the validity of the estimated relationships and enhancing the overall integrity of the dissertation's findings.

3.3.3 Wald test

The Wald test is a statistical test used in hypothesis testing to assess whether a particular parameter in a statistical model is significantly different from a hypothesized value. It is commonly employed in the context of regression analysis among other statistical models.

In the context of regression analysis, the Wald test is often used to test the null hypothesis that a specific coefficient in the regression model is equal to a certain value. The test compares the estimated value of the coefficient to the hypothesized value and assesses whether any observed difference is statistically significant.

Specifically in this study, the test is applied to examine the overall impact of the infrastructure development variables – transport, electricity, and water and sanitation – on the dependent variable – poverty, measured by household final consumption per capita. Additionally, the Wald test evaluates the combined significance of the control variables, namely the CPI, trade openness, and GNI per capita. The test was conducted utilising Stata.

The null hypothesis for the Wald test posits that all the coefficients associated with a particular set of variables (either infrastructure or control variables) are jointly equal to zero. In contrast, the alternative hypothesis suggests that at least one coefficient within the set is non-zero, indicating a significant impact of the variables on the dependent variable.

The use of the Wald test enhances the robustness of our analysis, providing insights into the collective importance of the variables of interest. A statistically significant result would suggest

that the included variables jointly contribute to explaining the observed variations in poverty, strengthening the empirical foundation of our study.

In summary, the Wald test helps researchers assess the significance of specific parameters in a statistical model, providing insights into whether these parameters have a meaningful impact and contribute to explaining the variability in the dependent variable.

CHAPTER 4

DISCUSSION OF RESULTS

4.1 INTRODUCTION

In this chapter, we aim to operationalise the research approach and methodology outlined in the preceding chapter. We commence by presenting an overview of the statistical characteristics of the sample data. Subsequently, we conduct diagnostic testing to scrutinise both the robustness and validity of the model employed. Following this, we proceed to estimate the correlation coefficients for each independent variable. Finally, we conclude with an interpretation of the observed relationships, providing insights that will contribute to the formulation of conclusions and recommendations in the subsequent chapter.

4.2 DESCRIPTIVE STATISTICS

The below descriptive statistics as seen in Table 2, offer a concise summary of key measures and the composition of the study sample. This investigation encompasses a dataset ranging from 357 to 385 observations, examining the dynamics of poverty as the dependent variable, along with three independent variables – transport, electricity, and water and sanitation. Additionally, three control variables – Consumer Price Index, Trade openness, and GNI per capita growth – were incorporated. The study spans a duration of 11 years, covering the period from and including 2005 to 2015, and involves a comprehensive analysis across 35 countries in SSA.

Table 2: Descriptive statistics

Stats	Mean	Median	Std. dev.	Min	Max	N
PVT	1 371.7	834.2	1 326.6	203.6	6 899.9	369
TRAindex	10.6	6.8	10.7	0.6	53.3	385
ELEindex	7.7	1.9	15.8	0.1	82.4	385
WSSindex	54.8	54.2	20.7	4.9	99.6	385
CPI	6.7	5.4	6.8	-16.9	44.4	376
TOP	74.8	63.6	36.7	18.4	222.1	377
GNIPC	2.1	2.1	5.3	-26.8	30.6	357

Note: PVT = Poverty, TRAindex = Transport index, ELEindex = Electricity index, WSSindex = Water and Sanitation index, CPI = Consumer Price Index, TOP = Trade Openness, GNIPC = GNI per capita growth. Source: Author's estimate based on panel data

The average household final consumption, as reflected by the mean poverty level, stands at $1 371.7. However, the median, at $834.2, reveals an asymmetry, indicating a leftward skew in the overall distribution. This skewness suggests that a portion of the population experiences higher poverty levels, contributing to the observed imbalance. The relatively high standard deviation of $1 326.6 underscores the wide dispersion of poverty values. This variability is inherent in countries within SSA, where economic, social, and structural factors contribute significantly to disparities. The standard deviation, in this context, reflects the diverse and complex nature of poverty across the region. As one examines the range, we see the disparity in poverty across the region. Over the period under investigation, Burundi represented the lower bound of the range with a household final consumption expenditure per capita of $203.6, while Mauritius accounted for the upper bound at $6 899.9. This wide range emphasizes the substantial variability in poverty levels, and further underscores the intricate interplay of economic factors and societal structures within SSA. The disparity across this range solidifies the notion that the region exhibits diverse poverty experiences. In summary, the mean, median, standard deviation, and range collectively paint a nuanced picture of poverty in SSA. The values not only provide insights into the average household consumption but also highlight the complexity and diversity of poverty levels, reflecting the multifaceted challenges faced by countries in the region.

The mean transport index, at 10.6, offers a comprehensive average assessment of various transportation-related variables. Meanwhile, the median, situated at 6.8, suggests a rightward skew in the distribution, indicating that a significant portion of the data is concentrated towards higher values. The standard deviation, standing at 10.7, signifies a noteworthy degree of variability in transport index values, underscoring the diverse nature of the dataset. The range, spanning from 0.6 to 53.3 represented by Sudan and Mauritius respectively, illuminates the extensive spread of transportation development within SSA. Only two countries namely, Seychelles and Mauritius over the 11 year period under investigation had a transport infrastructure index value of above 30, while seven countries, including Angola, Chad, Congo, Republic, Ethiopia, Mali , Niger, and Sudan all held average index values of below 3.

With a mean electricity index, of 7.7, and a median situated at 1.9, we may deduce that the distribution is skewed to the right, implying a concentration of data towards higher electricity index values. The standard deviation, notably high at 15.8, underscores the broad dispersion observed in electricity index values. This suggests a significant degree of variability, emphasizing the wide range of values captured within. The range, extending from 0.1 (Sierra

Leone) to 82.4 (South Africa), indicates the extensive span of electricity generation within SSA countries, showcasing both low and high extremes. It should be noted that regarding the upper end of electricity generation for SSA countries, South Africa is an outlier, within SSA, averaging 77.9 over the period, 2005 to 2015. The nearest state being Seychelles who averaged 50.4 over the same period. Countries who averaged the poorest Electricity infrastructure development from 2005 to 2015, with an index value of below 1 include – Benin, Burkina Faso, Burundi, Chad, Ethiopia, Guinea-Bissau, Niger, Rwanda, Sierra Leone, and Togo.

The mean water and sanitation index, computed at 54.8 encapsulating the average assessment of the percentage of the population with access to improved water sources and sanitation facilities. Examining the distribution, the median value of 54.2 indicates a relatively symmetric spread of the water and sanitation index. This suggests a balanced distribution of values around the centre, highlighting a more even distribution. The standard deviation, recorded at 20.7, signifies a degree of variability in water and sanitation index values. This variability reflects differences in the extent of access to improved water and sanitation facilities within the dataset. Furthermore, the expansive range spanning from 4.9 (Ethiopia) to 99.6 (Mauritius) starkly portrays the wide spread of water and sanitation access in SSA. It is noted that all countries (Mauritius, Seychelles, South Africa, and Botswana) which hold a water and sanitation index value of above 80 are located in Southern Africa.

The mean CPI, positioned at 6.7%, acts as a pivotal metric conveying the average inflation rate across SSA for the period under investigation. Delving into the distribution, the median value of 5.5% hints at a rightward skew, indicating that a significant portion of the data leans towards higher inflation rates. This asymmetry suggests a propensity for occasional instances of higher inflation impacting the overall distribution. The standard deviation, registering at 6.8%, highlights the variability inherent in inflation rates. This statistic underscores the diverse nature of price fluctuations within the dataset, emphasizing the dynamic economic landscape. Notably, the range spanning from -16.9% to 44.4% is noteworthy, encapsulating both negative and positive values. This broad range implies potential periods of deflation or inflation, showcasing the economic volatility and the capacity for prices to both contract and expand over the observed period. This dual representation of negative and positive values adds a layer of complexity to the analysis, capturing the multifaceted nature of economic conditions affecting the consumer price index.

The mean trade openness, standing at 74.8%, depicts the average extent of a country's participation in international trade. Examining the distribution, the median value of 63.6%

points towards a right-skewed pattern, indicating that a significant proportion of countries tend to higher trade openness levels. This skewness suggests that there are countries with particularly robust international trade relations, contributing to the overall rightward shift in the distribution. The standard deviation, marked at 36.7%, highlights the diverse range of engagement levels in international trade, signifying the heterogeneity among countries in their economic interactions with the global market. The expansive range, stretching from 18.4% to 222.1%, underlines the wide spread in trade openness across SSA. This extensive range encapsulates the diverse spectrum of engagement levels, with some countries exhibiting more restrained trade practices while others are notably open.

The mean growth rate of gross national income per capita, standing at 2.1%, indicates the average economic expansion across SSA. Exploring the distribution, the median growth rate of 2.1% indicates a relatively symmetric pattern, suggesting a balanced distribution of countries experiencing comparable levels of economic growth. This symmetry underscores the presence of a diverse yet collectively balanced economic landscape across the studied nations. The standard deviation, recorded at 5.3%, reveals a degree of variability in growth rate values. This variation highlights the diverse economic trajectories within SSA, emphasizing the unique circumstances and growth patterns experienced by individual countries. The range, spanning from -26.8% to 30.6%, illustrates the substantial spread in gross national income per capita growth rates. This wide range signifies the significant heterogeneity in economic performance among SSA countries, capturing instances of both contraction and robust growth. The inclusion of negative values in the range provides insight into periods of economic contraction, contributing to a comprehensive understanding of the economic landscape within the region.

4.3 MULTICOLLINEARITY RESULTS

Multicollinearity emerges when there is a pronounced correlation among two or more explanatory variables, potentially leading to increased variability in the predicted variable, in this case, poverty.

Table 3 displays the results of the multicollinearity test, revealing that, at a 5% significance level, all variables exhibit correlations below 0.75. This suggests the absence of multicollinearity concerns within the model, reinforcing the robustness of the regression analysis in capturing the dynamics influencing poverty.

Furthermore, Table 3 indicates that all infrastructure sectors are positively correlated with household final consumption per capita. Transport and electricity infrastructure exhibit the joint highest correlation value at 0.73, while water and sanitation closely follows at 0.72.

Turning attention to the control variables, it is evident that both trade openness and gross national income per capita growth share a positive relationship with household final consumption per capita, holding correlations of 0.56 and 0.03, respectively. As a result, inflation stands out as the sole control variable with an inverse relationship to household final consumption.

Table 3: Correlation matrix

	PVT	TRAindex	ELEindex	WSSindex	CPI	TOP	GNIPC
PVT	1.00						
TRAindex	0.73	1.00					
ELEindex	0.73	0.55	1.00				
WSSindex	0.72	0.71	0.60	1.00			
CPI	-0.02	-0.08	-0.06	-0.14	1.00		
TOP	0.56	0.60	0.36	0.44	-0.06	1.00	
GNIPC	0.03	0.03	0.01	-0.02	0.02	0.05	1.00

Note: PVT = Poverty, TRAindex = Transport index, ELEindex = Electricity index, WSSindex = Water and Sanitation index, CPI = Consumer Price Index, TOP = Trade Openness, GNIPC = GNI per capita growth. Source: Author's estimate based on panel data

4.4 MODEL DIAGNOSTICS

A model diagnostic test for the equation was conducted. These diagnostics encompassed determining assessments for heteroskedasticity, assessment for overall significance of the model, and an estimation technique. The results are presented in Table 4 below.

4.4.1 Wald test results

The F-test statistic is highly significant for all three models, indicating that the overall fit of the models is statistically significant.

4.4.2 Heteroskedasticity results

The obtained p-value is > 0.05 for the TRAindex, and we therefore conclude that that heteroskedasticity is not present. Regarding ELEindex and WSSindex, the obtained p-value is

< 0.05 across both models including each of these variables. We therefore conclude that heteroskedasticity is present.

4.4.3 Hausman results

We conducted the Hausman fixed random test to determine the most suitable estimation technique for our dataset. The null hypothesis for this test posits that the preferred model is a random effect estimation technique. Without the inclusion of a year dummy, the obtained p-value is 0.0031, which falls below the 5% significance level. As a result, the significance of the TRAindex variable is established, leading us to reject the null hypothesis. This indicates that the error variance in our dataset is fixed, supporting the use of a fixed effect model for our analysis.

Conversely, when a year dummy is introduced as shown in Table 4, the p-value increases to 0.1254, surpassing the 5% significance level. Consequently, we consider this result insignificant and retain the null hypothesis. This suggests that the error variance in the dataset is random in the presence of a year dummy, implying that a random effect model is more suitable for the TRAindex variable in this scenario. Turning to the ELEindex and WSSindex, we consistently observe a p-value of 0.000, which does not exceed the 5% significance level, both in the absence and presence of a year dummy. This leads us to infer that the error variance in our dataset for these two variables is fixed, supporting the appropriateness of a fixed effect model in both cases.

4.5 REGRESSION RESULTS

Table 4 provides a comprehensive overview of the regression results, shedding light on the impact of distinct infrastructure indicators on poverty. All infrastructure sectors share a positive and significant relationship with that of poverty, proxied by household final consumption per capita. The coefficients of determination (R-squared) for estimated models indicates that 38.75%, 48.95% and 47.18% of the variations in poverty (household consumption) are collectively explained by model 1 (Transport investments), model 2 (Electricity investments) and model 3 (Water and sanitation investments) respectively.

The positive and significant coefficient for TRAindex suggests that a one-unit increase in transport infrastructure is associated with a 1% increase in household consumption, signifying a reduction in poverty levels. This finding aligns with previous works including, that of Mutiiria et al. (2020) and Saadaoui Mallek et al. (2023) and was expected due to the productive nature of transport infrastructure and the crucial role it plays in fostering economic growth. It is well

understood that an extensive transport network provides the necessary physical connectivity which facilitates the movement of goods and people. This enhanced accessibility, reduces transportation costs, and improves overall efficiency in the movement of goods and services. As businesses gain easier access to markets and resources, they can expand their operations, leading to increased economic activity. Additionally, the interconnectedness encourages the development of economic corridors and facilitates the movement of people and resources between different regions. Research tells us that this economic expansion facilitated by efficient transport infrastructure can provide access to job opportunities, and access to essential services. This has a direct impact on poverty reduction, contributing to improved living standards and income levels for the population. Moreover, the enhanced connectivity provided by transport infrastructure allows people in rural and remote areas to access education, healthcare, and more easily, reducing the isolation that can contribute to poverty.

The positive and significant coefficient observed for ELEindex implies that a one-unit increase in the electricity infrastructure is associated with a 0.3% increase in household consumption, indicating a potential reduction in poverty. This result is consistent with that of Zhang & Zhang (2002) and Runsinarith (2010). This result is also expected due to the significant role that electricity plays in the production process and the support it provides to several key sectors within any economy. Mutiiria et al. (2020) tells us that, in some regions across Africa, electricity shortages has resulted in limited business activity as that only takes places during the daytime. This heightened economic activity, businesses can increase productivity, and expand their activities. This leads to the creation of job opportunities, higher income levels, and a more robust local economy. The growth of economic activities, driven by electricity infrastructure, is a key driver in reducing poverty by providing individuals with the means to support themselves and their families. For persons who live in rural areas, access to electricity may facilitate the modernisation of agricultural activities through the adoption of more efficient farming practices, allowing for crop diversification. This not only increases agricultural output but also provides rural communities with the opportunity to move beyond subsistence farming, leading to improved incomes and reduced vulnerability to food insecurity. As a result, electricity infrastructure contributes to poverty reduction by transforming traditional agricultural practices. In the realm of education, electricity plays a crucial role in enhancing learning opportunities. Access to electricity ensures that schools are equipped with lighting, enabling extended study hours and facilitating the use of modern teaching tools and technologies. By providing a conducive environment for education, electricity infrastructure

contributes to building human capital and breaking the cycle of poverty through improved educational outcomes. One may therefore conclude that electricity infrastructure is a cornerstone of poverty reduction, influencing economic development, education, healthcare, and overall well-being. By providing a reliable and affordable source of power, electricity enables communities to break free from the constraints of poverty, fostering sustainable development and creating opportunities for individuals to improve their quality of life. As governments and organisations invest in expanding and maintaining electricity infrastructure, they contribute significantly to the global effort to alleviate poverty.

The positive and significant coefficient observed for WSSindex also implies that a one-unit increase in the water and sanitation infrastructure index is associated with a 0.5% increase in household final consumption per capita and thus a reduced level of poverty. Similar findings were noted by Sasmal & Sasmal (2016) and Chotia & Rao (2017b). Water and sanitation infrastructure plays a crucial role in poverty reduction by addressing fundamental human needs, promoting health, and supporting overall economic development. Access to clean water and proper sanitation facilities is essential for lifting communities out of poverty and improving the quality of life for individuals. Firstly, improved water and sanitation infrastructure directly impact health outcomes. Access to clean water reduces the prevalence of waterborne diseases, such as cholera and dysentery, which disproportionately affect impoverished communities. Sanitation facilities, including proper sewage systems and toilets, contribute to preventing the spread of diseases and creating a healthier living environment. As a result, reduced illness and better overall health contribute to increased productivity, allowing individuals to engage more fully in economic activities and breaking the cycle of poverty caused by preventable diseases. In the economic sphere, reliable access to water and sanitation is critical for various industries and businesses. Agriculture, for instance, heavily relies on water for irrigation, and proper sanitation practices contribute to the safety and quality of agricultural products. Furthermore, those who bear the responsibility of water collection and sanitation management in many developing regions, benefit significantly from improved water and sanitation infrastructure. Access to clean water and sanitation facilities can free up time to engage in income-generating activities contributing to poverty reduction. These findings collectively underscore the importance of infrastructure investment in reducing poverty levels. The positive coefficients across all models suggest that improvements in transport, electricity, and water and sanitation infrastructure are associated with increased household consumption and, consequently, reduced levels of poverty.

Shifting attention to control variables, the coefficient for inflation, proxied by CPI is not statistically significant across all three models (p-value > 0.05). This suggests that changes in the consumer price index do not have a significant impact on poverty in the context of the models. In other words, fluctuations in consumer prices may not be a significant driver of changes in household consumption or poverty levels. This finding contradicts that of Anyanwu & Erhijakpor (2009) and Chotia & Rao (2017b), who find that inflation exacerbates poverty. It should be noted that in the study by Anyanwu & Erhijakpor (2009) poverty is proxied by means of a poverty head count ratio as opposed to this study which applies household final consumption as the measurement of poverty. The coefficient for TOP is positive and statistically significant at the 1% level in all three models. This implies that increased trade openness is associated with an increase in household consumption and thus a reduction in poverty. This finding aligns to that of Chotia & Rao (2017b) and is expected as trade openness often leads to increased economic activity, as nations engage in international trade and commerce. This heightened economic activity may contribute to higher employment levels and income generation, potentially lifting households out of poverty. Stemming from the access to a broader market, trade openness can result in a wider variety of goods and services being available to consumers at competitive prices. This can enhance the purchasing power of households, leading to improved standards of living and potentially reducing poverty. The coefficients for GNIPC are not statistically significant across all three models (p-value > 0.05). This suggests that changes in Gross National Income per capita may not have a significant direct impact on poverty levels in the models. Other factors, such as infrastructure development, seem to play a more prominent role. The weak relationship between poverty reduction and GNIPC growth could be explained through inequality. Overall GNIPC might be increasing, however, if the income distribution is highly skewed, with a substantial portion of the wealth concentrated among a few, the positive impact on poverty rates may be limited. High income inequality can thus offset the positive effects of rising GNIPC on poverty reduction. Another factor may be inflation. If the increase in GNIPC is primarily driven by inflation, without corresponding real income growth, the cost of living may rise, potentially offsetting the positive impact on poverty rates. Finally, poor governance, corruption, and subpar public administration could divert the benefits of economic growth away from poverty reduction efforts. Not fit-for-purpose institutions may result in the misallocation of resources, limiting the positive impact of GNIPC growth on poverty reduction.

Table 4: Regression results for poverty in SSA

	Model 1	Model 2	Model 3
	REM	**FEM**	**FEM**
Constant	6.569*** (0.121)	6.652*** (0.034)	6.382*** (0.139)
TRAindex	**0.010*** (0.003)**		
ELEindex		**0.003** (0.002)**	
WSSindex			**0.005*** (0.002)**
CPI	0.000 (0.001)	0.000 (0.001)	0.000 (0.001)
TOP	0.001** (0.000)	0.001** (0.000)	0.001*** (0.000)
GNIPC	0.000 (0.001)	0.001 (0.001)	0.000 (0.001)
Year dummy	Yes	Yes	Yes
F/Wald χ^2	293.49***	20.82***	268.91***
R-squared	0.3875	0.4895	0.4718
Hausmanχ^2 (Prob > χ^2)	20.15 (0.1254)	30.001 (0.000)	60.91 (0.000)
Hettest χ^2 (Prob > χ^2)	0.68 (0.4092)	9.69 (0.0019)	6.83 (0.009)
AR 1: F (Prob > F)	5.032 (0.0315)	5.458 (0.0255)	4.18 (0.0487)
Countries	35	35	35
Observations	353	353	353

*Note: PVT = Household final consumption, TRAindex = Transport index, ELEindex = Electricity index, WSSindex = Water and Sanitation index, CPI = Consumer Price Index, TOP = Trade Openness, GNIPC = GNI per capita growth. ***, ** and * denote significance at 1%, 5% and 10% respectively. Source: Author's estimate based on panel data*

CHAPTER 5

SUMMARY, CONCLUSION AND POLICY RECOMMENDATIONS

5.1 INTRODUCTION

This chapter summarises the findings of the study. It also makes policy recommendations before closing off by identifying the potential for future studies.

5.2 SUMMARY AND CONCLUSIONS

The literature underscores the critical role of infrastructure investment in fostering economic development and alleviating poverty, aligning with the overarching goal of governments worldwide to eradicate poverty. This study was motivated by this imperative and sought to empirically investigate whether infrastructure investment within the MDG period (2005 to 2015) in SSA had indeed led to poverty reduction. Covering 35 countries in the region, rigorous criteria were applied to ensure data integrity, excluding nations marred by extensive conflicts and those lacking sufficient data points.

Regression analysis was employed, with household final consumption per capita serving as the dependent variable, while infrastructure investment was proxied by the transport composite index, electricity index, and water and sanitation composite index. Additionally, three control variables – namely, inflation, trade openness, and gross national income per capita growth – were incorporated to refine the analysis.

The empirical findings reveal a compelling narrative: poverty was significantly reduced through investment in all three infrastructure sectors during the investigation period. Notably, the transport sector exhibited the most pronounced impact, followed by water and sanitation, and electricity infrastructure. This corroborates existing literature, affirming a positive relationship between infrastructure development and poverty reduction.

The robustness of our results was meticulously examined through various tests. The Wald test underscored the overall model's significance, validating its suitability for our research purpose. Moreover, the Hausman test facilitated the selection of the most appropriate estimation technique, favouring the random effects model for the transport index (Model 1) and fixed effects models for the electricity index (Model 2) and water and sanitation index (Model 3). Finally, the Heteroskedasticity test provided insights into the variance structure across models, guiding further analysis.

Despite the broader increase in the poverty headcount observed across Africa during the fifteen-year MDG period, this study unequivocally demonstrates that infrastructure investment has played a pivotal role in poverty reduction within SSA. By empirically substantiating the literature, our findings underscore the significance of infrastructure development in enhancing the standard of living and fostering economic prosperity for the people of SSA.

5.3 POLICY RECOMMENDATIONS

Moving forward, the above insights can inform policy discussions, emphasizing the imperative of sustained infrastructure investment as a catalyst for sustainable development and poverty alleviation in the region. These include:

- **Increase investment in transport infrastructure:** Governments in SSA should prioritise investment in transport infrastructure, given its significant impact on poverty reduction. This includes developing comprehensive road networks, railways, ports, and air transport systems to enhance connectivity, facilitate trade, and improve access to markets and essential services in both urban and rural areas.
- **Enhance access to water and sanitation services:** Efforts should be made to expand access to safe water and sanitation facilities across the region. This involves investing in infrastructure for clean water supply, wastewater treatment, and sanitation services, particularly in underserved communities. Policies should prioritise equitable access, targeting areas with the highest levels of poverty and vulnerability.
- **Promote electrification initiatives:** Governments should implement policies to increase access to reliable electricity services, particularly in rural and peri-urban areas where electrification rates are low. This may involve investing in renewable energy sources, improving energy distribution networks, and promoting off-grid solutions to ensure universal access to electricity.
- **Promote Public-Private Partnerships (PPPs):** Governments should explore opportunities for engaging the private sector through PPPs to mobilise additional resources and expertise for infrastructure development. PPPs can facilitate innovative financing mechanisms, improve project efficiency, and mitigate fiscal constraints faced by governments.
- **Foster regional co-operation and integration:** Regional cooperation and integration initiatives can play a crucial role in enhancing infrastructure connectivity, promoting trade, and facilitating cross-border investments. Governments should prioritise regional

infrastructure projects, harmonise regulatory frameworks, and strengthen institutional mechanisms to foster regional co-operation and integration.

- **Ensure stable macroeconomic policies:** Considering the long-term nature of infrastructure investments, governments should pursue sound macroeconomic policies aimed at maintaining price stability, fiscal discipline, and a sustainable balance of payments. This includes implementing prudent monetary and fiscal policies to control inflation, manage public debt, and promote macroeconomic stability.
- **Strengthen anti-corruption laws and enforcement:** Strengthen anti-corruption laws and enforcement mechanisms to deter corrupt practices in infrastructure projects. This may involve enacting stricter penalties for corruption-related offenses, enhancing law and enforcement capacity.
- **Investment mandates and asset allocation:** Governments can encourage pension funds to allocate a portion of their assets under management to infrastructure investments by defining specific investment mandates and targets. This may involve setting minimum allocations or providing incentives for infrastructure investment through tax incentives or regulatory reforms.
- **Credit enhancement mechanisms:** Governments can provide credit enhancement mechanisms, such as guarantees, or insurance to mitigate investment risks and enhance the creditworthiness of infrastructure projects. These mechanisms can help institutional investors overcome perceived investment barriers and increase their appetite for infrastructure as an investment asset class.

5.4 AVENUES FOR FUTURE STUDIES

Future research endeavours could delve into the nuanced dimensions of infrastructure development and its multifaceted impacts. An area ripe for exploration involves expanding the study beyond mere quantity of infrastructure to also encompass its quality within the SSA context. High-quality infrastructure is often linked with heightened efficiency and a longer useful life, thereby enabling prolonged benefits to be derived from it.

In addition, focusing on the poverty aspect, future studies could incorporate two additional factors. Firstly, examining poverty depth – measuring how far individuals fall below the poverty line. This metric provides crucial insight into the gravity of deprivation experienced by individuals. Secondly, exploring poverty severity – indicating the extent to which poverty is concentrated among the most impoverished individuals within society. This factor offers

valuable insights into the distribution of incomes among the poor, shedding light on the vulnerability and inequality experienced by marginalised populations.

APPENDICES

Appendix A – AIDI components and indicators selected for this study

Index	Indicators
Transport composite index (TRAindex)	**a. Total Paved Roads (km per 10,000 inhabitants):** The country's total surface with crushed stone (macadam) and hydrocarbon binder or bituminized agents, with concrete, or with cobblestones. The indicator is measured in km per 10,000 inhabitants as a proxy of access to the paved road network.
	b. Total Road Network (per km² of exploitable land area): The total road surface (both paved and nonpaved roads) of a given country. The indicator is measured in km (per km² of exploitable land area). Exploitable land area is the total surface area of a country minus the surface area of deserts, forest, mountains and other inaccessible areas.
Electricity Index (ELEindex)	**Net Generation (kWh per inhabitant):** The total electricity production of a given country, including the energy imported from abroad. This includes both private and public energy generated. The indicator is measured in millions of kilowatt-hours produced per hour and per habitant.

Index	Indicators
Water and Sanitation Composite Index (WSSindex)	**a. Improved Water Source (% of population with access):** Access to an improved water source refers to the percentage of the population with reasonable access to an adequate amount of water from an improved source, such as a household connection, public standpipe, borehole, protected, well, or spring, and rainwater collection. Unimproved sources include vendors, tanker trucks, and unprotected wells and springs. Reasonable access is defined as the availability of at least 20 litres a person per day from a source within 1 km of the dwelling.
	b. Improved Sanitation Facilities (% of population with access): Access to improved sanitation facilities refers to the percentage of the population with at least adequate access to excreta disposal facilities that can effectively prevent human, animal, and insect contact with excreta. Improved facilities range from simple but protected pit latrines to flush toilets with a sewerage connection. In order to be effective, facilities must be correctly constructed, in addition to being properly maintained.

Source: Adapted from the AfDB Statistics Department

REFERENCES

AfDB. (2018). *African Economic Outlook 2018*. African Development Bank. https://www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/African_Economic_Outlook_2018_-_EN.pdf

African Union. (2013). *Agenda 2063*. https://au.int/en/agenda2063/goals

Aiken, L. S., & West, S. G. (1991). *Multiple Regression: Testing and Interpreting Interactions*. Sage Publications, Inc.

Akinbobola, T. O., & Saibu, M. O. O. (2004). Income inequality, unemployment, and poverty in Nigeria: a vector autoregressive approach. *The Journal of Policy Reform*, *7*(3), 175–183. https://doi.org/10.1080/1384128042000261800

Ali, I., & Pernia, E. M. (2003). *Infrastructure and Poverty Reduction - What is the Connection? Asian Development Bank* (13; ERD Policy Brief Series). http://www.adb.org/Economics/default.asp

Anyanwu, J. C., & Erhijakpor, A. E. O. (2009). The Impact of Road Infrastructure on Poverty Reduction in Africa. In *Poverty in Africa* (p. 281). Nova Science Publishers.

Aschauer, D. A. (1989). Is Public Expenditure Productive? *Journal of Monetary Economics*, *23*, 177–200.

Asian Development Bank. (1999). *Fighting Poverty in Asia and the Pacific: The Poverty Strategy*.

AUDA-NEPAD. (2023). *Programme for Infrastructure Development in Africa (PIDA): First 10-Year Implementation Report.* www.nepad.org

Barro, R. J. (1990). Government Spending in a Simple Model of Endogenous Growth. *Journal of Political Economy*, *98*(5, Part 2), S103–S125. https://doi.org/10.1086/261726

Beegle, K., Christiaensen, L., Dabalen, A., & Gaddis, I. (2016). *Poverty in a RISING Africa*. https://doi.org/10.1596/978-1-4648-0723-7

Belsley, D. A., Kuh, E., & Welsch, R. E. (1980). *Regression Diagnostics*. Wiley. https://doi.org/10.1002/0471725153

Biyase, M., & Zwane, T. (2018). An Empirical Analysis of the Determinants of Poverty and Household Welfare in South Africa. *The Journal of Developing Areas*, *52*(1), 115–130. https://doi.org/10.1353/jda.2018.0008

Calderón, C., & Servén, L. (2008). *Infrastructure and Economic Development in Sub-Saharan Africa* (4712). http://econ.worldbank.org.

Canning, D., & Pedroni, P. (1999). *Infrastructure and Long Run Economic Growth* (57; Consulting Assistance on Economic Reform II).

Chotia, V., & Rao, N. V. M. (2017a). An empirical investigation of the link between infrastructure development and poverty reduction: The case of India. *International Journal of Social Economics*, *44*(12), 1906–1918. https://doi.org/10.1108/IJSE-06-2016-0154

Chotia, V., & Rao, N. V. M. (2017b). Investigating the interlinkages between infrastructure development, poverty and rural–urban income inequality: Evidence from BRICS nations. *Studies in Economics and Finance*, *34*(4), 466–484. https://doi.org/10.1108/SEF-07-2016-0159

Dagume, M. A. (2021). Factors Influencing Poverty in South Africa: Time Series Analysis. *International Journal of Economics and Financial Issues*, *11*(5), 86–95. https://doi.org/10.32479/ijefi.11629

Dissou, Y., & Didic, S. (2013). Infrastructure and Growth. In J. Cockburn, Y. Dissou, J.-Y. Duclos, & L. Tiberti (Eds.), *Economic Studies in Inequality, Social Exclusion and Well-Being*. Springer. https://doi.org/10.1007/978-3-319-03137-8_2

Easterly, W., & Levine, R. (1997). Africa's Growth Tragedy: Policies and Ethnic Divisions. *The Quarterly Journal of Economics (JSTOR)*, *112*(4), 1203–1250. https://inequality.stanford.edu/sites/default/files/media/_media/pdf/Classic_Media/Easterley%20and%20Levine_1997_Development%20Economics.pdf

Easterly, W., & Rebelo, S. (1993). *Fiscal Policy and Economic Growth: An Empirical Investigation* (4499; NBER Working Paper Series).

Escribano, A., Guasch, J. L., & Pena, J. (2010). *Assessing the Impact of Infrastructure Quality on Firm Productivity in Africa*. http://econ.worldbank.org.

Esfahani, H. S., & Ramírez, M. T. (2003). Institutions, infrastructure, and economic growth. *Journal of Development Economics*, *70*(2), 443–477. https://doi.org/10.1016/S0304-3878(02)00105-0

Fedderke, J. W., Perkins, P., & Luiz, J. M. (2006). Infrastructural investment in long-run economic growth: South Africa 1875–2001. *World Development*, *34*(6), 1037–1059. https://doi.org/10.1016/j.worlddev.2005.11.004

Fourie, J. (2006). Economic Infrastructure: A review of Definitions, Theory and Empirics. *South African Journal of Economics*, *74*(3), 530–556. https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1813-6982.2006.00086.x

Great Britain. Department for International Development. (2002). *Making connections: infrastructure for poverty reduction.* DFID.

Greene, William. H. (2003). *Econometric Analysis* (5th ed.). Pearson Education.

Hausman, J. A. (1978). Specification Testsin Econometrics. *Econometrica*, *46*(6), 1251–1271.

Heathcote, C., & Mulheirn, I. (2018). *Global Infrastructure Outlook*.

ICA. (2020). *Infrastructure Financing Trends in Africa*. www.icafrica.org

ICRC. (2008). *How is the Term "Armed Conflict" Defined in International Humanitarian Law?*

Jerome, A. (2011). Infrastructure, Economic Growth and Poverty Reduction in Africa. *Journal of Infrastructure Development*, *3*(2), 127–151. https://doi.org/10.1177/097493061100300203

Jerome, A., Oyeyinka, O., Zhang, X. Q., Kebede, G., Orina, E., & Ondoo, A. (2011). *Infrastructure for Economic Development and Poverty Reduction in Africa*. UN-HABITAT. https://unhabitat.org/sites/default/files/download-manager-files/Infrastructure%20for%20Poverty%20Reduction%20and%20Economic%20Development%20in%20Africa.pdf

Johnston, J. (1984). *Econometric Methods* (3rd ed.). McGraw-Hill.

Jolliffe, D., Daniel, M., Lakner, C., Atamanov, A., & Kofi Tetteh-Baah, S. (2022). *Assessing the Impact of the 2017 PPPs on the International Poverty Line and Global Poverty*. http://www.worldbank.org/prwp.

Jolliffe, D., Lanjouw, Peter., World Bank. Development Research Group, & World Bank Group. (2015). *A Measured Approach to Ending Poverty and Boosting Shared Prosperity: concepts, data, and the twin goals.*

Jones, B. (2023, June 26). *Flying without wings: The world's fastest trains*. CNN. https://edition.cnn.com/travel/article/worlds-fastest-trains-cmd/index.html#:~:text=Morocco%27s%20Al%20Boraq%20is%20Africa%27s%20fastest%20train.

Kammerman, S. B., & Kahn, A. J. (1997). The Problem of Poverty in Industrialized Countries and the policy and Programme Response. In *UNDP Poverty and Human Development* (pp. 81–124).

Kates, R. W., & Dasgupta, P. (2007). African poverty: A grand challenge for sustainability science. *Proceedings of the National Academy of Sciences*, *104*(43), 16747–16750. https://doi.org/10.1073/pnas.0708566104

Keho, Y. (2017). Financial Development and Poverty Reduction: Evidence from Selected African Countries. *International Journal of Financial Research*, *8*(4), 90. https://doi.org/10.5430/ijfr.v8n4p90

Kheir, V. B. (2018). The nexus between financial development and poverty reduction in Egypt. *Review of Economics and Political Science*, *3*(2), 40–55. https://doi.org/10.1108/REPS-07-2018-003

Kodongo, O., & Ojah, K. (2016). Does infrastructure really explain economic growth in Sub-Saharan Africa? *Review of Development Finance*, *6*(2), 105–125. https://doi.org/10.1016/j.rdf.2016.12.001

Kumo, W. L. (2012). *Infrastructure Investment and Economic Growth in South Africa: A Granger Causality Analysis* (160; Working Paper Series). www.afdb.org/

Lakmeeharan, K., Manji, Q., Nyairo, R., & Poeltner, H. (2020). *Solving Africa's infrastructure paradox*. https://www.mckinsey.com/~/media/McKinsey/Industries/Capital%20Projects%20and%20Infrastructure/Our%20Insights/Solving%20Africas%20infrastructure%20paradox/Solving-Africas-infrastructure-paradox.pdf

Lübbe, J. J. (2015). *Project finance as a driver of economic growth in Africa* [University of Stellenbosch Business School]. https://scholar.sun.ac.za

Mafusire, A., Anyanwu, J., Brixiova, Z., & Mubila, M. (2010). *Infrastructure Deficit and Opportunities in Africa*.

Majumder, R. (2012). *Removing poverty and inequality in India: the role of infrastructure*. University of Burdwan.

Malefane, M. R., & Odhiambo, N. M. (2018). Impact of Trade Openness on Economic Growth: Empirical Evidence from South Africa. *Economic Internazionale/ International Economics*, *71*(4), 387–416. www.iei1946.it

Mutiiria, O. M., Ju, Q., & Dumor, K. (2020). Infrastructure and inclusive growth in sub-Saharan Africa: An empirical analysis. *Progress in Development Studies*, *20*(3), 187–207. https://doi.org/10.1177/1464993420927507

Odhiambo, N. M. (2009). Financial deepening and poverty reduction in Zambia: an empirical investigation. *International Journal of Social Economics*, *37*(1), 41–53. https://doi.org/10.1108/03068291011006166

OECD, UN ECA, & AfDB. (2022). *Africa's Urbanisation Dynamics 2022*. OECD. https://doi.org/10.1787/3834ed5b-en

Ogun, T. P. (2010). Infrastructure and poverty reduction: Implications for urban development in Nigeria. *Urban Forum*, *21*(3), 249–266. https://doi.org/10.1007/s12132-010-9091-8

Poverty Measurement, From Noise to Signal... And how the Media can help. (n.d.). World Bank. Retrieved January 7, 2024, from https://www.worldbank.org/content/dam/Worldbank/document/eca/central-asia/TJ-Poverty-Measurement-Media-Training.pdf

Prinsloo, C. (2019). *The Pitfalls of Private Sector Investment in Infrastructure Financing* (187; African Perspectives Global Insights). https://www.icafrica.org/en/

Ravallion, M. (2005). A Poverty-Inequality Trade-off? *Journal of Economic Inequality*, 169–181.

Ruch, W., & Geyer, H. S. (2017). Public capital investment, economic growth and poverty reduction in South African Municipalities. *Regional Science Policy and Practice*, *9*(4), 269–284. https://doi.org/10.1111/rsp3.12104

Runsinarith, P. (2010). *Infrastructure Development and Poverty Reduction: Evidence from Cambodia's Border Provinces*. Nagoya University.

Saadaoui Mallek, R., Awad, A., Ozturk, I., & ben Douissa, I. (2023). Infrastructure development and poverty eradication in sub-Saharan Africa; Its effect and transmission channels. *Cities*, *144*. https://doi.org/10.1016/j.cities.2023.104658

Saghir, J., & Santoro, J. (2018). *Urbanization in Sub-Saharan Africa: Meeting Challenges by Bridging Stakeholders*. https://en.oxforddictionaries.com/definition/sharing_economy.

Sanchez-Robles, B. (1998). Infrastructure Investment and Growth: Some Empirical Evidence. *Contemporary Economic Policy*, *16*(1), 98–108. https://doi.org/10.1111/j.1465-7287.1998.tb00504.x

Sasmal, R., & Sasmal, J. (2016). Public expenditure, economic growth and poverty alleviation. *International Journal of Social Economics*, *43*(6), 604–618. https://doi.org/10.1108/IJSE-08-2014-0161

Seipel, M. M. O. (2003). Global poverty, No longer an untouchable problem. *International Social Work*, *46*(2), 191–207.

Seneviratne, D., & Sun, Y. (2013). *Infrastructure and Income Distribution in ASEAN-5: What are the Links?* (41).

Straub, S. (2011). Infrastructure and Development: A Critical Appraisal of the Macro-level Literature. *Journal of Development Studies*, *47*(5), 683–708. https://doi.org/10.1080/00220388.2010.509785

Stupak, J. M. (2018). *Economic Impact of Infrastructure Investment*. www.crs.gov

Sy, A. N. R. (2017). *Leveraging African Pension Funds for Financing Infrastructure Development*. https://www.brookings.edu/about-us/annual-report/.

UN. (2015). *The Millennium Development Goals Report 2015*.

UN-HABITAT. (2011). *Infrastructure for Economic Development and Poverty Reduction in Africa*. UN-HABITAT.

UNICEF. (2015). *Generation 2030 Africa: Child Demographics in Africa*. https://data.unicef.org/resources/generation-2030-africa-child-demographics-in-africa/#:~:text=Generation%202030%20%7C%20Africa%3A%20Child%20demographics%20in%20Africa,-August%202014&text=In%20the%20next%2035%20years,to%20reach%20almost%201%20billion.

United Nations. (2015a). *The Millennium Development Goals 2015*. https://www.un.org/millenniumgoals/2015_MDG_Report/pdf/MDG%202015%20rev%20(July%201).pdf

United Nations. (2015b, September). *The 17 goals*. https://sdgs.un.org/goals

Weiss, J. (1999). *Infrastructure and Economic Development* (50; Economic Research Paper).

White, H. (1980). A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity. *Econometrica*, *48*(4), 817–838. https://doi.org/10.2307/1912934

WHO, & UNICEF. (2010). *Progress on Sanitation and Drinking-Water, 2010 Update*.

Wooldridge, J. M. (2002). *Econometric Analysis of Cross Section and Panel Data*.

World Bank. (1994). *World Development Report, Infrastructure for Development*. Oxford University Press.

World Bank. (2000). *World Development Report 1990*. Published for the World Bank, Oxford University Press.

World Bank. (2022a). *Poverty and Shared Prosperity 2022: Correcting Course*. The World Bank. https://doi.org/10.1596/978-1-4648-1893-6

World Bank. (2022b). *World Bank Data*. https://databank.worldbank.org/metadataglossary/world-development-indicators/series/NY.GNP.MKTP.KD.ZG#:~:text=GNI%20(formerly%20GNP)%20is%20the,and%20property%20income)%20from%20abroad.

World Bank. (2022c, September 14). *Fact sheet: An Adjustment to Global Poverty Lines*. The World Bank. https://www.worldbank.org/en/news/factsheet/2022/05/02/fact-sheet-an-adjustment-to-global-poverty-lines

Zhang, L., & Zhang, X. (2002). *Growth, inequality, and poverty in rural China: The role of public investments*. https://www.researchgate.net/publication/5056948