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Public Debt Sustainability in Sub-Saharan Africa: A Mathematical and Administrative Review

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Abstract
Public debt in Sub-Saharan Africa has grown rapidly over the last decade, driven by rising borrowing needs, pandemic-related spending, and increased reliance on commercial and bilateral loans. This surge has led to escalating debt-servicing costs, often consuming a significant share of government revenues and constraining social and developmental expenditures. While regional growth projections remain moderately positive, weak per-capita income gains and limited fiscal space continue to undermine long-term debt sustainability. This review combines mathematical assessments—including debt-to-GDP ratios, debt service-to-revenue thresholds, and fiscal sustainability benchmarks—with an administrative analysis of revenue mobilization, restructuring measures, and governance frameworks. Together, these perspectives provide an integrated understanding of the challenges and pathways toward sustainable debt management in Sub-Saharan Africa.

Keywords: Public Debt Sustainability, Sub-Saharan Africa, Fiscal Governance, Debt Management Frameworks, External Market Vulnerabilities

1. Introduction

The public debt in Sub-Saharan Africa has gone up drastically over the past ten years, from around 30% of GDP in 2013 to almost 60% by the end of 2022 and then gradually increasing to roughly 63% by the end of 2024 [1, 2]. Large infrastructure borrowing, pandemic relief expenditures, and currency rate depreciation are the main causes of this sharp increase [3, 4]. More ominously, debt service costs have ballooned: governments in SSA now spend about 50 % of their domestic income servicing debt—some like Kenya approaching 60 %—crowding out crucial social and developmental outlays [2, 5]. Formally, half of the SSA's low-income states are in or at significant risk of debt distress [1, 3].

These data emphasize a stark reality: SSA's debt burden currently poses structural concerns to fiscal stability and long-term development. Interest payments on external obligations are estimated to hit US $20 billion in 2025, representing around 3.4 % of regional GDP in the 2025–27 window [6]. In many cases debt service exceeds health and education expenses combined [6]. In the meanwhile, refinancing and currency risks are increased by growing global borrowing costs (bond yields 6 times concessional loans), a significant reliance on private and non-Paris Club creditors, and unstable exchange rates [1, 6]. In economies like Angola, where social services funding has decreased by more than 50% since 2015, more than half of the budget is now allocated to debt payments [7]. In light of this, debt sustainability in SSA needs to be urgently reevaluated as a dynamic junction of mathematical measurements and administrative capabilities rather than just as arithmetic ratios. Nominal public debt was briefly lowered by previous debt relief programs like HIPC/MDRI, going from roughly 104% prior to relief to 30% during the 2006–11 period, although this reprieve was only temporary [4].

The nominal debt levels in many SSA nations have tripled since 2010, substantially surpassing GDP growth, and the composition has shifted toward riskier bilateral and commercial borrowing [4, 5]. Additionally, domestic debt rose sharply, rising from 8.2%of GDP in 2012 to almost 20% by 2024 [6]. Rollover, liquidity, and institutional governance risks are increased by the combination of external and domestic commitments [5-7]. Although they offer helpful benchmarks, existing sustainable debt frameworks (such as debt/GDP levels and debt service/revenue ratios) must be executed with discretion in SSA. More than half of the countries have already surpassed median debt anchor levels of about 55% of GDP [1].

At the same time, high interest rates, currency rate volatility, and restricted capacity to raise revenue must all be taken into consideration in stress tests and projections. Real sustainability depends on whether debt service is still sustainable in relation to fiscal space and economic growth, even when the debt-to-GDP ratio may be structurally high. Consequently, this review unites two critical viewpoints. It uses debt-to-GDP trends, debt service as a percentage of revenue and exports, and scenario models to mathematically evaluate SSA's debt trajectory.

In terms of administration, it evaluates the effectiveness of restructuring or relief efforts, revenue mobilization mechanisms, debt management institutional structures, and fiscal governance quality. The study offers a comprehensive perspective on sustainability by integrating quantitative indicators with institutional and governance research.

2. Shifting Patterns of Public Debt in Sub-Saharan Africa

2.1. From Relief to Resurgence

Sub-Saharan Africa's governmental debt saw a fascinating decline from a GDP-weighted average of roughly 104% before to relief to nearly 30% between 2006 and 2011 after significant debt reduction via HIPC and MDRI in the early 2000s [21]. This reprieve however, turned out to be short-lived. Debt ratios again increased significantly between 2013 and 2019 from about 28 percent of GDP to almost 50 percent due to favorable global financial circumstances, fluctuations in commodity prices, growing fiscal deficits, and slower growth (from 6.9 percent in 2010 to 3.2 percent in 2019) [4]. From US$565 billion in 2006 to approximately US$1.25 trillion by the end of 2023, the nominal public debt nearly quadrupled before leveling off at US$1.18 trillion in 2024 [9].

2.2. The Pandemic and Beyond: Structural Reacceleration

The COVID-19 pandemic significantly accelerated the accumulation of debt in SSA. The median public debt-to-GDP ratio grew from almost 50% in 2019 to 57% in 2021 before dipping slightly to roughly 60% in 2023 (63.3 percent excluding South Africa and Nigeria) [3, 19]. While government revenue ratios fell from 12.7% of GDP in 2019 to 11.4% in 2020, external debt to exports rose from 88% in 2009 to 153% by 2019 [6]. Service-to-revenue ratios increased from less than 20% in the early 2010s to almost 50% by 2023, with some nations, like Kenya, paying about 59% of their regular revenue on debt service by 2022–2023 [3, 10]. Interest payments increased from 6.4% of GDP in 2017 to over 10% in 2023, and they currently outstrip health spending by an average of 5.5 times [2].

2.3. Regional Divergences: Typologies of Vulnerability

The debt trajectory varies throughout SSA nations. Resource-rich nations like Ghana, Angola, and the Republic of Congo have had to contend with unstable export markets, instability in commodity prices, and a significant reliance on external borrowing. Service responsibilities are fast increasing in economically fragile states like Burundi, Chad, and Sierra Leone. Reform-oriented nations like Rwanda and Senegal, on the other hand, continue to face challenges with plummeting fiscal margins and rising servicing costs, however, maintaining lower risks [3,13]. About 19 of the 35 low-income SSA nations were affected by the debt situation by 2024 [1].

2.4. Composition Shifts and Elevated Costs

Commercial markets and non-concessional creditors like China and Eurobond investors became the primary sources of post-HIPC borrowing. Nearly 75% of external debt service obligations are now for commercial financing [11], and average bond coupons in 2024 will be close to 8.5 percent, compared to previous averages of ~7.3 percent [15]. Additionally, domestic debt skyrocketed, rising from about 15% of GDP in 2010 to about 30% by 2020 [15]. Nominally, SSA's government debt has tripled since 2012, and interest expenditures as a percentage of revenue have increased by about 25 percentage points, significantly surpassing Latin America and tying governments to heavy servicing obligations for years [15].

3. Mathematical Approaches to Debt Sustainability

3.1. Debt Burden Ratios

Debt-to-GDP ratios remain the baseline for quantifying the magnitude of public debt and benchmarking sustainability. In Sub-Saharan Africa (SSA), average public debt soared from approximately 30 % in 2013 to nearly 60 % by end-2022, stabilizing around 57–61 % by 2023–24 [10,16]. Conventional benchmarks, including the IMF-World Bank anchor of about 55%, imply that many SSA nations surpass safe boundaries. However, a mechanical interpretation of these thresholds runs the risk of oversimplifying: the significance of a 55 percent anchor is reflected according to institutional strength, borrowing costs, and income capacity [16]. Research from recent times has shown that when debt reaches certain thresholds, the impact on growth accelerates significantly. For example, in emerging nations, a debt-to-GDP ratio of 64 percent is linked to a 0.02 percentage point drop in real GDP annually for every percentage point of debt that is added [17].

$$\text{Debt-to-GDP ratio} = \frac{\text{Total Public Debt}}{\text{Gross Domestic Product}} \times 100$$

This indicator benchmarks overall indebtedness. For example, if Kenya's total public debt in 2023 was $70 billion against a GDP of $120 billion, its debt-to-GDP ratio is:

70/120 x 100 = 58.3%

Values above the IMF/World Bank benchmark of ~55 % typically raise sustainability concerns [16].

3.2. Debt Service Pressures

Table 1

Country	Debt-to-GDP (%)	Debt Service-to-Revenue ((%)	Debt Service-to-Exports (%)	
Kenya	58	59	14	Rising Eurobond exposure [11]
Ghana	76	59	22	In debt distress; IMF program [14]
Zambia	61	45	17	Defaulted; restructuring ongoing [14]
Rwanda	47	32	12	Lower risk, reform-oriented [13]
Angola	68	54	21	Oil dependence; refinancing challenges [15]

Source: Compiled from IMF, World Bank, Ecofin Agency, and Fitch Solutions data [10–15, 21].

Compared to debt stock alone, debt service ratios—more especially, debt service payments as a percentage of exports or government revenues—are more dynamic stress indicators. Since the 2010s, interest payments to revenue have more than doubled in SSA, reaching an average of almost 4 times that of advanced nations [16]. While debt service contributed for roughly 46–62 percent of revenues in various nations [11, 12], as of 2023, external debt servicing devoured nearly 15 percent of export earnings (compared to 4.5 percent in 2011) [18]. These ratios are important because if the flow burden exceeds fiscal space, even moderate debt-to-GDP levels may become unsustainable. For example, Kenya severely limited its spending on development in 2022–2023 by allocating over 59% of its usual revenue to debt servicing [11]. Accordingly, service pressures must take precedence over stock alone in stress-testing frameworks.

$$\text{Debt Service-to-Revenue Ratios} = \frac{\text{Annual Debt Service Payments}}{\text{Government Revenues}} \text{ x } 100$$

This reflects fiscal space directly. For instance, Ghana in 2022 allocated about $8 billion to debt service out of $13.5 billion in revenues:

8/13.5 x100 = ~59.3%

Ratios above 40 % usually indicate severe fiscal stress [11, 16]
For debt-service ratio exports,

$$\text{Debt Service-to-export ratios} = \frac{\text{External Debt Service}}{\text{Total Export Earnings}} \text{ x } 100$$

This shows external liquidity risks. If Zambia's external debt service was $2 billion against $12 billion in exports,

2/12 × 100 =16.7%

Values that exceed 15–20 % are widely considered unsustainable in low-income settings [18].

Projection Models and Stress Testing

Projections of debt-to-GDP and service ratios across a range of macroeconomic conditions are applied in the IMF-WB Debt Sustainability Framework (DSF). However, as seen by World Bank internal discussions over Ethiopia's DSA, critics argue that the DSF has limits in low-income nations and that its assumptions, particularly with regard to interest rates and exchange-rate dynamics, may understate stress [16]. Fiscal anchors and stress scenarios are combined in more rigorous methodologies. A critical economic uncertainty is what then would be the outcome if exports collapsed or interest rates spiked. Even in the absence of restructuring, one in four country-years in SSA saw debt stabilization episodes, which are multi-year periods in which debt/GDP decreased by ≥10 pp [16]. Moderate growth and persistent primary surpluses were crucial for such occurrences.

Gaussian control frameworks and other structural models provide more detailed information. They combine default risks, growth uncertainty, and fiscal policy decisions. These models, such as the Hamilton-Jacobi-Bellman methods, produce the best fiscal routes that minimize costs and gradually reduce debt [20]. Stress-testing should include probabilistic simulations of interest rate, exchange rate, and growth scenarios—not simply deterministic forecasts—in SSA, where economic downturns and volatility are prevalent.

4. Administrative and Institutional Dimensions of Debt Management

In Sub-Saharan Africa, the capacity and structure of administrative institutions are equally important as quantitative thresholds of debt sustainability. Three interconnected pillars are examined in this section: the function of central banks and debt management offices (DMOs), domestic revenue mobilization approaches, and fiscal policy frameworks and budgetary discipline. The review looks at how governance structures influence how effective debt policies function within each pillar.

4.1. Fiscal Policy Frameworks and Budgetary Discipline

Budget planning's coherence and credibility are shaped by fiscal policy frameworks, primarily medium-term fiscal frameworks (MTFFs). The use of MTFF has grown more urgent in SSA. In late 2024, an IMF-hosted workshop in southern Africa showed how useful MTFF tools facilitate the integration of fiscal risk management, debt anchors, and macro-forecasting [22]. The assessment highlights that governments can precommit to debt targets and manage expenditures consistently under fiscal frameworks anchored to multi-year ceilings, which lessens the likelihood of pro-cyclical policy moves. However, the conversion of MTFFs into credible fiscal discipline is limited by challenges with capacity, such as inadequate fiscal risk reporting and a lack of cooperation within ministries [22]. Therefore, even while frameworks are in place in many nations, their application is still inconsistent, necessitating institutional change as well as technical instruction to make theoretical models operational.

4.2. Domestic Revenue Mobilization Strategies

To boost budgetary autonomy and lessen dependency on borrowing, domestic revenue mobilization is essential. The tax-to-GDP ratio in Sub-Saharan Africa fell from almost 16 percent in 2010 to 14.2 percent in 2021, falling below the

minimum threshold of 15 percent required to finance sustainable development [6]. The review links this deficiency to extensive exemptions, ineffective tax laws, and substantial unorganized industries. Results are starting to emerge from recent policy initiatives, such as digital filing systems, VAT reforms, and Medium-Term Revenue Strategies (MTRS) [6, 4]. Using tax policy reform, Rwanda, Senegal, and Uganda have quickly increased their revenue by 3–5% of GDP [1, 4]. However, public trust is necessary for these gains to occur: A flawed fiscal social contract, where taxpayers demand services in exchange for compliance, is a constant drag on collections, according to Wilson Center studies [4]. Strengthening revenue mobilization thus requires linking policy changes to visible public service benefits and enforcing tax expenditures oversight [9].

4.3. Role of Central Banks and Debt Management Offices

Through institutional coordination, market operations, and policy advice, central banks and DMOs have an impact on debt strategy. Nigeria's DMO is an ideal instance of outstanding institutional architecture, a legislative structure that requires annual borrowing plans and medium-term debt strategies, having been formed under enabling legislation in 2000 and updated by the Fiscal Responsibility Act of 2007 [21]. Its design minimizes ad hoc commercial borrowing by guaranteeing that debt issuance and fiscal policy are in line. According to the World Bank, Kenya's Public Debt Management Office, which received assistance after 2019, was able to improve procurement and transparency procedures while successfully lowering the country's exposure to commercial debt from 35.6% to 28.8% [5]. These examples demonstrate how operational DMOs, which possess both technological and legal autonomy, provide enhancements in debt reporting, risk management, and borrowing terms.

Central banks also have a crucial but sometimes disregarded functionality. Central banks support reserve management, liquidity supervision, and monetary coordination even if they are not always in charge of issuing debt. For instance, the central bank of Mozambique supports frameworks for credit control, advises the government on public finance, and supervises state cash management operations [22]. Central banks can improve macro stability through exchange-rate supervision and inflation targeting, even if they are not direct debt agents. This has an impact on the cost of debt servicing.

5. External Debt and Global Market Forces

The foreign debt profile of Sub-Saharan Africa and its susceptibility to global financial events significantly influence the sustainability of its debt. This section examines the manner in which market uncertainties, fluctuating exchange rates, and shifting creditor landscapes intensify budgetary pressure throughout the region.

5.1. Shifting Lenders: From Multilateral Partners to Commercial and Bilateral Creditors

Historically, concessional multilateral finance has accounted for the majority of SSA's external debt. However, from the early 2010s, financing shortfalls have been filled more and more by commercial creditors and new bilateral lenders, especially China. By 2023, SSA's proportion of commercial lenders' external debt increased from about 25% in 2010 to almost 55% [30]. This change impacts pricing and risk profiles since commercial borrowing has stricter commitments, higher yields, and frequently shorter maturities. Despite their occasional concessions, bilateral Chinese loans have complicated collateral requirements and currency connections, which raise the risk of contingent liability [31]. The risk of rollover and refinancing has increased as governments that traditionally depended on Paris Club and multilateral organizations now turn to bond markets and non-Paris Club lenders.

5.2. Market Vulnerabilities: Eurobond Issuance, Refinancing Risks, and Interest Rate Shocks

For SSA countries looking to obtain market access, issuing Eurobonds has become crucial; yet, the cost and risk of these securities have gone up sporadically. With yields reaching 8–10% in a number of nations, average SSA government bond spreads increased from ≈300 bps over US treasuries in 2019 to over 550 bps by early 2024 [32]. Rollover risk is severe for nations issuing Eurobonds, such Ghana, Nigeria, and Kenya, because of their short tenors (5–7 years) and hefty coupon commitments. For example, Kenya used approximately 20% of its foreign exchange reserves to repay a US$2 billion Eurobond in mid-2023 at a coupon of around 9% and refinance into fresh issuance at a cost of 9.2% [32].

5.3. Currency Dynamics: Exchange Rate Volatility and Debt-Servicing Challenges

SSA debtors are also more vulnerable to currency risk due to their persistent exposure to commercial borrowing. Debt loads rise simultaneously when domestic currencies devalue because most external borrowing is valued in USD or other major currencies. Even without fresh borrowing, Nigeria's external debt-to-GDP rose by ~5 percentage points abruptly between 2020 and 2024 as the naira lost about 45% of its value against the dollar [34]. In Zambia, debt payment costs increased from 16 percent to over 24 percent of earnings when the kwacha depreciated by about 60 percent between 2019 and 2023 [35]. Projections and stress testing are particularly hampered by currency volatility; in order to capture actual risk, debt sustainability models need to account for exchange-rate shocks. Forecasting scenarios where a 20 percent devaluation raises debt-to-GDP by 3 to 7 percentage points, depending on composition, forward-looking frameworks increasingly stress-test exchange-rate sensitivity [36].

6. Pathways toward Sustainable Debt Management

This section of the study transitions from diagnosis to prescription, examining how Sub-Saharan African (SSA) countries can chart sustainable pathways toward credible non-predatory debt through restructuring, regional cooperation, and fiscal innovation. Each subsection explores how pragmatic policy tools and institutional mechanisms can impact both borrowing practices and fiscal credibility.

6.1. Restructuring and Relief Options: Lessons from Recent Negotiations and Debt Swaps

When debt obligations become exorbitant, restructuring—rather than just relief—is a strategic tool. Ghana's 2022 external debt restructuring, through a blend of Eurobond haircuts and bilateral agreements, produced a decrease in debt-to-GDP of around 12 percentage points, albeit at the cost of reduced market access for two years [37]. Zambia achieved a debt swap deal with China and private creditors to prolong maturities and lower coupon rates after defaulting in 2020.

However, some investors still have confidence difficulties [38]. These experiences show that successful restructuring requires transparent discussion, realistic fiscal adjustment, and timely communication with stakeholders.

Debt-for-nature or debt-for-health swaps, pioneered in Seychelles and Belize, offer potential for SSA nations to promote sustainable development while relieving debt stock. However, acceptance in Africa remains restricted [39]. The analytical takeaway: Well-structured restructuring can stabilize budgetary expectations and create breathing room, but only if it is linked to reform commitments.

6.2. Regional and Continental Strategies: The Role of AU, AfDB, and Cross-Border Cooperation

Continental and regional institutions are critical for coordinating debt strategy. The African Union's Debt Vulnerability Framework (AVDF) provides unified indicators and peer assessment. Although non-binding, it demonstrates political commitment to debt discipline [40]. The African Development Bank (AfDB) has begun debt sustainability support facilities, offering technical assistance, funds for risk hedging, and capacity building for DMOs and ministries of finance [41]. Cross-border cooperation platforms, such as the EAC macroeconomic convergence criteria, help align fiscal benchmarks and verify compliance, lowering the risk of competitive devaluation or currency wars causing debt crises. The planned African Monetary Fund might provide temporary financing to SSA debtors during a crisis, minimizing reliance on external IMF to reprofile debt in the short term [41].

6.3. Innovation in Fiscal Management: Harnessing Fintech, Digital Taxation, and Automated Compliance

Digitization is a potential approach for enhancing fiscal capacity in SSA. Mobile money ecosystems support 60% of transactions in Kenya and Tanzania, allowing tax administrations to test real-time revenue collection, withholding, and digital VAT remittance systems [42]. In Ghana, implementing e-invoicing and SAP-based integrated tax administration led to a 35% rise in monthly VAT filings and a roughly 18% reduction in arrears within 18 months [43]. Automated compliance systems—which use machine learning to detect evasion patterns—are being tested in Rwanda and Uganda, and they show promise for closing the informal tax gap. Blockchain-based public procurement publicly tracks contracts and spending, reducing corruption and overruns that might increase contingent liabilities [44]. Integrating fintech with fiscal management, particularly for medium-sized states, decreases execution inefficiencies and hence the need for expensive borrowing. More crucially, innovation increases public trust and tax morale, both of which are essential for long-term viability.

7. Conclusion

As this review has shown, Sub-Saharan Africa's debt sustainability cannot be distilled to solely numerical thresholds. Although mathematical indicators, such debt-to-GDP or debt service ratios remain essential for indicating fiscal deficiencies, their interpretive value is constrained in the absence of strong administrative and institutional anchors. Even when their ratios approach or exceed conventional deficiency levels, nations that combine debt analysis with robust fiscal frameworks, independent debt management offices, and open revenue systems typically demonstrate higher resilience [45]. Essentially, government sets the direction, whereas mathematics supplies the compass.

Insights can be gained from previous debt crises in SSA, ranging from the pre-HIPC buildup of arrears to the present post-pandemic Eurobond pressure. First, in the absence of structural changes, debt reduction frequently results in a short-term rather than long-term reprieve. Restructuring is necessary, but it must be supported by credible budgetary restraint and institutional reform to prevent future crises, according to evidence from Zambia and Ghana [46]. Second, because short-term market optimism can quickly turn around and force vulnerable economies into expensive refinancing, the growing involvement of commercial creditors emphasizes the necessity of proactive risk management. In addition, dependence on borrowing in foreign currencies has continuously increased vulnerability, underscoring the significance of managing exchange rates and having a variety of revenue streams. These lessons demonstrate that developing institutional memory and recalculating ratios are both important components of debt sustainability.

The path forward is a careful balancing act: governments must avoid excessive borrowing that undermines solvency while also promoting growth to increase their tax bases. AfDB's debt sustainability facilities and the AU's Debt Vulnerability Framework are two examples of regional innovations that are significant milestones in integrating fiscal responsibility within African institutions [47]. The fiscal social contract could be recalibrated in ways that are not possible with conventional approaches thanks to the potential for fintech and digital taxation systems to significantly increase fiscal space, automate compliance, and decrease leakages [48]. However, maintaining these advancements calls for more than just technology, it also calls for public trust and political will.

In conclusion, Sub-Saharan Africa's quest for debt sustainability is a process rather than a final goal. It is a developing convergence of innovation, governance, and mathematics. The continent may escape recurrent debt traps and progress toward a robust future if fiscal innovations are welcomed, regional frameworks are reinforced, and lessons learned from previous cycles are internalized. Finding a pragmatic balance between funding urgent development and maintaining solvency for future generations is the ultimate goal.

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