# Computation of weighted average cost of capital (WACC) in the power sector for African countries[1]

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**Abstract:**

African countries seeking transformative economic growth and to transition to a low carbon future need access to finance. The high cost of capital—due to perceived and real risks—has made it difficult for these countries to attract investment in projects, especially for capital-intensive electricity infrastructure. It remains difficult to access crucial information about the Weighted Average Cost of Capital (WACC) for African countries. The WACC is a composite of the equity and debt costs that is vital for assessing risks in investments, especially in the electricity sector. Lack of information on WACC hinders investments, strategic planning, efficient resource allocation, competitiveness, and infrastructure development within the continent. This study projects the costs of equity and debt for 48 African countries and five regional groupings between 2023 and 2070 by employing country-specific data, including GDP and population projections, equity risk premiums, sovereign default spread rates, commercial lending rates, and corporate tax rates. We find that the WACC values for African countries in the electricity sector are consistently higher than global and other regional benchmarks. We also find significant disparities in regional values. Additionally, our research reveals that, on average, the cost of equity in Africa is nearly double that of debt. To unleash the full electricity potential of African countries, it is imperative to systematically address inherent risks and foster an environment conducive to attracting investments.

**Keywords:** Weighted average cost of capital; cost of equity; cost of debt; cost of capital; energy transition.
**JEL classification:** C82, F34, G12, Q40

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## 1. Introduction

In developing countries, especially in Africa, households and businesses face challenges in accessing modern energy services, particularly electricity. This struggle is primarily attributed to inadequate power supply (Murshed and Ozturk, 2023; Nussbaumer et al., 2012). More than three-quarters of the global population without access to electricity (i.e., around 600 million) live on the African continent (IEA, 2023). In recent decades many African countries have implemented energy policies and reforms to reduce these deficits. Access to finance however, has been a critical barrier closing the electricity access gap. According to the African Development Bank (2019), the continent requires an average annual investment of 32-42 billion USD between 2018 and 2030 to build a modern power system. Achieving this goal would require engagement and collaborative efforts between the public and private sectors for large deployment of innovative financial solutions.

In 2023, Africa's public debt reached USD 1.8 trillion, corresponding to 60.1% of GDP with a 135% increase since 2010—about four times faster than the growth of its GDP (UNCTAD, 2024). Due to this debt crisis, many African countries lack public capital to finance project development even for state-owned utilities (IEA and AfDB, 2023). Therefore, the private sector will play a vital role in funding energy projects. According to the IEA (2021), private sector will drive 70% of future clean energy investments globally. The ability of African countries to attract private investors will depend on the attractiveness of local financial and energy markets, together with ambitious policies and regulations to provide more confidence to private investors. Additionally, the high perceived and actual risks, including payment, political, and reputational risks, drive policy uncertainties and deteriorate business confidence in Africa. This leads to cost of capital increases and makes investments in electricity projects more expensive in Africa, particularly capital-intensive projects such as those in clean electricity. These expenses can delay investments, inhibit the speed of the energy transition, as well as the necessary phase-out of fossil fuels (Ameli et al., 2021; Hirth and Steckel, 2016).

To better appreciate the high capital cost in each African country and the implications for finance mobilization in the electricity sector, it is important to investigate how investors perceive investment risks in each African country. In this paper, we compute the weighted average cost of capital (WACC) for 48 African countries to reflect country-specific investment costs in electricity technologies. We apply the conventional approach to calculating the WACC, composed of the cost of debt and the cost of equity, all weighted by their corresponding shares. We use GDP and population projections from the Shared Socioeconomic Paths (SSPs), along with cross-sectional data on equity risk premiums and sovereign default spread rates, to project the two key components of the cost of equity from 2023 to 2070. We use this projected cost of equity together with the calculation of the cost of debt (based on commercial lending rates and corporate tax rate) to project the WACC.

To the best of our knowledge, no study uses clear, extensive, and consistent country-specific information to calculate and make projections for the cost of capital in all African countries and discusses their application to derive country-specific cost of electricity technologies. Blimpo et al. (2024) demonstrate in a recent review of research on energy transition modelling on Africa, that most studies do not consider investment costs for energy technologies that reflect the realities in African countries. More often, studies use the cost information at a global level, or apply a specific value for Africa to all African countries. One of the disadvantages of using uniform cost of capital is the potential underestimation bias of energy costs, mainly in developing countries (Egli et al., 2019), which may mislead policy formulation towards costly energy options. Similarly, Gollier (2021) and Iyer et al. (2015) both address critical concerns: Gollier (2021) discusses the adverse social costs resulting from applying a uniform risk-free rate to public investment, while Iyer et al. (2015) highlight the implications of considering non-uniform investment risks, particularly in diminishing investments in low-carbon technologies.

As an alternative, WACC can be used as a discount rate to reflect investment risks in each country and derive country-specific capital costs. Bogdanov et al. (2019) argue that the projection of WACC to 2050 and beyond remains unsatisfactory in the literature and constitutes a challenge in energy system analysis. This is particularly accentuated in African countries lacking relevant data, which could undermine their ability to inform policy decisions, as well as their medium- and long-term planning. Amid the growing body of research on WACC, it is noticeable that minimal attention has been directed towards energy investments in African countries. A limited number of studies focus on Africa as a continent (Ameli et al., 2021), and only very few focus on each African country (see Ondraczek et al., 2015; Sweerts et al., 2019). For example, Sweerts et al. (2019) calculates the WACC for 46 African countries and applies them to compare the impact of financial conditions on the cost of electricity generation across six clean electricity technologies and three fossil-based technologies. They find considerable variations in the cost of those technologies across countries due to the current financial context in each African country. However, most of those studies do not use country-specific information but rather some values from the Clean Development Mechanism's Executive Board (CDMEB) methodology (UNFCC, 2011). They also make projections directly on the WACC and not on the different components of the WACC (i.e., cost of debt and cost of equity).

The main contribution of this study is to fill the gap in the literature by providing an extensive methodology and estimates for the cost of capital in all African countries, which can be used as the discount rate in the electricity sector to derive country-specific electricity technology costs. Recognizing the crucial role of private capital in Africa's electricity projects underscores the importance of gaining a deeper understanding of the factors influencing the determination of the WACC in the region. The WACC varies based on country or region, as well as the technology or fuel investment. This paper explores how the evolving WACC rates affect the country-specific system costs and investment needs for both renewables and firm sources of electricity. The analysis contributes to the understanding of the different WACC values – including disaggregation of cost of capital and cost of debt–between countries and at the regional level on the continent. The projected WACC values can inform project finance and corporate decision-making in African countries on the most cost-effective way to raise capital for financing new electricity projects or expansions. Furthermore, another significant contribution of this study is its applicability to other industries. Hence, this formulation can be extended to various sectors across the continent by adjusting the sensitivity of the assets to the relevant market (i.e., β).

We demonstrate that despite a global decrease in the WACC value over time from 18% to 13% between 2023 and 2070, with an annual average of 15.60%, the rates persist at elevated levels for Africa. This reduction is driven by the lowest WACC values in Northern Africa, while Eastern Africa has the highest WACC. Thus, for a given electricity technology (for instance, solar power or gas power), the same investment will require a higher capital cost in Eastern Africa than in Northern Africa. This discrepancy highlights the need to improve the business environment on the continent, with more effort in countries where the real and perceived risks are too high. In this regard, policymakers should design innovative finance solutions specific to each country's context, including attractive central bank interest rates, subsidies (which might be challenging for some African governments given their limited national budget), purchasing mandates (i.e., clean energy standards, clean fuel standards), regulatory reforms (especially for utilities), etc. To this end, we highlight the disparities among countries in the same sub-region and further show that the high cost of capital in Africa is primarily driven by the cost of equity, which is two times the cost of debt. Thus, the risk perceived by equity investors is higher than that of lenders[9]. This calls for more efforts by African countries to attract investors in the electricity sector by driving down the cost of capital and emphasizing the cost of equity. Nations should also coordinate with regional and international institutions to reduce risks and improve the business environment.

The rest of this paper is structured as follows. In Section 2, we summarize relevant literature. Section 3 explains the methodology and data for computing country specific WACC values. Results are presented in Section 4, starting with the projections of WACC (Section 4.1), and then the projections of cost of equity and cost of debt (Section 4.2) and the drivers of the WACC (Section 4.3), while Section 4.4 discusses the implications of different debt to equity ratios. Section 5 concludes with policy recommendations.

## 2. Literature review

Financial analysts employ different indicators in investment decision-making, with WACC being a prominent measure (Krüger et al., 2015; Leland, 1994). For an investor seeking to acquire shares or stocks, WACC establishes the minimum anticipated rate of return on an investment corresponding to the risk associated with the operation of a specific enterprise. Conversely, for an entrepreneur evaluating the profitability of an investment project, WACC represents the cost of acquiring capital. Consequently, WACC serves as a tool used by issuing companies, portfolio investors, and financial institutions, guiding them in validating decisions. Therefore, WACC serves as a crucial gauge for companies, indicating the threshold at which they should invest to meet obligations to creditors and shareholders (Modigliani and Miller, 1958). Assuming all other factors remain constant, a higher cost of capital diminishes the likelihood of investing in a project. In the private

[9] Note that the cost of equity is not fully attributable to perceived risk - it is also partially about the expected return from alternative investments.

sector, WACC is employed to understand risk levels and ascertain expected financial returns before committing to projects (Donovan and Corbishley, 2016). However, it is hard to get this information, particularly in the energy sector, where project developers do not officially release details of finance deals and each project has its own WACC.

Stakeholders within the energy sector are deeply interested in understanding how WACC is used to compute the costs for projects (Dobrowolski et al., 2022). This interest stems not only from the intricate nature of energy investments and their prolonged recovery period, but also from the myriad risks that affect operations, spanning economic, social, and geopolitical spheres. Many studies have used this metric in the realm of energy investment analysis. Angelopoulos et al. (2017) find that WACC values could reach approximately 12% for onshore wind projects in Greece with slightly lower estimates for solar photovoltaic (PV) projects (i.e., between 7% and 12%). The United Nations Development Program (UNDP) (2014) finds similar results in Organization for Economic Co-operation and Development (OECD) countries, which indicate that WACC values for renewable energy investments typically span from 6% to 12%. Analyzing data from 46 countries globally between 2009 and 2017, Steffen (2020) identifies a consistent global cost ranking of renewable technologies, with solar PV projects having the lowest and offshore wind power having the highest cost of capital. The study also reveals that, on average, the cost of capital is notably higher in developing countries compared to industrialized ones.

Apart from calculating the WACC for various energy investments, several studies have focused on factors that underlie the determination of WACC. By examining data extracted for new onshore wind projects in 28 European Union member states, Angelopoulos et al. (2016) show that policy-related risks, after country risk, have the most considerable influence on the cost of capital. By conducting semi-structured interviews and focus group sessions with 40 experts specialized in onshore and offshore wind project development and financing in Europe, Đukan and Kitzing (2021) conclude that auctions establish a competitive environment compelling the industry to embrace elevated risks and diminished returns. Examining data from the European market, Mariani et al. (2021) analyze a selection of companies listed on the Stoxx Europe 600 Index from 2014 to 2018. Their findings indicate that capital markets exhibit heightened sensitivity to environmental concerns, consequently rewarding environmentally responsible firms with a reduced after-tax WACC.

In addition, WACC can be utilized as an alternative discount rate to provide a means to capture investment risks within each country and determine country-specific capital costs. However, this analytical perspective is notably absent in studies concentrating on African countries, primarily due to the scarcity of pertinent data, potentially hindering the studies' effectiveness in contributing to policy decisions and long-term planning. Thus, in the expanding realm of WACC research, limited attention has been given to energy investments on the African continent (Ameli et al., 2021), with only a minimal subset of research delving into individual African nations (see Ondraczek et al., 2015; Sweerts et al., 2019). For example, Sweerts et al. (2019) computed WACC for 46 African countries to evaluate the impact of financial conditions on electricity generation costs across various clean and fossil-based technologies. Their research shows noteworthy variations in technology costs among the countries—a pattern influenced by the diverse financial contexts prevalent in each country—and shows the impact that lowering financing costs has on accelerating deployment of technologies. Considering these findings, Sweerts et al. recommended integration of country-specific analyses when analyzing data for the African economies. Despite this suggestion, the few studies within this region tend to abstain from utilizing country-specific data, instead adopting the CDMEB values, as indicated above. These CDMEB values, however, operate on the premise of a uniform cost of capital, thereby introducing the possibility of underestimation bias in energy costs (Egli et al., 2019). This inclination holds the potential to misguide the formulation of policies, potentially leading to considerations that may favor more expensive energy options in African countries. For example, while energy transition planning studies and subsequent policy formation often use uniform values, they tend to overweigh capital-intensive projects like wind and solar and under-weigh those that are not capital-intensive like natural gas.

Furthermore, Egli et al. (2019) focus on the substantial challenges that endure within the domain of energy system analysis, particularly concerning the unsatisfactory resolution to projecting WACC to 2050 and beyond. This difficulty is underscored by the contention of Bogdanov et al. (2019), similarly asserting that the current literature presents an unsatisfactory state of WACC projection to 2050 and beyond, posing a notable challenge in the field of energy system analysis particularly impacting developing nations, including those on the African continent. In the absence of such analysis on the continent, Bogdanov et al. (2019) urges the need to initiate comprehensive studies to fill this critical gap and enhance the understanding of the dynamics influencing WACC projections for sustainable energy development in the African context. Again, it is noteworthy that these prior studies often provide direct projections for WACC without delving into the distinct components of WACC, such as the cost of debt and the cost of equity as highlighted by Harvey (2020). Providing a breakdown of these individual components of WACC aids in clarifying the prevailing confusion by highlighting the connections among different energy investment costs and their relevance to various sources of project financing.

In the current global economic context, African nations face challenges due to rising capital costs, which particularly influence the financing of energy projects. This issue is more pronounced for capital-intensive initiatives, such as those in clean energy, potentially slowing down investments and impeding progress in the energy transition and fossil fuel phase-out on the continent (Ameli et al., 2021; Hirth and Steckel, 2016). Therefore, achieving significant strides in development and energy goals will require improved access to financial resources.

To secure robust financial support, it is essential to calculate estimates for the cost of capital for all African countries, serving as a crucial discount rate in the energy sector and aiding in deriving country-specific energy technology costs. This study bridges the existing literature gap, providing a comprehensive methodology and estimates for the cost of capital in all African countries. This information serves as a valuable tool in the energy sector for determining country-specific energy technology costs. It also provides evidence to stakeholders (i.e., firms, governments, financial institutions, development banks, NGOs, etc.) operating in the power sector in Africa to make more informed decisions. Recognizing the pivotal role of private capital in Africa's energy projects emphasizes the need for a deeper understanding of the factors influencing the determination of WACC in the region. This understanding involves acknowledging WACC's variability based on country and the diverse assumptions applied, depending on the technology or fuel investment.

The article explores how dynamic WACC rates impact country-specific system costs and the necessary investments for deploying both variable renewables and firm sources of energy. The analysis significantly contributes to elucidating different WACC values, including the disaggregation of the cost of equity and cost of debt, between countries and at the regional level on the African continent.

## 3. Method and data

### 3.1. Method

Our computation approach adheres to the prevailing methodology widely accepted in finance for computing the WACC, particularly entrenched in company valuation practices. We recommend referring to the comprehensive source (See Corporate Finance Institute, 2024[10]) for an in-depth exploration of WACC principles.

In this study, we apply the conventional approach to WACC, tailored to assess the investment cost at the country level. WACC, in this context, encapsulates the combined cost of capital across diverse sources employed to finance electricity capital investments. This encompasses equity, sovereign bond debt, and other relevant financial components. The computation involves weighting the cost of each type of capital by its proportion within the total capital structure, followed by a summation. The determination of these weights is a nuanced process influenced by policy considerations and practical implications, often aligning with the dynamics of capital markets and development finance. Our approach follows established practices, with the intricacies elaborated in the aforementioned source.

The WACC is composed of the cost of equity and the cost of debt. The cost of debt primarily hinges on policy decisions and is contingent upon factors such as corporate tax rates and the commercial lending rate, the latter serving as a proxy for the average debt yield for a country (Corporate Finance Institute, 2024). On the other hand, the cost of equity represents a composite reflection of the equity risk premium and risk-free rate (Corporate Finance Institute, 2024). Following Johri et al., (2022), Paluszynski (2021), and Damodaran (2023), we use sovereign default spread rates as a proxy for the risk-free rate, which in the US context is called Treasuries. Noteworthy in our methodological contribution is the extended forecasting of the cost of equity at the country level for almost 50 years using country-specific information to cover the timeline in the African Union Agenda 2063.

[10] https://corporatefinanceinstitute.com/resources/valuation/what-is-wacc-formula/

To forecast the two key components of the cost of equity, we use GDP and population projections, along with cross-sectional data on equity risk premiums and sovereign default spread rates. The market exposure premium beta remains constant throughout our analysis. We employ geometric interpolation based on five-year growth rates to obtain annual GDP and population projections. Additionally, we conduct cross-sectional regressions by correlating country GDP per capita with the annual country risk free rate (RFR), and country GDP per capita with the annual equity risk premium (ERP), sourced from the most recent data (year 2022) available on Damodaran (2023) (See Appendix C for more details). This process yields coefficients of regression between the risk-free rate and GDP per capita, as well as between the equity risk premium and GDP per capita. The regression coefficient between GDP per capita and the RFR is -0.0003[11] meaning that across Africa one dollar increase in GDP per capita decreases the RFR in the economy by 0.03%. Similarly, the regression coefficient between GDP per capita and the ERP is -0.0004[12] meaning that across Africa one dollar increase in GDP per capita decreases the ERP in the economy by 0.04%. Leveraging these coefficients, GDP and population projections, we establish a link between GDP per capita and compute the projected equity risk premium and risk free rate from 2023 to 2070, underscoring a forward-looking assessment of the cost of equity and the overall cost of capital[13]. The first and second equations show the formula for WACC and its intermediary components that we compute.

$$WACC = \frac{D}{V} * Cd * (1 - t) + \frac{E}{V} * Ce \; (1)$$

Where: D=Debt, V=Total value of investments, i.e., D+E, E=Equity, t=Corporate tax rate, Cd=Cost of debt, and Ce=Cost of equity.

The next step is to compute the cost of equity for year 2023 to 2070 using the following equation.

$$Ce = r_f + \beta * ERP (2)$$

Where: $r_f$=the risk-free rate, β=The sensitivity of the assets to the market, measuring market exposure or risk, and ERP = The equity risk premium.

For the value of β, we use the default and constant value of 0.88 that is practically unchanged over years for utilities sector in emerging markets (See Damodaran, 2023). Note that this value of levered β is the main parameter specific to the power sector. Thus, choosing a relevant value for β can easily adjust the methodology for other pertinent industries in African countries.

[11] RFR = 9.0633 -0.0003*GDP *per capita*

[12] ERP = 17.8547 -0.0004*GDP *per capita*

[13] Note that the negative relationship that we observe between GDP and ERP or RFR from the econometric estimations align with the assumption that capital costs will decrease with economic growth and political stability. However, different scenarios may emerge in the future for each of those African countries that diverge from the forecasts.

$$ERP = r_m - r_f$$

Where $r_m$ is the expected return on the market.

We follow the common weight split used in WACC calculations of 70% equity and 30% debt, which represents a balance between higher-risk equity financing and lower-risk debt financing. This weight split is realistically close to the recommendation used in capital markets. Different weighting options are also discussed in Section 4.4. For the sub-regional WACC calculations, we computed the average WACC values based on the component countries' values.

### 3.2. Data

To compute the WACC across African countries, we rely on a robust framework supported by four primary data sources available at the national level given that more granular data at the project level is not available for African countries.[14] These sources include Damodaran (2023), the Shared Socioeconomic Pathways (SSP) projections data from 2015 to 2100, the World Bank's World Development Indicators data, the International Monetary Fund (IMF) lending rate, and corporate tax data from Tax Foundation (2023).

Damodaran (2023), an online repository, curated by Aswath Damodaran, a professor at NYU Stern Business School, serves as a comprehensive finance data repository encompassing company-level information, as well as aggregated data for countries and sectors across multiple years. This semi-annual refreshed repository, last updated in January 2023, facilitates our analysis by providing essential metrics such as risk-free rates, equity risk premiums, and market exposure premiums (beta) for the pertinent African countries under consideration. It is imperative to note that eleven out of the 48 countries lack complete data for risk-free rates and equity risk premiums during the analyzed years. The missing information has been estimated following rigorous imputation strategies discussed in Section 3.3. Further details on the database, supporting research, and its accolades can be accessed in Damodaran (2023).

The SSPs, integral to our research, represent scenario-based projections of global economic dynamics. Developed and hosted by the International Institute for Applied Systems Analysis, the SSP database offers quantitative projections for the Shared Socioeconomic Pathways and related Integrated Assessment scenarios. These scenarios, part of the climate change research framework, facilitate the integrated analysis of future climate impacts, vulnerabilities, adaptation, and mitigation. Additional information on the scenario process and the SSP framework can be found in Riahi et al. (2017). Our study utilizes GDP and population projections to calculate GDP per capita for each country across years, informing the projection of the cost of equity from 2023 to 2070. Among the available scenarios, we adopt the OECD-environment scenario due to its complete data

[14] Also, note that as country-level WACC captures broader macroeconomic factors, regulatory conditions, and market development nuances, this approach provides a comprehensive view of the cost of capital across diverse regions on the continent. This is particularly valuable for multinational companies and investors looking to compare investment opportunities across different African countries, ensuring a more accurate and contextually relevant financial analysis.

coverage for all 48 countries. The OECD SSPs projections are based on the ENV-Growth modeling framework, which is used to project future levels of global and country-specific GDP and income, quantified as the average level of GDP per capita in a country (Château et al., 2015). The ENV-Growth modeling framework assumes that each country gradually catches up to its own frontier level of income that is consistent with its endowments and institutions (Barro and Sala-i-Martin, 2004), also known as conditional convergence (Dellink et al., 2017).

While SSP GDP projections are based on 2005 current level, the most complete WDI GDP are based on 2017 current level. For a consistent comparison and to address inflation, we use the WDI GDP deflator and Power Purchase Parity (PPP) data for the years 2005 and 2017 for an appropriate conversion, following Sweerts et al. (2019). The conversion follows the formula below:

$$GDP\ per\ Capita\ Converted = GDP\ per\ Capita_{2005} * \frac{PPP_{2005}}{PPP_{2017}} * GDP\ Deflator_{2017}$$

The lending rate panel data, a crucial component of our analysis, is sourced from the IMF's International Financial Statistics (IFS) database. Notably, we use the average lending rate for the last ten years for each country when available. Approximately nineteen countries lack data points for the commercial lending rate, prompting us to supplement this information with data from the respective countries' central banks when available.

Corporate tax data, a key determinant in our WACC computation, are extracted from the Tax Foundation database, encompassing all countries and years relevant to our analysis, with the exception of one country. The Tax Foundation, an American Think Tank dedicated to tax research since 1937, provides a globally relevant dataset for our study.

**Table 1**: Data Sources, Variables and Countries with Missing Data

| Data Sources | Variables | Number of Countries with complete data | Countries with Missing data |
|---|---|---|---|
| Damodaran (2023) Online Database | Risk Free Rate | 37 | Central African Rep., Chad, Congo Democratic Rep. Of, Congo, Equatorial Guinea, Burundi, Djibouti, Eritrea, Mauritania, Lesotho, South Sudan |
| | Equity Risk Premium Rate | | |
| IIASA-SSP database, WDI | GDP per capita | 48 | NA |
| IMF- IFS Database | Commercial Lending rate | 27 | Gambia, Guinea, Guinea-Bissau, Lesotho, Mauritania, Somalia, Central African Rep., Chad, Equatorial Guinea, Djibouti, Eritrea, Congo, Chad, Cameroon, Ghana, Tunisia, Sudan, Morrocco, Kenya, Ethiopia, South Sudan |

| | | | |
|---|---|---|---|
| Tax Foundation Database | Corporate Tax | 47 | Eritrea |

### 3.3. Missing data handling and imputation strategies

The task of computing the WACC across 48 African countries necessitates combining statistical methodologies with practical considerations addressing missing data, since it is not always possible to access financial data on risk premiums, commercial bank rates, government bonds, and their proxies. Our approach to handling missing data involves a judicious combination of seeking actual data, utilizing forward-filling techniques for certain variables, and employing imputation strategies based on regional peers. This approach ensures that the computed WACC reflects the best approximation of the financial landscape across the diverse African countries under consideration. This process aims to maintain fidelity to a reasonable approximation of reality, acknowledging the challenges posed by data disparities. Two primary strategies guide our approach: seeking actual data beyond centralized authoritative databases such as the International Monetary Fund (IMF), the World Bank, Tax Foundation, or Damodaran (2023), and employing imputation methods that prioritize regional peers. When possible, we adopt forward-filling techniques for variables expected to exhibit only gradual or no changes. For instance, in cases where the PPP conversion factor was missing for Eritrea and South Sudan, we applied forward filling using the last observable year's data.

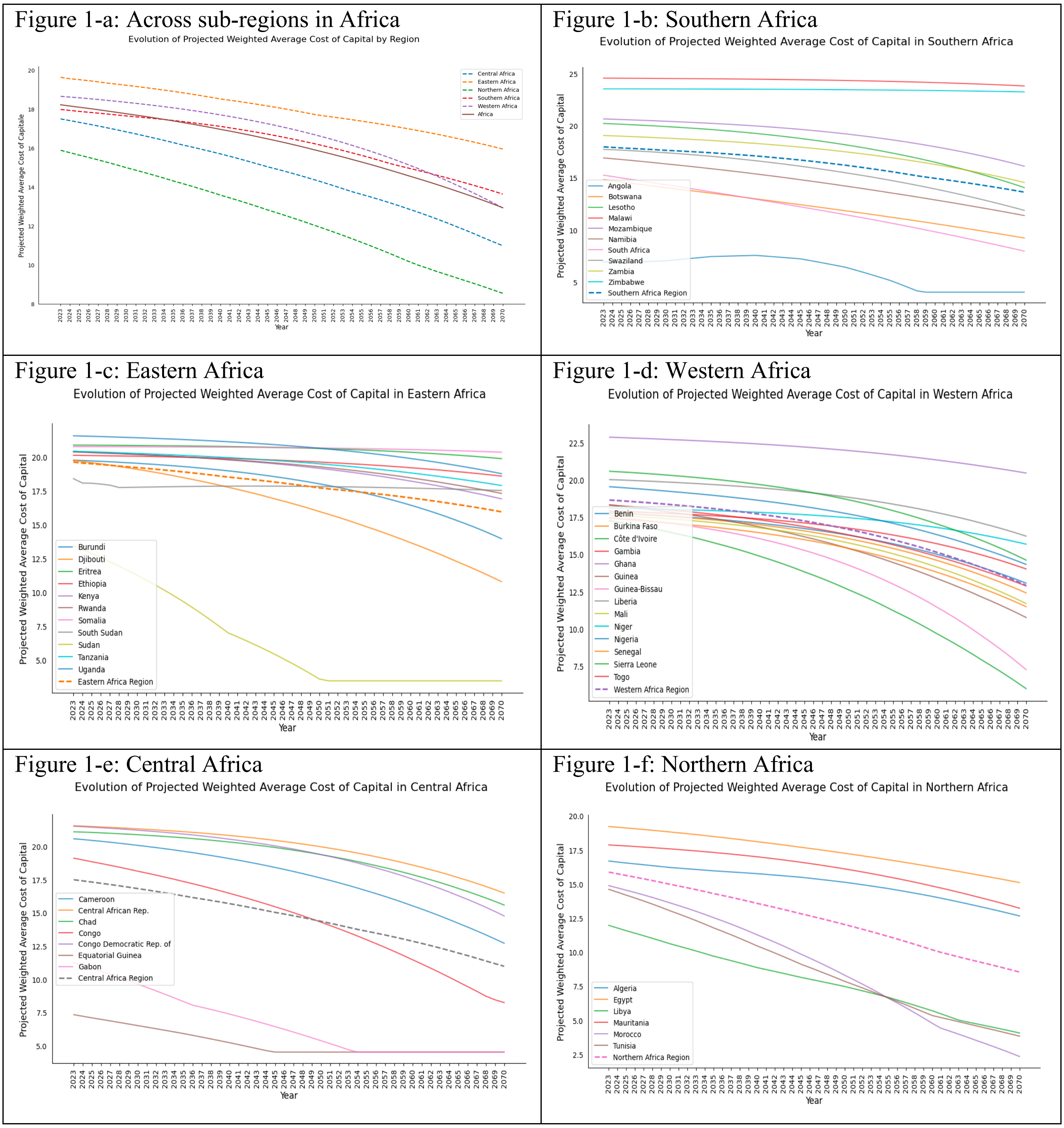
To fill in missing data in the commercial lending rate, a pragmatic approach considers whether data points exist in individual country central bank databases beyond the IMF's centralized database (IFS). In instances where actual data is available at the central bank level, as observed in countries like Morocco, Ghana, Guinea, etc., we prioritize using that data. In the absence of such data, we proceed with an imputation aligned with regional trends, employing the regional peers imputation strategy. For variables such as the risk-free rate and equity risk premium, regional peers imputation is predominantly employed due to the lack of available historical country-level data. Fortunately, Damodaran (2023) provides a comprehensive and rigorous database, instilling confidence that the regional peers imputation strategy yields robust results. Corporate tax information, marked by very few missing data points, is addressed with the regional peers imputation strategy. Given the limited variation in this data across the studied countries, we are confident that our missing data approach captures a nearly invariant reality over the study period. SSP data is quite complete for all the countries we have considered in this study. However, the projections are paced at an interval of five years. We interpolate the data to a year pace by using the growth rate of GDP per capita.

## 4. Results and discussions

### 4.1. Projections of WACC

Figure 1 shows the projections of WACC in Africa across subregions (Figure 1-a), and within each of the five subregions (Figure 1-b to 1-f). Globally, the WACC projections indicate a negative trend. At the continent level, WACC decreases from 18% to 13% between 2023 and 2070 with an average of 15.60% over this period (see Figure 1-a). Even though the WACC values have reduced over time, they remain high compared to the often-used uniform assumption of 10% (see Egli et al., 2019; Pappis et al., 2019) and the values in other regions such as 2.4% in Japan, 4,2% in Western Europe, 5.1% in the USA, and 6.6% in China (Ameli et al., 2021). These high values are also in line with findings from previous studies on African countries: between 8% and 32% (Sweerts et al., 2019), 12% (Ameli et al., 2021), and an average of 20.1% (Ondraczek et al., 2015).

**Figure 1**: Projections of WACC for African countries and across sub-regions.

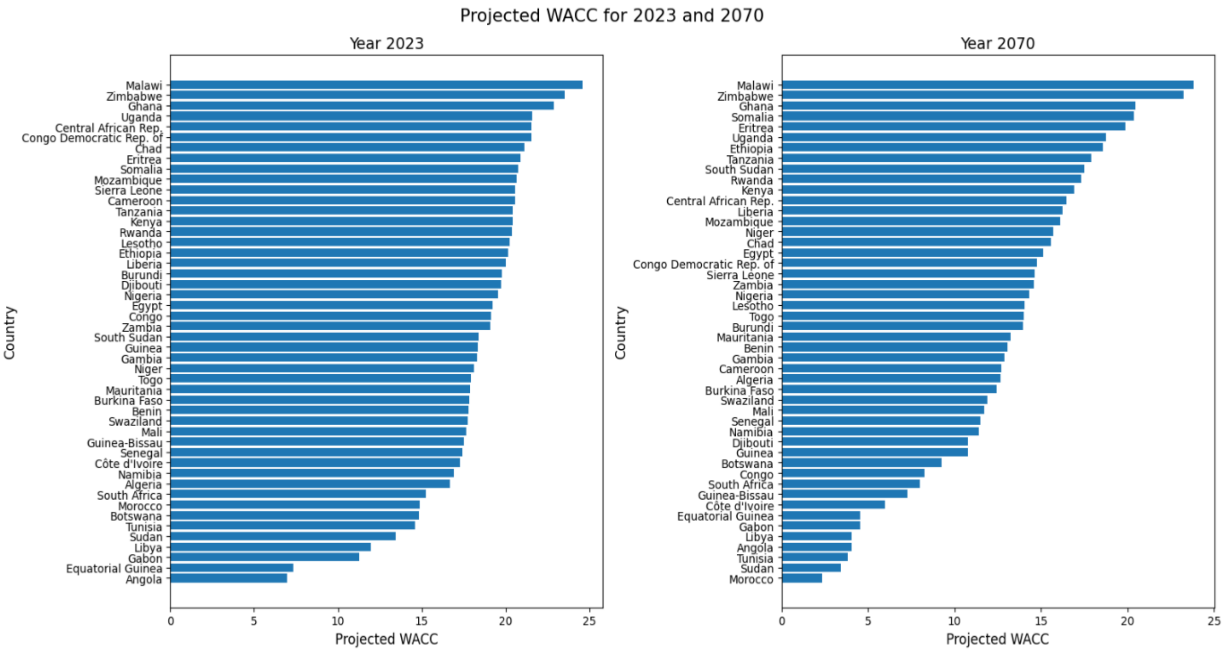


This evolution for Africa hides some disparities across different sub-regions. As shown in Figure 1-a, Northern Africa has by far the lowest WACC in Africa (between 8.6% and 15.88%). Eastern Africa has the highest WACC (with values between 15.95% and 19.63%). This highlights the existence of some regional catching-up, as from 2062, the WACC values in Southern Africa become higher than those in Western Africa. Central Africa has the second lowest WACC values in Africa. A possible explanation for the relatively lower WACC in Central Africa compared to Eastern Africa, despite the region's political instability, could be the region's abundance of natural resources and it ability to attract foreign direct investments (FDI). For instance, Central Africa's wealth in natural resources, such as hydroelectric potential and oil, has the potential to attract significant long-term investment in the power sector (UNIDO, 2024). Consequently, it is unsurprising that during the COVID-19 pandemic in 2020, this region was the only area in Africa to experience an increase in FDI (UNCTAD, 2021). These factors make investments in the region more appealing despite the political risks, thereby lowering the WACC. Thus, abundant natural resources can overcompensate these negative effects of the political instability. Additionally, from a statistical perspective, the average WACC can mask disparate realities driven by extreme values. For instance, the GDP per capita gap between Eastern African countries is narrower compared to that in Central Africa. If a few countries with high GDP per capita (which translates into low projected WACC) dominate the distribution, it would result in a lower WACC for the region. For example, Congo, Gabon, and Equatorial Guinea have some of the lowest WACCs overall, dominating their group and driving the overall regional WACC down compared to Eastern Africa. To gain a more nuanced understanding, it is essential to analyze the distribution in greater detail, such as by examining percentiles. This granular approach reveals deeper insights and provides a more comprehensive interpretation of our findings.

Furthermore, similar disparities can be observed within each subregion as some countries may drive down or up the subregional average due to their highly large or small WACC values. For Southern Africa, Malawi and Zimbabwe have the highest WACC (ranging from 23.25% and 24.60%), while Angola has the lowest WACC (i.e., between 4.05% and 6.96%) and the other countries have WACC values lying between 7.98% and 20.66%. Eastern Africa does not show a large disparity except Sudan, which has the smallest WACC between 3.45% and 13.43%. A similar pattern is observed for Central Africa, with Equatorial Guinea and Gabon having the smallest WACC from 2054 and reaching 4.54% in 2070. Ghana, with the highest WACC values (between 20.47% and 22.87%), drives up the average WACC in Western Africa, while Côte d'Ivoire has the lowest WACC (between 5.99% and 17.26%) and followed by Guinea-Bissau (between 7.27% and 17.50%). In Northern Africa, the distribution of countries is split into those above the average WACC in their sub-region (Mauritania, Egypt, and Algeria) and those below that average (Libya, Tunisia, and Morocco). Appendix A provides the WACC values for all the African countries.

Figure 2 provides a snapshot of the WACC for all modeled countries for the years 2023 and 2070. Among the top 10 highest WACCs in 2023, three countries are located in Central Africa, while the rest are for the most part characterized by conflict, fragility, or distressed macroeconomic conditions. Conversely, the top 10 lowest WACCs are predominantly observed in upper-middle-income countries or those with substantial natural resource endowments, including oil-producing nations such as Gabon, Angola, and Equatorial Guinea. This trend can be largely attributed to the SSP GDP forecast models utilized in this study, which are significantly influenced by countries' natural resource endowments. Looking ahead to 2070, the reduction in the cost of capital is closely aligned with factors such as resource endowment, initial economic fundamentals, income levels, and fragility status. Despite substantial natural resource endowments, countries plagued by fragility, conflict, and violence continue to lag in lowering their WACC. Notably, South Sudan falls within this category, reflecting persistent challenges despite its resource wealth.

**Figure 2**: Projected WACC for African countries in 2023 and 2070.




Based on the previous findings, we investigate the distribution of the cost of capital across countries' fragility, conflict, and violence (FCV) status and income groups. As indicated in Figure 7 (see Appendix D), FCV countries (e.g., Burkina Faso, Burundi, Chad, Sudan, etc.) display higher WACC values than non-FCV countries. Regarding the income classification (see Figure 8 in Appendix E), countries with low income have the highest values of WACC (e.g., Burundi, Burkina Faso, Central African Republic, DRC, Eritrea, Ethiopia, Gambia, Guinea-Bissau, Mali, Niger, Sudan, Somalia, etc.). On the contrary, countries with upper-middle income show by far the lowest values of WACC (e.g., Botswana, Gabon, Equatorial Guinea, Libya, Mauritius, Namibia, and South Africa). These results confirm that resource endowment, economic development and non-fragility status play an important role in reducing  cost of capital in African countries

Higher WACC in African countries reflects how prohibitive the cost of finance in those countries are, which can negatively affect investment in electricity technologies, particularly in some clean electricity technologies that require proportionally more capital than fossil fuels. The high cost comes from a combination of factors, including low economic development, under-development of the financial market, high instability leading to high-risk premiums, etc. The above discussion indicates that even though the capital cost for electricity technologies is decreasing over time, for the same electricity technology, the investment cost will be much higher in Eastern and Western Africa than in Northern Africa. As discussed by Ondraczek et al. (2015), Hirth and Steckel (2016), Sweerts et al. (2019), and Ameli et al. (2021), this higher WACC can slow the speed of the low-carbon energy transition. African policymakers should better identify what drives the finance cost of electricity technologies, such as political instability, poor regulatory practices, poor contracting procedures, and how to address them in the African context efficiently.

The disparities across and within subregions can be driven by the composition of WACC, mainly the cost of debt and the cost of equity. This is discussed in detail in Section 4.2. We also discuss the variables that are included in the calculation of the cost of equity like the equity risk premium and the risk-free rate in Section 4.3.

### 4.2. Projections of the different components of WACC

The cost of equity and cost of debt drive the WACC values presented in Figure 1. To explore which of these two components is more preponderant than the other, we computed a ratio that consists of the cost of equity divided by the cost of debt. A ratio that is larger than one translates the preponderance of the equity cost over the cost of debt. The projections of this ratio are presented in Figure 3 and show that in Africa, the cost of equity is much higher than the cost of debt. On average, equity is two times more costly than debt (See Figure 3-a). This may partly explain the high level of WACC values projected for Africa. As previously discussed, this reality at the level of the continent is not necessarily the same across sub-regions in Africa. Figure 3-a shows that the reality is different in Central Africa, as the debt cost is projected to be higher than the equity cost.

Even though many central African countries have shown trends like their sub-regional reality, there are exceptions for countries like Chad, Central Africa Republic and DRC which show the cost of equity higher than the cost of debt, at least in the short and medium terms (See Figure 3-e). The cost of equity is also higher than the cost of debt in all western and northern African countries (See Figure 3-d and Figure 3-f). However, some of those countries show a much high ratio reaching 4 (for example, Niger, Togo, Morocco). Furthermore, in Southern Africa and Eastern Africa, few countries have a ratio smaller than one: Sudan, Angola, Zimbabwe, and Malawi (See Figure 3-b and Figure 3-c).

The cost of equity and cost of debt have different implications for the differences observed in risk premiums associated with investments in electricity technologies and as it is reflected in the costs of financing those investments (i.e., WACC). For the same investment, the former translates the perception of risk by equity investors (via higher return expectations), while the latter reflects how lenders perceive the default risk (via higher interest rates). Thus, in the African electricity sector, on average, equity investors perceive a higher risk than default risk perceived by lenders. The implication is that financing electricity investments, particularly clean electricity technologies intensive in capital, such as geothermal, solar and wind, through equity is more costly than using debt.

As advanced economies have better access to debt than developing countries (IEA, 2021), African countries should implement financial policies to reduce risks and drive down the overall cost of equity. Policymakers need to make their electricity sector more attractive for equity investors. These policies can be elaborated at the national level or in coordination with regional and international institutions (bilateral and multilateral development banks), or with financial institutions. Also, there are some specific policies that target investments in decarbonization such as multilateral guarantee mechanisms that consist of global risk pooling and increasing market efficiency (see Matthäus and Mehling, 2020). Combining all these national and international efforts can help effectively reduce the electricity investment costs in Africa.

**Figure 3**: Projections of Cost of Equity/Cost of Debt ratio.

Figure 3-a: Across sub-regions in Africa

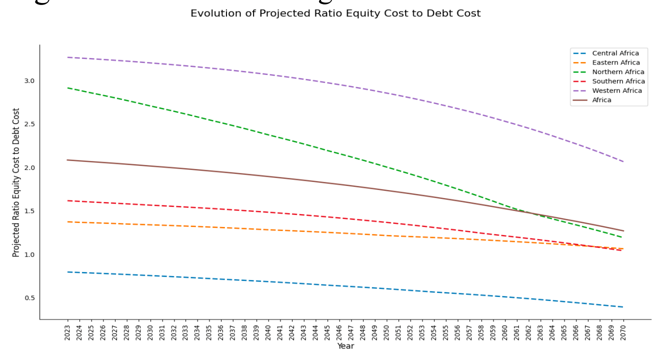



Figure 3-b: Southern Africa

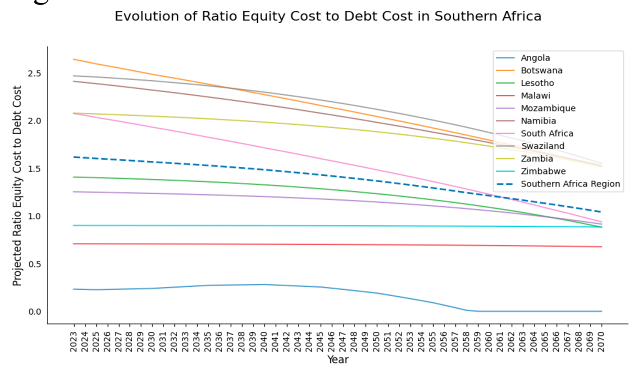



Figure 3-c: Eastern Africa

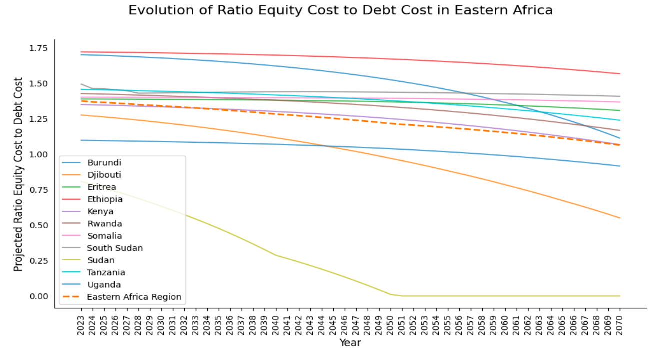



Figure 3-d: Western Africa

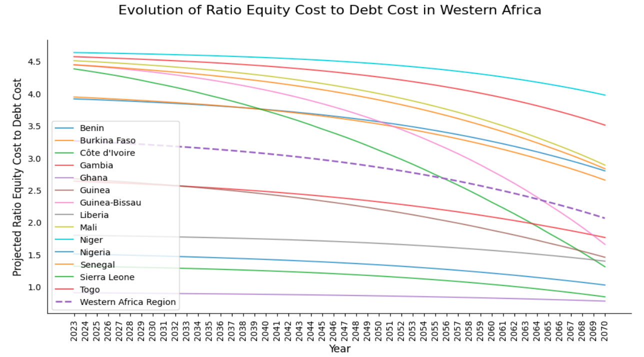



Figure 3-e: Central Africa

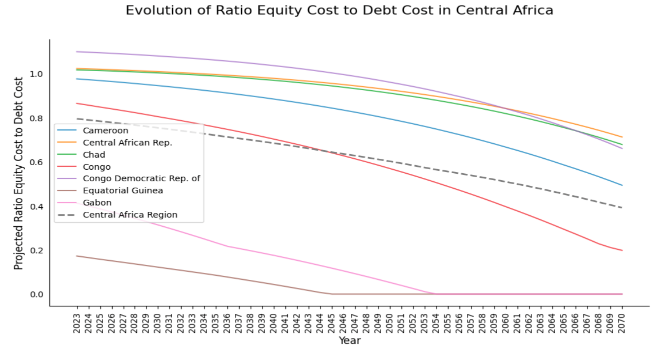
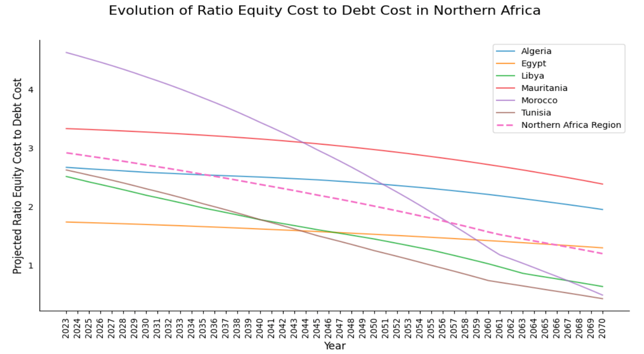



Figure 3-f: Northern Africa



### 4.3. Other drivers of WACC

Figure 4 and Figure 5 display the projections of two key equity cost components: Equity Risk Premium (ERP) and the Risk-Free Rate (RFR), respectively. Our results show the same trend for both ERP and FRF. This can be explained by the fact that GDP per capita is used to project the two variables. However, given that their calculation relies on different results from the econometric regression, the two variables are not at the same levels as ERP is higher than RFR, overall.

At the aggregate level, Figure 4-a shows that the ERP decreases from 15.92% in 2023 to 11.02% in 2070. Western Africa has the highest ERP (between 12.15% and 17.17%) up to year 2059 and then it is surpassed by Eastern Africa (between 13.28% and 16.75%), while Northern Africa (between 8.04% and 15.03%) and Central Africa (between 7.38% and 13.80%) have the lowest ERP in Africa. The small values of ERP in Central Africa are mainly driven by values projected in Equatorial Guinea and Gabon (See Figure 4-e), while Libya, Morocco and Tunisia drive those in Northern Africa (See Figure 4-f). Note that Angola has the lowest ERP in Southern Africa (See Figure 4-b), and we observe that the disparities among countries become large going forward in Western Africa (See Figure 4-d). The realities are similar for RFR as shown in Figure 5 with the exception that RFR shows much smaller levels. For example, while ERP for Africa ranges between 11.02% and 15.92%, RFR ranges between 4.42% and 7.65% (See Figure 5-a).

RFR and ERP are related to premiums that investors request to accommodate the market or country risks for their investments. While RFR is the rate of return from risk-free assets, ERP reflects the additional compensation expected by an investor for an equity investment relative to the risk-free rate. These rates are generally higher in developing countries than in developed countries (Donovan and Corbishley, 2016), resulting in a high cost of equity and high cost of capital in African countries. While the projections show a regional decreasing trend for ERP and RFR in Africa, given that African countries will be more financially stable driven by the projected economic growth, the rates are still high compared to developed countries. For example, the ERP in Africa will reach 11.02% in 2070, which is still higher than the current average of ERP in all the regions except Central and South America (See Damodaran, 2023) eventhough Africa is among the regions with the lowest debt default rate (i.e., 5.3% for all project finance, and 1.9% for infrastructure loans)[15]. More financial policies targeting the reduction of ERP and RFR could effectively reduce the cost of equity in African countries.

[15] https://www.gihub.org/infrastructure-monitor/insights/infrastructure-debt-default-rates-by-region/

**Figure 4:** Drivers of WACC: Equity Risk Premium (ERP).

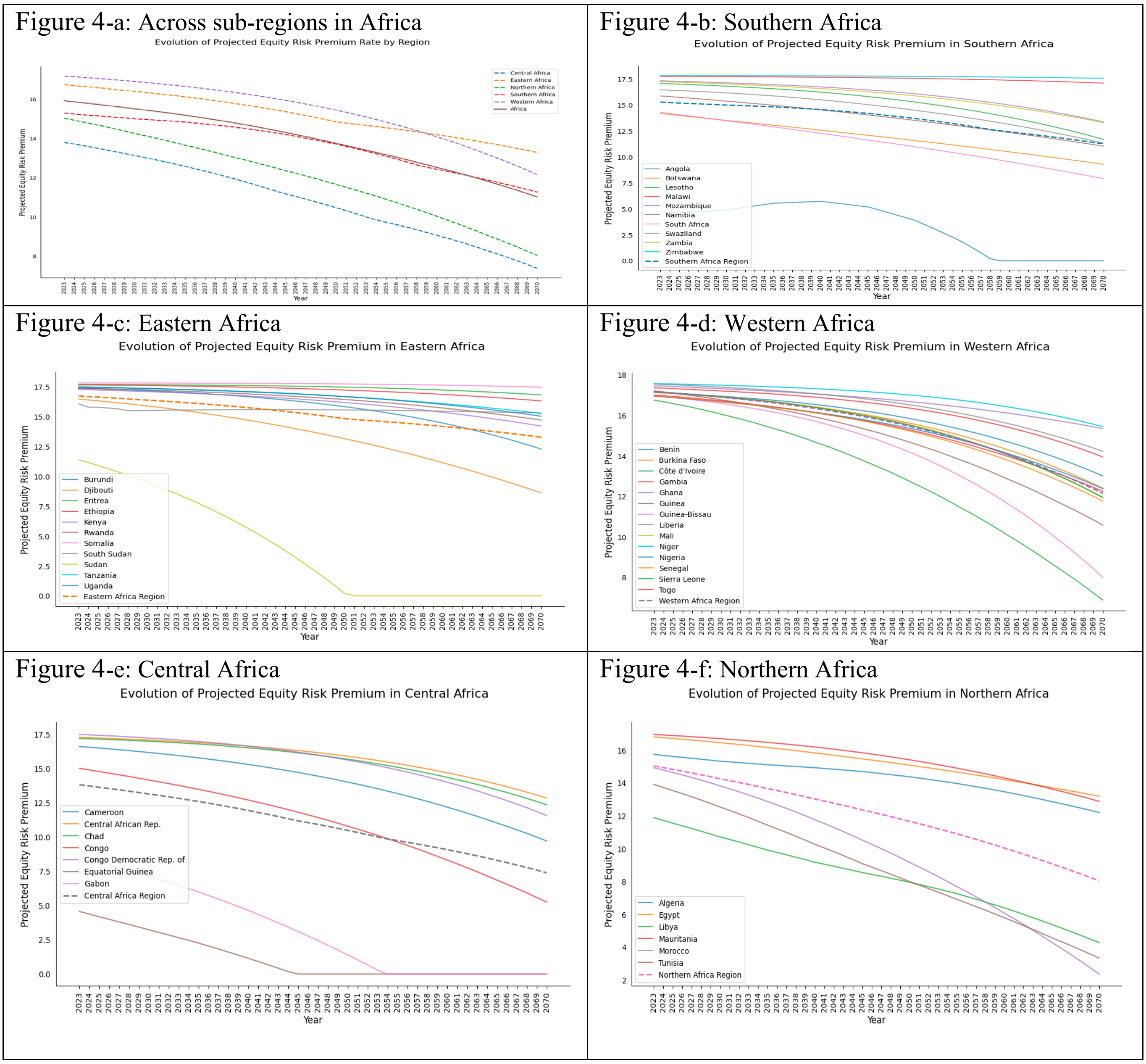
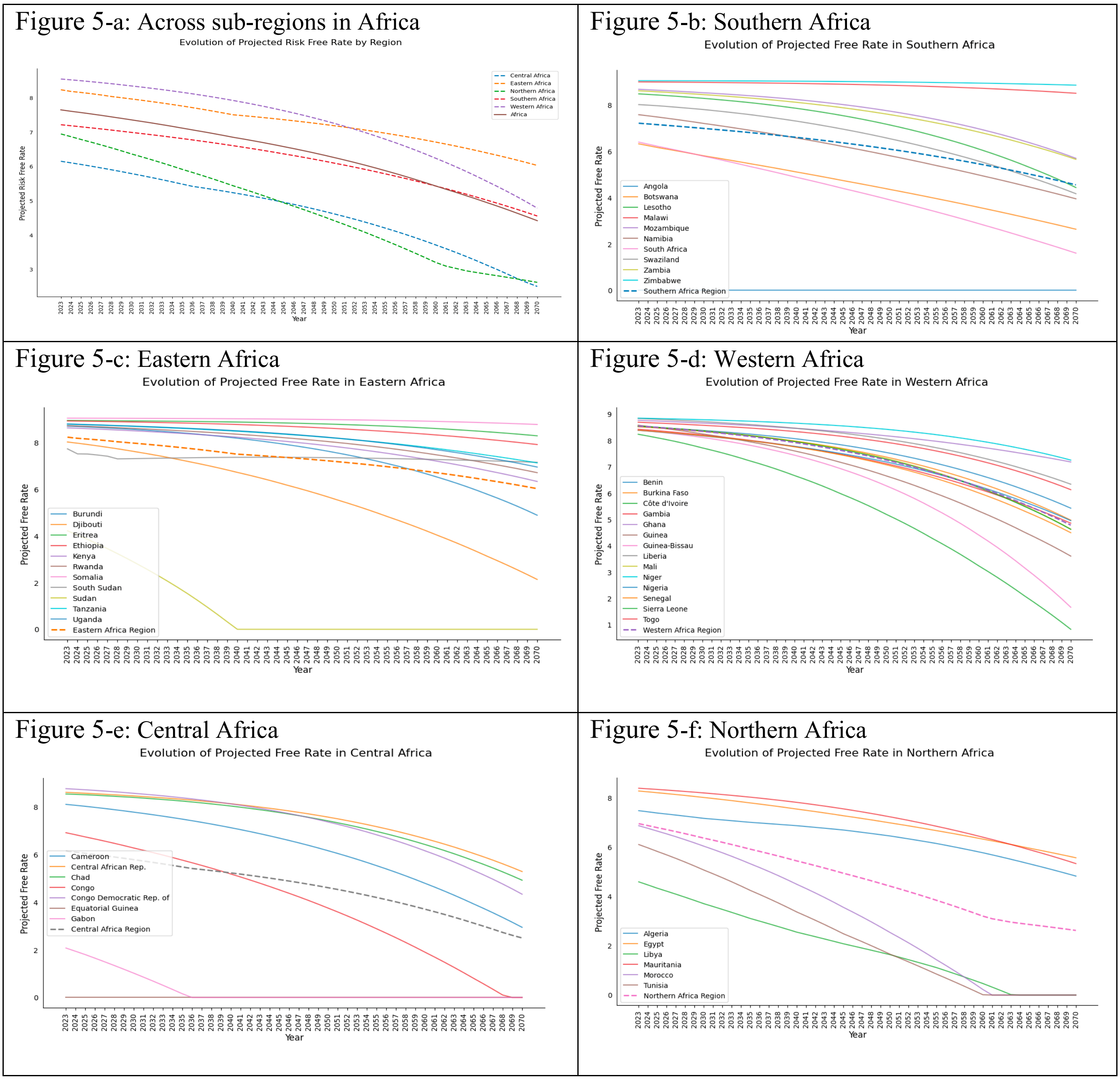


**Figure 5**: Drivers of WACC: Risk free rate (RFR).




## 4.4. Would equity or debt drive down the cost of capital?

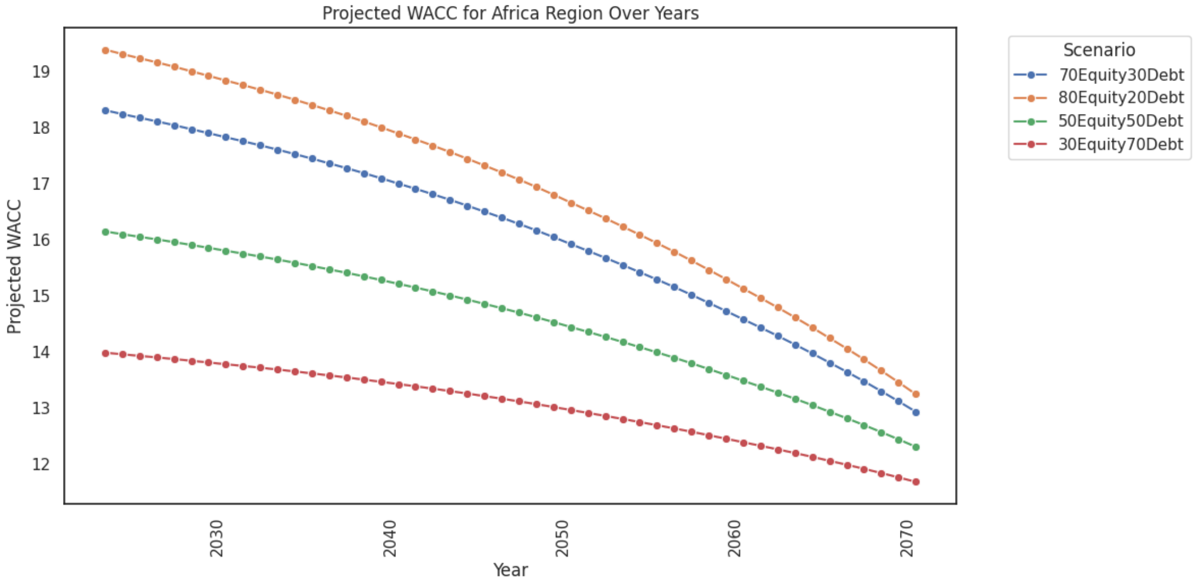
The allocation and financing dynamics between debt and equity are crucial to capital cost, which plays a pivotal role in facilitating access to finance and accelerating the transformation of the electricity sector in African countries. This section delves into three distinct scenarios, each varying the weight distribution between debt and equity and analyzing the resulting impact on the cost of capital. The baseline scenario, employed throughout this paper, maintains a 30-70 split between debt and equity unlike in Annex 1 countries including OECD countries, with split of 70-30. As elucidated in previous discussions, this configuration yields specific outcomes. The second scenario strategically diminishes the weight of debt, thereby reducing risk for private investors by elevating the share of equity to a 20-80 split, as more finance is coming from private equity in Africa[16]. Conversely, the third scenario considers an equal distribution of risks and capital (i.e., 50-50), epitomizing an equitable balance between debt and equity as suggested by the UNFCC's guidelines for non-annex I countries. This scenario accentuates the ascendant role of private capital through debt in the capital structure. In the fourth scenario, we consider a 70-30 debt equity ratio based on the common practice in different African countries[17].

Across the observed scenarios, a discernible pattern emerges: scenarios favoring higher weight on equity exhibit elevated overall costs of capital. The ascending order of cost structures is evident, with the 80Equity20Debt scenario displaying the highest cost of capital, followed successively by the 70Equity30Debt, 50Equity50Debt, and 30Equity70Debt scenarios. A noteworthy observation pertains to the temporal and economic influence on the cost structure. Figure 6 illustrates a correlation between an overall reduction in the cost of capital and a narrowing gap between the scenarios considered. This phenomenon suggests that as economies grow and countries become wealthier, the risk differentials between equity and debt diminish. With the maturation of capital markets, the disparities in risk between equity and debt are mitigated alongside increase in lenders' confidence regarding contract enforcement, reducing the salience of weight distribution in shaping the cost of capital.

In conjunction with the preceding analysis, this observation underscores the current and near-future state of affairs in risk-sharing associated with the allocation of weight between equity and debt for electricity project financing on the continent. The policy implications are multifaceted. In the immediate term, our projections indicate a future reliant on increased equity investments to reduce risks in the sector. This carries implications for the role of the private sector, particularly in choosing between equity and debt. Moreover, it underscores the material importance of development finance in bridging the gap between investment needs and the current situation. Looking ahead, capital market development strategies must complement sustained policies promoting economic growth. Such development strategies aim to reduce the gap in project capital costs, regardless of whether they are predominantly financed by equity or debt. The deliberate pursuit of this strategy serves to dilute both risk perception and its material impact, progressively minimizing the delta between the risk structures associated with capital through debt or equity. This overarching objective aligns with the imperative of fostering prosperity on the continent through judicious and forward-looking financial strategies.

[16] https://www.morganlewis.com/-/media/files/publication/outside-publication/article/world-stage-financing-infrastructure-projects-in-africa-24nov15.pdf
[17] https://www.afdb.org/fileadmin/uploads/afdb/Documents/Generic-Documents/WAFCEF2_finalists.pdf

**Figure 6**: Projected WACC for Africa region over years for different scenarios of equity and debt allocation.




## 5. Conclusion

This paper addresses a significant gap in the literature by providing a comprehensive analysis of the weighted average cost of capital (WACC) in the power sector for 48 African countries. The findings reveal a negative trend in WACC overall, with a decrease from 18% to 13% between 2023 and 2070. Despite this decline, WACC values in Africa remain high compared to global and regional benchmarks, increasing the cost of finance for electricity technologies. The disparities across subregions and individual countries within Africa highlight the importance of understanding the composition of WACC, particularly the cost of debt and the cost of equity. Northern Africa stands out with the lowest WACC, while Eastern Africa faces the highest WACC, indicating regional variations. These disparities are driven by factors such as economic development, financial market maturity, and instability, contributing to the observed high cost of finance in some countries.

The analysis of the components of WACC, specifically the cost of equity and cost of debt, underscores that, on average, equity is two times costlier than debt in Africa. This finding has significant implications for electricity investments, as equity investors perceive higher risks compared to lenders who are often multilateral development banks that secure sovereign guarantees. We urge policymakers to design innovative finance solutions specific to each country's context, including attractive central bank interest rates, subsidies (which might be challenging for some African governments given their limited national budget), purchasing mandates (i.e., clean energy standards, clean fuel standards), regulatory reform (especially for utilities), government guarantees, and currency swap agreements, etc., to attract more investment and make the electricity sector more appealing to investors.

The paper also explores the drivers of WACC, including the Equity Risk Premium and Risk-Free Rate. Despite a decreasing trend, these rates in Africa remain high compared to developed countries, highlighting the need for targeted financial policies to reduce the cost of equity in African countries. Examining the impact of equity and debt allocation on the cost of capital, the paper introduces three scenarios. The results indicate that scenarios favoring higher weight on equity lead to elevated overall costs of capital. The findings emphasize the importance of understanding the dynamics between equity and debt in shaping the cost of capital and call for strategic policies to increase investment.

Importantly, the paper contributes to a deeper understanding of the complexities surrounding WACC in Africa and offers insights for fostering sustainable and prosperous electricity development on the continent. The study emphasizes the disparities among countries within the same sub-region, shedding light on the primary driver of the high cost of capital in Africa, namely, the elevated cost of equity, which is twice that of debt. Recognizing the critical role of private capital in electricity projects, the paper advocates for national-level efforts and collaboration with regional and international institutions to implement financial risk reduction policies. Such policies aim to reduce the overall cost of capital, making the electricity sector more attractive to investors.

Fundamentally, the paper challenges the prevailing approach of using uniform cost of capital for electricity projects in Africa, highlighting the potential underestimation bias of electricity costs in African countries. Additionally, while energy transition planning studies and subsequent policy formation often use uniform values, they tend to overweigh capital-intensive projects like wind and solar and under-weigh those that are not capital-intensive like natural gas. The proposed alternative of using country-level WACC as a discount rate reflects investment risks in each country, allowing for the derivation of country-specific capital costs. Our methodology, supported by extensive data and analysis, contributes to a more accurate understanding of the factors influencing WACC determination in Africa. In sum, the paper calls for strategic policy interventions, efficient financial mechanisms to reduce risks, and a nuanced understanding of the diverse factors shaping cost of capital across African countries to facilitate sustainable electricity development and bridge the electricity access gap on the continent.

While the study provides valuable insights into the computation of WACC in the African power sector, there are several caveats that should be considered. The accuracy and reliability of the WACC projections heavily depend on the quality of projections of GDP, population, tax, etc. data used here. The study relies on various assumptions such as the 30-70 split between equity and debt, which is further extended to include additional scenarios reflecting different capital allocations. These assumptions are not exhaustive and may not fully capture the complexities of real-world financing dynamics in African countries and could introduce bias into the limited scenarios results. The projections extend up to 2070, assuming consistent economic and financial market conditions. Predicting such long-term trends is inherently challenging, and unforeseen changes in economic, political, or financial landscapes could significantly impact the accuracy of the projections. Thus, our findings should be considered as an illustration of how capital costs will evolve in the future based on the current assumptions rather than being an exact prediction of the trends of the costs. Furthemore, using sovereign default spread rates as a proxy for the risk-free rate may underestimate the true value of the cost of capital. Moreover, future research endeavors could delve into project-level and energy technology-specific analyses of capital costs, which could include, for instance, the evaluation of technology-specific risk premia for different types of energy projects (i.e., off-grid solutions versus grid, fossil fuel generation versus renewables, mature power technologies versus innovative renewable technologies), offering detailed scrutiny of the subject, provided that such data becomes more accessible. We encourage future studies to utilize alternative methodologies for estimating the cost of capital such as the Capital Asset Pricing Model (CAPM), Dividend Discount Model, Bond Yield Plus Risk Premium, or Marginal Cost, to complement our projections of WACC for African countries. The methodogy used in this study can also be applied to other regions of the world, such as Asia and Latin America. While acknowledging these limitations, we assert that our study offers valuable insights that can significantly contribute to informed decision-making in the field of electricity investments across the continent.

## 6. Acknowledgement:

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## 8. Appendix

### 8.1. Appendix A: Values of WACC, cost of equity, cost of debt for 48 African countries.

**See the link:**

**https://docs.google.com/spreadsheets/d/10r332973WVyNNWkUVeqr-6ljpGduqnGGMTqF2bN4fXI/edit#gid=1076403368**

### 7.2 Appendix B: Codes for the computation

**See the Link:**

**https://colab.research.google.com/drive/1FMB3K9DslbGxbEMDsBALCzMBdcit_v4E?usp=drive_link**

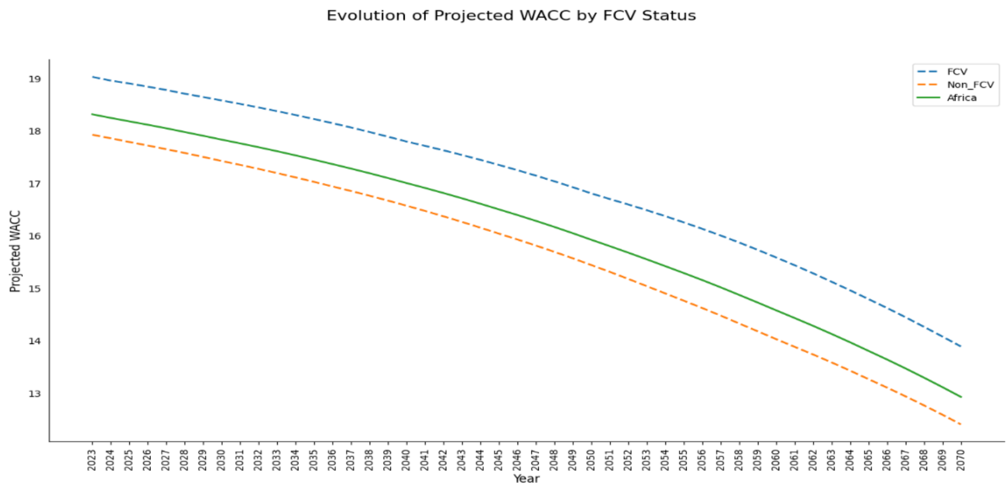
### 7.3 Appendix C: Econometric estimation

| Variables | ERP | RFR |
|---|---|---|
| Constant | 17.85*** | 9.21*** |
| | (0.789) | (0.436) |
| GDP | -0.0004*** | -0.0003*** |
| | (0.00) | (0.0000571) |
| Observations | 48 | |

**Notes:** Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

### 7.4 Appendix D: Distribution of projected WACC across FCV status

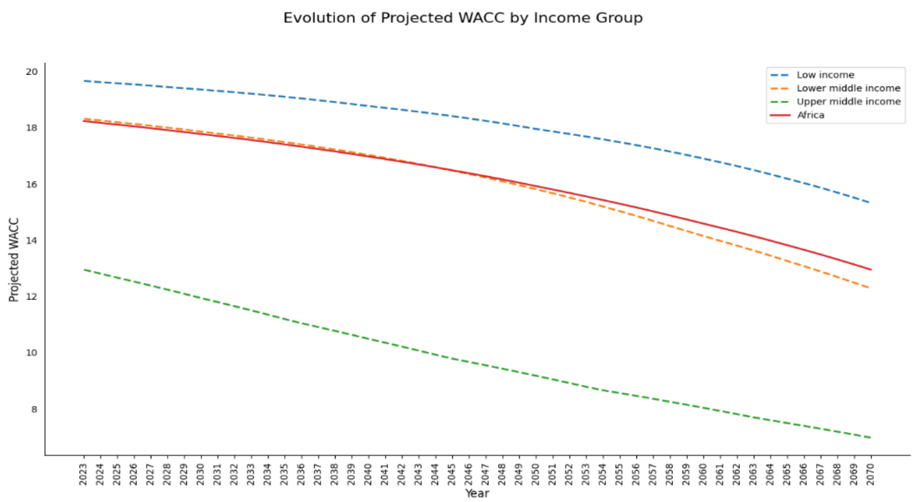
**Figure 7**: Projections of WACC across Fragility, Conflict amd Violance (FCV) Status.




**Note:** The classification of Fragility, Conflict amd Violance (FCV) include two catergories: (i) Conflict, and (ii) Institutional and social fragility.[18]

### 7.5 Appendix E: Distribution of projected WACC across income group classifiaction

**Figure 8**: Projections of WACC across categories of income group




**Note:** The World Bank provides the income group classification of countries that includes: (i) Low income, (ii)Lower middle income, (iii)upper middle income, and (iv) High income.

[18] https://www.worldbank.org/en/topic/fragilityconflictviolence/brief/harmonized-list-of-fragile-situations