The Impacts of Public Expenditure on Sustainable Environmental Development in Sub-Saharan Africa

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Abstract

This study examined the impacts of public expenditure on sustainable environmental development (SED) in sub-Saharan African countries using the annual data of 35 countries during the period of 2008--2022. This study is needed because previous studies failed to consider a significant share of sustainable environmental development goals, and their findings were inconsistent. The study employed Dynamic Panel, two step-System-Generalized method of Moments (GMM) estimation techniques to test the effect of military, agricultural, health, and education expenditure on the sustainable environmental development. The results indicate that changes in public spending in the military, health and agriculture positively and significantly affect sustainable environmental development in SSA, whereas education expenditure has a positive but insignificant effect. For agricultural, health and education expenditures, sustainable development theory is valid, whereas for military spending expenditure, ecological modernization theory is valid, and sustainable development theory is not supported. To realize SED development in sub-Saharan Africa, policy makers in sub-Saharan African countries have suggested increasing expenditures on defense technology to improve environmental development sustainability; investment in sustainable farming practices, promoting organic agricultural practices that reduce waste, pollution, and the use of renewable energy using technologies; and incentivizing programs that increase public awareness of ecological quality and upsurge investment in

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the health sector to improve the health status of people by so doing enhance SED.

Keywords: Development, Environment, Government Expenditure, Sustainability

1. Introduction.

1.1. Background of the study

In Sub-Saharan Africa (SSA), 1.21 billion (15%) of the world's population resides. However, countries in the region are facing numerous challenges, such as environmental crises, high rates of unsafe and unskilled jobs (ILO, 2022), low infrastructure (Thusi, 2023), extreme poverty and natural resource depletion (United Nations, 2023), high risk of debt sustainability and persistent climatic shock (Estevão, 2022). Furthermore, in 2022 in SSA, many countries never achieve a significant portion of sustainable environmental development goals. For example, apart from Mauritania and Seychelles, 46 states failed to achieve SDG6 (clean water and sanitation), except Namibia; 47 countries did not achieve SDG15 (life on land), and no nation recorded significant progress in SDG14 or life below the water goals of the SDGs (Sachs et al.,2023). In general, counties in a region are unable to achieve immense SDGs (AfDB, 2022; UN, 2023). These problems can be attributed to weak development policies, the incorrect allocation of public resources (Lin & Chen, 2020) and the inability of governments to allocate resources appropriately to the SDGs((Gaghman, 2020). Moreover, many states in SSA are still unable to provide sufficient resources for education, influencing the quality of education, which in turn affects sustainable development (IMF, 2019; World Bank, 2021). In addition, in SSA, government spending on healthcare most often falls below the required amount of funds to meet the desires of escalating populations, driving poor health care services (McKinsey & Kenner, 2020).

To revert these crises and achieve the SDGs, the government in SSA is required to increase its expenditures (IMF., 2023). However, in the region, public expenditure as a percentage of GDP has fallen in one period and stagnated in the other in the past 3 decades (World Bank., 2024). In additions, to realize sustainable development, fiscal policy in general and effective

public expenditure management in particular are vital instruments that the government employs. Public expenditures are aggregate resources allocated by the public body or authority (IMF, 2014). However, there are multifaced public expenditure allocation and management problems in SSA that significantly influence the performances sustainable development goals. One of the main problems is the extravagance and inadequacy of budgets (United Nations, 2020), the lack of a precise link between policy, effective planning and expenditure allocation (Pearson, 2022), the gap in resource allocation in pro-poor sectors (Singh & Chudasama, 2020) and the agricultural sector's impact blind budgeting (FAO, 2021).

In this context, scholars have argued that realizing the SDGs is recognized as a public development agenda demanding strong integration of fiscal policy and development goals (Veselovská., 2017). In the domain of fiscal policy, the political economist Maynard Keynes played an extensive role and laid a foundation for research on public spending. According to Keynes (1936), public spending during economic slumps induces economic growth. In support of him, institutional and structural economists state that the government must spend on infrastructure, human capital and institutional quality to foster development (Veblen., et al,1889). Similarly, other theorists argue that public spending on education, health and infrastructure positively contributes to long-term economic growth and development (Becker & Barro, 1988). Likewise, peace dividend theory argues that reducing public expenditure on the military can be used to shift resources to sustainable development agendas, leading to environmental development (Radelet & Sachs,1998), and ecological modernization theory posits that technological advancement can lead to efficient utilization of resources. The theory states that public expenditure can be in line with environmental development goals (Mol & Spaargaren, 2000). The theory suggests that military activities could improve sustainable practices such as deployment of clean technologies within defense activities to reduce the negative impacts from their operation. Moreover, investment in defense modernizations could be focused toward creating eco-friendly technologies, such as power-efficient armaments, low carbon emission defense automobiles, or waste management schemes that are more environmentally friendly through the use of dual-purpose technologies

viz., the technologies using energies from renewable resources and waste management tools which can be used for both civilian and military sectors.

According to the reviewed theoretical literature, traditional economic theories emphasize increasing short-term economic output and ignore its long-term adverse effects on environmental development. Generally, theories lack sufficient consideration of the relationship between SEDs and public spending practices. These factors make the theories poor in addressing how fiscal policies interact with the complex conditions of SED, leading to disorganized analysis. Hence, a comprehensive theory (theory of sustainable development) is critically important in examining the impacts of public expenditure on sustainable environmental development in SSA. According to sustainable development theory (World Commission for Environment and Development [WCED,1987]), public spending is viewed as a tool for inclusive and sustainable social, environmental and economic development.

In this context, understanding the impacts of public resource allocation on environmental sustainability is a top priority for allocating valuable public funds. To grasp how public expenditures on the military, agriculture, health, and education impact the sustainability of environmental development in SSA, numerous global, regional and local empirical studies have been reviewed. However, the empirical findings are diverse across continents, countries and scholars because of the lack of exhaustiveness of the environmental development indicators used by researchers. In addition, previous studies overlooked the impacts of agricultural, health and education expenditures on the sustainability of environmental development in SSA. Additionally, the unilateral (single country based) studies in SSA examined environmental impact of military expenditure, but the study results are inconsistent and they have used only CO_2 emissions as a proxy of environmental development while real sustainable environmental development is the result of wide-ranging SDGs such as clean water and sanitation (SDG6), climate action (SDG13), life below water (SDG14) and life on land (SDG15). To seal this empirical vacuum in terms of the impacts of public expenditure on SEDS, conducting comprehensive development analysis using the United Nations' sustainable environmental development goals (SDGs) is at the top of the urgent list for empirical studies on the impact of public expenditure on the sustainable environmental development of Sub-

Saharan Africa. Thus, this study examines how public spending in Sub-Saharan Africa impacts sustainable environmental development.

1.2 Hypothesis:

The hypothesis is a tentative declaration subject to verification (Kothari., 2004). On the basis of theories and reviewed empirical literature, the study hypothesizes the following:

$H1_1$: Government military expenditure significantly affects sustainable environmental development in SSA.

$H1_2$: Government agricultural expenditure significantly affects sustainable environmental development in SSA.

$H1_3$: Government health expenditure significantly affects sustainable environmental development in SSA.

$H1_4$: Government education expenditure significantly affects sustainable environmental development in SSA.

2. Theoretical and Empirical Reviews

2.1 Theoretical Review

In Africa, agriculture and sustainable agricultural practices, as pillars of numerous economies, particularly in pastoral areas, aid the SDGs by alleviating food insecurity. It contributes to natural resource development and sustainability by improving soil fertility, preserving water, and reducing greenhouse gas emissions (Taylor., 2020). In addition, implementing methods that reduce CO2 is vital for managing climate shocks (Davis et al., 2022). In addition, education plays a key role in nurturing consciousness and empowering people to take informed action concerning sustainability. It prepares individuals with the skills and knowledge required to resolve ecological challenges (Smith, 2020). Moreover, sustainable health care schemes are indispensable for resilience against diseases and natural calamities, which can threaten economies and hamper development (Johnson & Miller, 2018).

A central objective in examining the impact of public spending is to understand the role of the government in the welfare of citizens (Hyman., 2011). Public finance is an effort to develop standards by which public resource mobilization and spending ought to be measured (Musgrave & Peackok., 1967; Nemec., 1999). Public spending is an outlay of financial resources by the government to provide public goods and services, and it

provides insight into the size of government across states (OECD., 2023). The Keynes (1936), English economist and philosopher insisted that increasing public spending during economic downturns induces economic growth. Similarly, other theorists have hypothesized that optimized public spending on education, health and infrastructure positively contributes to long-term economic growth and sustainable economic development. An opponents of Keynes theory stated that better development can be achieved with limited government size (amount of public spending), a free market system (Smith.,1776), and individuals' (market participants') rational economic decisions (Jevons.,1888; Walras., 2014). Additionally, Battaglini and Coate (2008) argued that public spending in areas other than health, education and infrastructure must be controlled.

Nevertheless, the mentioned theories emphasize only economic growth and development. The public goods theory proposed by Samuelson (1954) posits that since markets often struggle to efficiently provide public goods, government intervention becomes essential. Under public goods theory, public expenditure on environmental protection, conservation, and sustainable development is justified as a means to address market failures and ensure long-term ecological sustainability. Furthermore, the Environmental Kuznets Curve Hypothesis, also states that the impact of public expenditure in military sectors (nonproductive expenditure category) on development depends on the type of military armament, disposal mechanism and environmental policies of a specific country (Kuznets, 1959). The theory calls an inverted U-shaped bond between GDP and environmental degradation. In the early stages of development, industrialization and economic expansion lead to increased pollution and environmental harm. As income levels rise, societies initiate prioritizing environmental protection, investing in cleaner technologies, and implementing stricter regulations. At higher levels of economic development, economies transition toward more sustainable growth models, leading to a decline in environmental degradation.

The traditional economic model (theories), for example, classical theory, focuses on saving (capital accumulation) and economic growth. This approach mainly emphasizes increasing economic output and ignores future adverse effects on environmental development. Above all, economic theories and models suggest diverse views on how to manage short-term development

challenges, with varying focuses on the role of public intervention, the monetary system, and market forces. These factors make traditional economic theories inadequate for addressing how fiscal policies interact with the complex conditions of sustainable environmental outcomes. This can be further translated into inadequacy when these economic models are used to examine the sustainable development implications of government spending decisions. Resource curse theory claims that states with plenty natural resources conducts extensive extraction of resources and prioritizes militarization over the protection of natural resources, which can exhaust natural capital as the resources take out and assigned for military sectors (Auty., 1993). In this regard, natural resources governance institute, NRGI (2015) stated that though one might assume to see good growth after states realize natural capitals, resource-rich nations tend to have higher rates of war and dictatorship. The institute also argued that, resources rich countries less likely to spend in productive sectors and they fight for control of resources. The natural resources are sources of conflict and public spending from this source is inefficient due to volume and price volatility of resources leading to weak public institution, environmental and social problems.

The states that intend to achieve economic growth and environmental development simultaneously tend to invest in sustainable urban development and climate change management. This tendency underlines the increasing understanding that public spending on sustainability is not a waste of resources but an opportunity for sustainable economic, social and environmental development. Additionally, public expenditure is vigorous in addressing universal sustainability challenges. The World Bank and the International Monetary Fund (IMF) have increasingly recommended that countries align their public resources with the goals and principles of SD (World Bank, 2020). Moreover, Brollo et al. (2021) stated that to realize the SDGs, public expenditures, especially health and education expenditures, need to be intensified. In addition, the fiscal monitoring statement of the IMF (2023) argues that wisely managing government expenditures in pro-poorer areas, e.g., healthcare, educational services and infrastructures, improves overall sustainable development. Additionally, in the green growth and sustainable development framework, public spending in productive sectors is

viewed as a tool for socioeconomic and environmental development sustainability (WCED, 1987).

In contrast, the theory of SD advocates that public military spending can have adverse influences on SD, mainly by diverting funds away from crucial areas such as social wellbeing, ecological development, and sustainable growth in national output. High military expenditure is usually observed as inconsistent with the SDGs, as it naturally cuts existing public resources for investments in key socioeconomic and environmental development sectors (Sachs, 2015). Moreover, augmented defense spending can aggravate ecological destruction through the manufacturing and use of defense technologies, worsen pollution, contribute to the depletion of natural capital, and disrupt socioeconomic sustainability (Muradian et al., 2012). SD theory highlights the advantages of reallocating defense expenditures in the direction of SDGs (Barbier, 2011). However, politicians in many developing countries ignore public choice theory and what, how and why public goods and services should be provided; instead, they prioritize public investment on the basis of their own interest (Buchanan & Tullock., 2017).

There are significant disputes surrounding economic theories on the impact of public expenditure. These theories also overlook environmental aspects and the complex conditions required for sustainable development. Furthermore, the theoretical arguments of sustainable development have yet to be empirically tested in Africa. Thus, this study examines how public spending impacts sustainable environmental development.

2.2 Empirical Reviews

From the reviewed economic theory, it is evident that theoroticians have multifaceted views on the effects of public spending on economic, social and environmental development. In the past 3 decades of government expenditure, the percentage of GDP (% of GDP) has fluctuated frequently in SSA. In an attempt to examine the feasibility of the proposed theories, various scholars have conducted studies using regional, national, continental and global data and explored the effects of these ever-fluctuating public expenditures in different countries on various environmental development goals and targets.

Environmental impacts of military expenditure

The findings from Intercontinental studies that in Asia, America and Australia on the effects of defense spending on environmental development support the treadmill theory of destruction. The researchers claim that the intensification of public spending in the military leads to an increase in CO_2 emissions, in turn increases environmental degradation(Isiksal, 2021; Tarczyński et al., 2023)**.** Additionally, Habibullah et al. (2023) noted that an increase in defense spending deepens the depletion of biodiversity. In the next eleven (N-11) countries, militarization worsened environmental degradation (Zhu et al., 2023). However, this is not true for BRICS economies; in these states, spending on the ecological footprint is determined to be insignificant (Zhu et al., 2024). A study of the top 20 military powers possessed by nations in the period 1991--2020 revealed that spending on the defense crowding-out effect on green capital formation in eight states contributed positively to eco-friendly investment in the rest of the states (Das & Hussain., 2023). A recent study revealed that in the member countries of Organization for Economic Cooperation and Development (OECD) nations, an increase in defense spending diminishes renewable supply (Kilinc-Ata etal, 2024)**,** which is incompatible with the green growth of OECD members (Ahmed et al., 2021). In industrialized Mediterranean countries, defense also intensifies the environmental crisis and escalates carbon dioxide emissions (Erdogan et al., 2021). The United States of America is also suffering from rising carbon dioxide emissions due to increased spending defenses. In addition, NATO was organized to protect member states from foreign aggression. However, being affiliate with NATO does not rescue member states from environmental degradation (Pata et al., 2022)

In an attempt to understand the impacts of ever-increasing defense spending on the environmental development of Africa, Africa-wide and unilateral (country-specific) studies have been conducted. Researchers have reported that although African countries have no gun (weapons) manufacturing industries, they are deadly affected by carbon dioxide (CO_2) emissions and nitrous oxide (N_2O) due to intensified defense expenditures (Ngounou etal., 2024). In South Africa, the study findings rejected the treadmill theory of destruction. The results revealed that in the short run, an increase in military expenditure was found to be positive but insignificant, whereas in the long

run, an immense reduction in CO2 emissions (Saba., 2023).. A similar study in sub-Saharan Africa revealed that defense expenditure increases CO_2 emissions in the region (Asongu & Ndour, 2023).

Environmental impacts of agricultural expenditure

Sustainable development theory posits that as the state allocates resources to sustainable farming practices (organic farming and agroforestry), they can drive greater environmental development (WCED,.1987; Pretty.,2008). Additionally, innovation and diffusion theory states that public investment in agricultural research and development can accelerate the implementation of ecologically friendly technologies, improving production efficiency and sustainability (Rogers., 2003). Studies on the impacts of public agricultural expenditure in India have shown that amplified agricultural investment, especially when focused on sustainable practices, has a constructive effect on environmental development, as measured by soil health (Lal., 2015). Additionally, Gurr (2016) reported that government agriculture expenditures reduce land degradation and improve water quality in Brazil. Furthermore, a study by the FAO (2013) revealed that in Bangladesh, the public resources allocated to farmers help them adjust to dynamic climate settings, which can lessen the risk of ecological degradation. Furthermore, studies in Ethiopia and Kenya and South Africa by Pretty, (2018) and Niles (2019) revealed that government expenditures on agricultural extension and agricultural infrastructure improved environmental development, whereas research by Dey (2022) revealed that in some developing countries, public investment in agricultural development positively impacts the environment but negatively affects other states.

Environmental impacts of health and education expenditures

Environmental sustainability aims to increase human well-being through the safeguarding of natural wealth (e.g., land, air, water, and minerals). Africa has encountered historic ecological challenges, including land degradation, desertification, loss of biodiversity and dangerous vulnerability to weather and climate change (United Nation Environmental Program., 2024). Public expenditure on education can have several environmental impacts. The construction of educational facilities involves the consumption of natural resources and can lead to environmental degradation and greater $CO2$ emissions. In addition, schools need energy for light, laboratories (heating

and freezing), and electronic devices. When energy is produced from renewable sources, it can deteriorate the environmental quality (Gough & Scott, 2007). On the other hand, trained and equipped people are more likely to implement eco-friendly actions, such as recycling, saving energy, and supporting natural resource protection efforts (Sterling, 2004; Tilbury, 2011). A global study by Ozbay et al. (2022) on "the role of education on environmental quality and renewable energy" revealed that a lower educational level significantly intensifies CO2 emissions and vice versa. In addition, Wu et al. (2023) argued that environmental education can increase ecological importance via green consumption and by controlling smog. Moreover, research by Ahmed. et al.(2021) in Pakistan on the impact of educational expenditure on environmental development has shown that educational expenditure has no long-term effect on environmental development. Furthermore, a study by Yang and Fang (2024) in China on "The impact of education expenditure on environmental innovation" indicated that in addressing the sustainability challenges of the environment, educational expenditure plays a critical role in harmonizing the human and environmental relationship.

Some studies have been conducted in SSA on the environmental impacts of general public expenditure. Osuji and Nwani1(2020) conducted research in Nigeria to determine whether government expenditures affect the SDGs. Researchers have concluded that government expenditure hurts environmental development. Furthermore, Furthermore, Khurshid et al.(2023) explored the effect of education expenditure on environmental sustainability in Pakistan and reported that the effect was negative. According to Bird et al. (2016) Ethiopia's expenditure on climate change activities is comparable to nearly half of the countrywide expenditure on primary schooling and has achieved significant results.

The empirical gaps in studies on the impacts of public expenditure

Empirical studies have one thing in common: carbon dioxide intensifications due to increases in military expenditures. However, these studies focused only on carbon dioxide emissions and greenhouse gas (GHG) emissions, whereas sustainable environmental development is the result of a wide range of actions, such as ensuring Clean Water and Sanitation (SDG6), Climate Action (SDG13), Life Below Water (SDG14) and Life on Land (SDG15). To express

this in an imperative manner, earlier global, regional, and national empirical studies overlooked (ignored) multiple sustainable environmental development goals when examining the environmental impact of public military expenditure. Furthermore, the most important problem of earlier studies on the environmental impacts of government expenditures on agriculture was that they failed to take into account the compressive sustainable environmental development goals suggested by the United Nations. For example, to measure environmental development, Lal (2015) employed organic farming in India, Gurr. (2016) used only soil degradation in Brazil, Niles. (2019) in Kenya employed only ecofriendly agriculture.

3. Research Methodology

The purpose of this research was to examine the impact of military expenditures, agricultural expenditures, health expenditures, and education expenditures on SED in SSA. The environmentally sustainable development index was computed using (SDG 6, 13, and 15) because data were not available for SDG14 (life below water). The world bank research group members Sachs et al (2023) have computed general sustainable developments index score using linear average of 17 SDGs. In this study the similar technique of creating SED index followed using 3 sustainable environmental development goals(SDG 6, 13, and 15) out of 17 SDGs.

$$\text{SED index}_{i,t} = \frac{1}{N}\sum_{n=1}^{n} SDGi, t$$

Where: SED index $_{i,\ t}$ =sustainable environmental development index of country i, at time t, SDG_{ij} =Sustainable environmental development goal j of country i, at time t. SDGi= *(SDG 6, 13, and 15)*

Using an aggregate index for development is a good guide for policy decision making and implementation, as it portrays the components behind it (Stiglitz., 2009). The data for the dependent variable (sustainable environmental development) were collected from the World Bank database, which is computed by Sachs et al. (2023), and the public expenditure data were collected from the World Bank, the IMF and the Ministry of Finance and Central Bank of some countries. In practical analyses, sustainable environmental development is proxied by an aggregate of sustainable environmental development goals computed by Sachs et al. (2023) for 193 states since 2000 by considering seventeen United Nations' sustainable development goals. For example, in 2016, for the index score of SDG6 for

country i, 52.5% means that a country has realized (performed) 52.5% of SDG6 (Clean Water and Sanitation), which is measured by the indicators of SDG6. The rationale behind considering agriculture, health and education expenditures is pro-poor, but their misallocation has been criticized for misallocation, extravagance and inadequacy of these expenditures (IMF, 2019; United Nations, 2020; AfDB, 2022; Singh & Chudasama, 2020; World Bank, 2021), and the agricultural sector's impact overlooked budgeting practice (FAO, 2021), while their impact on sustainable environmental development is open for empirical debate. Furthermore, military expenditure in SSA has increased for a decade in the absence of clear empirical evidence of its impact on environmental development. Expenditures are measured as a percentage of GDP because they can yield information on multinational comparisons and generate prominent information for policy makers to make conversant decisions on taxing and spending (Pettinger, 2019).

The countries in Sub-Saharan Africa have unique socioeconomic and environmental settings in Africa, consisting of 48 countries, whereas according to a World Bank research group Sachs et al. (2023), SDG data are not maintained by five states (i.e., Eritrea, Equatorial Guinea, Guinea-Bissau, São Tomé and Príncipe, and Seychelles). Hence, these patients were excluded from the study. Moreover, owing to the absence of sufficient (required) public expenditure data on the mentioned dependable data source, 8 (eight) states were not considered in the study; consequently, the study considered 35 countries with sufficient sustainable environmental development indicators and public expenditure data from credible sources. With respect to the required number of observations for dynamic panel data analysis, where the dependent variable is a regressor in a model, Roodman (2006) suggested that in dynamic panel estimation, the cross-section(N) >20 and time series(T) is a continuous observation >4. In determining the required time series data for a dynamic panel data model, Greene (2007) insisted that when the lagged value of the dependent variables is an explanatory variable in a model, a minimum of three consecutive period observations is needed. Additionally, Roodman (2006) suggested that for generalized methods of moments (GMMs), the panel data analysis time period (T)<15, but there is no fixed limit. This is why the most recent 15 years (2008--2022) of observations were used. In line with

this condition, the study used 15 years of balanced and consecutive SDG and public expenditure data from 2008--2022.

Model Specification

In the initial stage of analysis, to gain a general understanding of the empirical relationship between public expenditures and sustainable environmental development, the baseline regression model was important, but the model assumes that the beta coefficients of all explanatory variables are similar for each cross section or country (Dunne et al., 2004). The pooled OLS model is presented below.

$$Y_{it} = \alpha + \beta' X_{it} + \varepsilon_{it}$$

In the equation above, *Xit* denotes the vector of predictor variables, while t signifies the time and i stands for the dimension of the country. There are also other intricate methods of analysis available for understanding the associations between the explanatory and the outcome variables. When the time period is long and endogeneity is not a problem in a model, using fixed and random effects models is the right choice for analysis. This study examined the impacts of public expenditure on sustainable environmental development and how the lagged level of sustainable environmental development impacts current performance. Moreover, analyzing the impacts of lagged values of the outcome variable in traditional fixed and random effects estimation models leads to incorrect and unpredictable estimates (Pesaran, & Smith, 1995). Hence, dynamic panel estimators are used when the lagged outcome variable is regressor in a model (Roodman.,2006). Additionally, Arelleno and Bond (1991) insisted that the generalized method of moments (GMM) is the right choice for panels with endogeneity problems, correlations of the error term with the explanatory variable, large cross-sections (N>25) and small time series (T<15). When the lagged value of the outcome variable included in a model as a regressor variable and fixed effect exist, the coefficients of the explanatory variables are vulnerable to Nickell bias (the correlation of the lagged value of the dependent variable with the fixed effect) and drive unreliable parameter estimates (Nickell,1981). In these situations, fixed effect estimates never suitably address such correlations (Roodman.,2006)). Additionally, Arellano and Bond (1991) argued that fixed effect analysis runs against the assumption of exogeneity required for consistent estimates. To mitigate the misleading effects of fixed effects in the

dynamic panel data model, the transformation (differencing) of the data is a critical measure (Blundell & Bond,1998). Hence, in this study, the second lagged values of SED are employed as instrument variables to substitute for the endogenous variable to overcome the endogeneity problem.

Sustainable development theory suggests that the variance (change) in the dependent variable (i.e., SED) at time *t* is subjected to change in response to the change in the observed value of public expenditure at time *t* and its own lagged values:

The dynamic panel model is presented below shows the typical system-GMM specification in levels and first difference respectively presented to examine how government spending affect the sustainable environmental development presented.

1) $$SED_{i,t} = \sigma_0 + \sigma_1 SED_{i,t-\tau} + \sigma_2 GMILEX_{it} + \sigma_3 GAGREX_{it} + \sigma_4 GHEEX_{it} + \sigma_5 GEDUEX_{it} + \eta_i + u_t + \epsilon_{it}$$

2) $$SED_{i,t} = \sigma_0 + \sigma_1\left(SED_{i,t-\tau} - SED_{i,t-2\tau}\right) + \sigma_2(GMILEX_{it} - GMILEX_{it-\tau}) + \sigma_3(GAGREX_{it} - GAGREX_{it-\tau}) + \sigma_4(GHEEX_{it} - GHEEX_{it-\tau}) + \sigma_5(GEDUEX_{it} - GEDUEX_{it-\tau}) + (u_t - u_{t-\tau}) + (\epsilon_{it} - \epsilon_{it-\tau})$$

Where:

The $SED_{i,t}$ denotes sustainable environmental development index of country i in period t, σ_0 is a constant, τ, is the degree of auto-regression that is one as such a lag correctly handle past statistics, GMILEX, GAGREX, GHEEX & GEDUEX stands for government military, agricultural, health, and education expenditure, σ_1, σ_2, σ_3, σ_4 & σ_5 represent the (coefficients) magnitude of the effects of lagged social development, GMILEX, GAGREX, GHEEX & GEDUEX at time t, on the SED of country i at time t, respectively. η_i is the country-specific effect, u_t is the time-specific fixed effect, and ϵ_{it} is the disturbance terms.

Table 1: Discriptive Statistics—Sustainable Economic Development (2008--2022)

	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Mean
Countries	SDG 6	SDG 6	SDG 6	SDG 13	SDG 13	SDG 13	SDG 15	SDG 15	SDG 15	Sustainable Environmental Development
Angola	48.59	54.29	52.09	90.40	96.35	93.62	66.18	67.06	66.78	70.83
Benin	47.74	49.41	48.69	97.78	98.35	98.05	65.39	66.87	66.51	71.08
Botswana	60.49	68.14	65.27	85.06	89.43	87.74	74.09	74.42	74.19	75.73
Burkina Faso	44.84	46.02	45.39	98.80	99.15	98.96	83.59	87.94	87.64	77.33
Burundi	52.98	55.23	54.32	99.73	99.78	99.75	72.21	72.94	72.73	75.60
Cabo Verde	58.33	67.39	63.48	97.07	97.77	97.45	70.88	71.64	71.41	77.45
Cameroon	53.41	55.97	54.88	98.06	98.37	98.20	63.54	64.82	64.38	72.48
CAR	40.42	44.70	41.96	99.43	99.70	99.53	89.72	89.93	89.87	77.12
Chad	40.62	42.40	41.58	98.11	99.09	98.77	75.16	78.54	77.48	72.61
Congo (The)	47.45	51.99	50.37	89.96	92.50	91.58	77.54	83.54	80.39	74.11
Cote d'Ivoire	53.35	55.25	54.42	97.73	98.53	97.95	69.57	74.44	73.26	75.21
DRC Congo	42.11	43.18	42.62	99.42	99.61	99.56	69.10	70.64	69.37	70.52
Eswatini	43.42	50.52	47.64	96.62	98.05	97.45	49.98	50.55	50.35	65.15
Ethiopia	53.41	55.97	54.88	98.06	98.37	98.20	63.54	64.82	64.38	72.48
Gabon	58.72	61.37	60.39	83.85	89.92	86.63	82.69	83.19	82.81	76.61
Ghana	50.84	57.68	54.69	96.57	97.61	96.96	67.97	72.89	71.44	74.36
Kenya	45.64	46.96	46.23	98.38	98.83	98.56	58.50	60.80	59.78	68.19
Lesotho	41.41	49.65	46.13	96.22	97.56	97.16	74.23	74.29	74.26	72.51
Liberia	50.13	53.00	51.80	98.28	99.05	98.73	47.63	50.44	49.58	66.70
Madagascar	***40.71***	***44.87***	***42.96***	***99.34***	***99.48***	***99.40***	***42.53***	***49.89***	***47.16***	***63.17***
Malawi	48.57	52.47	50.80	99.40	99.58	99.51	60.36	61.56	61.23	70.51
Mali	***50.91***	***61.71***	***57.01***	***98.97***	***99.24***	***99.07***	***85.06***	***86.76***	***85.33***	***80.47***
Mauritania	47.61	58.16	54.31	96.13	97.52	97.08	51.10	51.29	51.20	67.53
Mauritius	68.64	71.13	70.75	91.24	92.75	91.89	26.17	27.41	26.66	63.10
Mozambique	42.89	54.70	48.94	97.46	98.89	98.32	63.11	67.06	65.63	70.96
Namibia	53.63	56.01	55.03	82.79	91.19	88.07	81.62	89.86	88.20	77.10
Niger (The)	40.67	43.31	42.23	99.43	99.54	99.48	58.02	73.98	64.28	68.67
Nigeria	50.54	59.71	55.69	96.19	97.35	96.85	74.61	79.70	78.22	76.92
Rwanda	53.72	57.75	56.28	99.25	99.46	99.34	66.80	67.96	67.25	74.29
Senegal	57.18	64.81	61.52	97.57	98.35	97.90	66.30	67.40	66.98	75.47
South Africa	61.63	64.12	62.42	77.50	82.70	80.60	56.93	58.15	57.65	66.89
Togo	45.08	50.89	48.52	98.44	98.94	98.76	77.56	82.91	81.15	76.14
Uganda	41.72	47.39	44.59	99.32	99.43	99.37	62.00	67.84	65.79	69.92
Tanzania	41.39	51.66	47.45	98.87	99.21	99.07	58.53	60.77	59.85	68.79
Zambia	48.34	52.93	50.98	97.46	98.47	97.99	68.37	70.62	69.98	72.98
SSA	**48.59**	**54.29**	**52.09**	**90.40**	**96.35**	**93.62**	**66.18**	**67.06**	**66.78**	**70.83**

Source: (SDG Transformation Center-2024)

Data standardization

The SED performance has numerical values for diverse gauges, and a larger achievement in one goal may overwhelm the small value's results in the other(s). In most countries in SSA, a significantly large score is noted in SDG13 (climate action); if standardization is overlooked, the SED score would have been deceptive. Hence, standardizing the performance score is vitally important (Petkovová et al., 2020; Sharm & Bandyopadhyay, 2023). In this context, Petkovová et al. (2020) stated that there are numerous means to standardize data, but the min–max method is the most efficient and largely recognized method for CI buildings.

$$N(X)_{ij} = \left[\frac{x_{ij} - \min(x_{ij})}{\max(X_{ij}) - \min(X_{ij})}\right]$$

4.2 Discriptive Analysis, Government Expenditure

The results in Table 3 show that in SSA, the average largest public expenditure in the period between 2008 and 2022 was health expenditure, followed by education expenditure. Additionally, the table shows that there are significant differences among states in the allocation of public resources in military, agriculture, health and education in SSA.

Table 2: Max-Min Standardized Sustainable Environmental development

Mean	0.539139
Median	0.562119
Maximum	1.00000
Minimum	0.00000
Std. Dev.	0.338060
Skewness	-0.173562
Kurtosis	1.646349
Jarque-Bera	42.71894
Probability	0.000000
Sum	283.0479
Sum Sq. Dev.	59.88500
Observations	**525**

Source: SDG Transformation Center-2024

Table 3: Public Expenditure in Percentage of GDP (2008-2022)

		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Countries	Observations	GMILEX(%GDP)	GMILEX(%GDP)	GMILEX(%GDP)	GAGREX(%GDP)	GAGREX(%GDP)	GAGREX(%GDP)	GHEEX(%GDP)	GHEEX(%GDP)	GHEEX(%GDP)	GEDUEX(%GDP)	GEDUEX(%GDP)	GEDUEX(%GDP)
Angola	15	1.29	4.71	2.96	0.08	1.12	0.30	1.08	2.60	1.54	2.04	3.87	2.77
Benin	15	0.46	0.92	0.66	0.47	1.73	1.09	0.28	0.87	0.55	2.78	4.40	3.26
Botswana	15	2.15	3.41	2.86	0.74	2.05	1.33	3.41	5.02	4.11	6.38	10.10	8.37
Burkina Faso	15	1.15	3.09	1.62	0.46	1.16	0.80	1.06	2.83	1.86	3.50	5.63	4.59
Burundi	15	2.00	4.00	2.59	0.48	1.69	0.98	1.06	2.83	1.94	4.69	8.00	6.05
Cabo Verde	15	0.49	0.66	0.55	0.57	1.78	1.07	2.45	4.71	3.17	2.87	3.94	3.41
Cameroon	15	0.95	1.29	1.12	0.61	1.11	0.80	0.14	0.64	0.47	2.50	3.10	2.78
CAR	15	1.34	2.83	1.84	0.20	1.84	0.96	0.42	2.64	0.89	1.11	2.64	1.77
Chad	15	2.02	7.96	3.92	0.38	1.65	0.87	0.65	1.22	0.89	1.79	2.89	2.38
Congo (The)	15	1.66	4.94	2.52	0.17	0.86	0.40	0.62	1.90	1.10	2.40	5.69	3.70
Cote d'Ivoire	15	0.89	1.26	1.06	0.32	1.01	0.53	0.32	1.33	0.70	2.87	3.94	3.41
DRC	15	0.54	1.30	0.85	0.07	0.83	0.28	0.25	0.76	0.50	1.28	2.93	2.12
Eswatini	15	1.65	2.37	1.96	0.50	3.02	1.06	2.74	4.46	3.57	5.08	7.07	5.90
Ethiopia	15	0.49	1.52	0.84	0.59	3.22	1.33	0.38	1.12	0.86	3.74	5.57	4.79
Gabon	15	1.14	2.00	1.58	0.05	0.22	0.10	1.06	2.01	1.65	2.21	3.56	2.97
Ghana	15	0.28	0.59	0.37	0.12	0.35	0.20	1.30	2.90	1.97	2.91	8.14	4.72
Kenya	15	1.00	1.62	1.27	0.39	1.02	0.61	0.85	2.22	1.72	4.02	5.11	4.70
Lesotho	15	1.47	3.16	2.04	1.12	2.51	1.71	3.98	6.38	5.31	6.43	12.33	8.21
Liberia	15	0.50	1.27	0.97	0.21	0.90	0.46	0.34	1.69	1.20	1.70	2.66	2.14
Madagascar	15	0.50	0.96	0.62	0.37	1.00	0.60	0.68	2.37	1.48	1.78	3.25	2.66
Malawi	15	0.45	0.95	0.69	1.14	4.82	2.97	0.96	2.50	1.64	2.43	5.85	3.63
Mali	15	1.16	3.44	2.17	1.44	4.06	2.92	0.41	1.39	0.96	3.09	4.36	3.66
Mauritania	15	2.00	3.14	2.35	0.14	1.44	0.84	0.73	1.60	1.13	1.28	3.71	2.34
Mauritius	15	0.14	0.19	0.16	0.44	1.29	0.68	1.39	3.33	2.33	3.05	4.88	4.16
Mozambique	15	0.66	2.02	1.12	0.32	1.44	0.67	1.24	3.50	1.80	5.39	8.21	6.17
Namibia	15	3.00	4.53	3.51	0.62	1.86	1.00	3.46	5.00	4.13	6.40	10.31	8.92
Niger (The)	15	0.74	1.92	1.38	0.33	1.76	0.94	1.04	2.31	1.59	2.58	5.10	3.51
Nigeria	15	0.41	1.01	0.54	0.09	0.44	0.15	0.40	0.66	0.51	0.80	1.75	1.12
Rwanda	15	1.04	1.51	1.25	0.74	1.56	1.12	1.82	4.20	2.39	3.07	5.59	4.01
Senegal	15	1.11	1.74	1.39	1.18	2.79	1.96	1.01	1.72	1.22	4.03	5.72	5.18
South Africa	15	0.74	1.09	0.96	0.32	0.75	0.47	3.38	5.30	4.36	4.37	6.56	5.53
Togo	15	1.53	5.44	2.24	0.37	1.64	1.03	0.61	1.63	1.03	2.42	4.23	3.55
Uganda	15	0.89	2.68	1.64	0.45	0.89	0.59	0.57	1.11	0.88	1.73	2.64	2.18
Tanzania	15	0.70	1.09	0.98	0.12	0.91	0.40	0.83	2.26	1.35	3.12	4.64	3.94
Zambia	15	0.98	2.08	1.43	1.14	2.90	1.64	1.31	3.60	2.05	1.10	4.74	3.57
SSA	**525**	**1.07**	**2.36**	**1.54**	**0.48**	**1.65**	**0.94**	**1.21**	**2.59**	**1.80**	**3.06**	**5.23**	**4.06**

Sources: World Bank, IMF and MOF (2024)

Table 4: Endogeneity test

Covariance Analysis: Ordinary, Sample: 2009 2022: Included observations: 490 Balanced sample						
	Correlation (t-Statistic) Probability					
	Error(ϵ_{it})	**L._SED**	**GMILEX**	**GHEEX**	**GEDUEX**	**GAGREX**
Error(ϵ_{it})	1.000000					
L.SED	0.579213	1.000000				
	15.12292	-----				
	0.0000***	-----				
GMILEX	-0.046963	-0.061155	1.000000			
	-1.000644	-1.304053	-----			
	0.3175	0.1929	-----			
GHEEX	0.039698	0.142880	0.182169	1.000000		
	0.845591	3.072557	3.943226	-----		
	0.3982	0.0023	0.0001	-----		
GEDUEX	-0.003760	0.067726	0.315166	0.720269	1.000000	
	-0.080033	1.444775	7.068137	22.09917	-----	
	0.9362	0.1492	0.0000	0.0000	-----	
GAGREX	-0.012512	-0.033472	0.121876	0.101466	0.192400	1.000000
	-0.266319	-0.712820	2.613459	2.170786	4.172976	-----
	0.7901	0.4763	0.0093	0.0305	0.0000	-----

Sources: Authors' own computation

Table 5: Heteroscedasticity

Panel Cross-section Heteroskedasticity LR Test Null hypothesis: Residuals are homoscedastic			
	Value	df	Probability
Likelihood ratio	323.3613	35	0.0000
LR test summary:			
	Value	df	
Restricted LogL	131.7757	484	
Unrestricted LogL	293.4563	484	

Sources: Authors' own computation

Table 6: Stationarity test

Newey–West automatic bandwidth selection and Bartlett kernel: Total (balanced) observations: 455 Cross-sections included: 35: Method: Levin, Lin & Chu t*		
Variables	Statistic	Prob.**
SED	-2.59888	0.0047
GMILEX.	-5.463191	0.0000
GAGREX	-5.472894	0.0000
GHEEX.	-2.691530	0.0036
GEDUEX.	-5.721083	0.0000

Source: Authors' computation

Table 7: Test for Cross-Sectional Dependence

Residual Cross-Section Dependence Test Periods included: 15, Cross-sections included: 35: Total panel observations: 525			
Test	Statistic	d.f.	Prob.
Breusch–Pagan LM	2288.891	595	0.0000
Pesaran scaled LM	49.10343		0.0000
Bias-corrected scaled LM	47.75728		0.0000
Pesaran CD	0.502976		0.6150

Source: (Authors' computation by-EViews 10)

Table 8: Multicollinearity test

Model		Collinearity Statistics	
		Tolerance	VIF
1	SED_1	.968	1.033
	MIL	.445	2.248
	AGR	.475	2.105
	HEALTH	.939	1.065
	EDU	.916	1.091
a. Dependent Variable: SED			

Source: (Authors' computation

Model selection

$\text{SEDD}_{it} = \Phi * \text{SED}_{it-1} + \beta X'_{it} + u_{it} + \epsilon_{1it}$ where i= 1, 2….. N (35), T= 1, 2, T (15) in deciding whether to use difference or system GMM, Bond (2001) suggested that the pooled OLS value of lagged SED(Φ) must be considered as the upper bound estimate and that the fixed effect figure of Φ should be considered as the lower bound estimate. If the value of Φ in difference GMM is close to or less than the value obtained by fixed effect estimate, difference GMM yields downward biased and inefficient estimates. The coefficient of the lagged value of the dependent variable in Table 9 (Φ=0.601781 obtained from the difference GMM< Φ=0.744737 obtained from the fixed effect estimate) suggests that the system GMM is the preferred estimate over the difference GMM.

Table 9: Model comparison: OLS, fixed and difference GMM estimates

Regressor Variables	OLS-Estimate Coefficient (Std. Error) Prob.	Fixed Effect-Estimate Coefficient (Std. Error) Prob.	Difference GMM-Estimate Coefficient (Std. Error) Prob.
L1. SSD (ϕ)	0.783716 (0.030296) 0.0000***	0.744737 (0.037514) 0.0000***	0.601781 (0.015956) 0.0000***
GMILEX.	-0.000644 (0.005849) 0.9124	0.008155 (0.017400) 0.6395	0.087931 (0.004382) 0.0000***
GAGREX.	0.008698 (0.006884) 0.2070	-0.002988 (0.021667) 0.8904	0.013725 (0.004535) 0.0000***
GHEEX.	0.011246 (0.006075) 0.0648*	0.045909 (0.022583) 0.0427**	0.128610 (0.005208) 0.0000***
GEDUEX.	0.000685 (0.005541) 0.9017	-0.020110 (0.009759) 0.0399**	0.013725 (0.004535) 0.0026***
R-squared	0.672524	0.689600	******
Adjusted R-squared	0.669141	0.662699	******
F-statistic	198.7941	25.63441	******
Prob(F-statistic)	0.0000***	0.0000***	******
		Hausman Test Chi-Sq. Statistic (Chi-Sq. d.f) Prob.	12.115646 (5). 0.0332****

Sources: Authors' own computation (EViews 10)

Arellano–bond serial correlation test result in Table 10 shows that endogeneity problem removed in Model-4 where the fifth lag of outcome variable used as explanatory. Moreover, the sign and significancy of the coefficients of all explanatory variables in five-alterative models are the same signifies that the stability of results under varied instrument variables.

Table 10: Model stability test and Valid Instrument Identification (Arellano-Bond Dynamic Panel Estimations (Two-Step System GMM))

	Model-1	Model-2	Model-3	Model-4	Model-5
L1. SED.	0.626242	0.531070	0.458769	0.399333	0.471621
	(0.022692)	(0.011881)	(0.021550)	(0.004824)	(0.011102)
	0.0000***	0.0000***	0.0000***	0.0000***	0.0000***
GMILEX.	0.088986	0.127762	0.154897	0.229190	0.165768
	(0.013205)	(0.008014)	(0.007821)	(0.005685)	(0.008094)
	0.0000***	0.0000***	0.0000***	0.0000***	0.0000***
GAGREX.	0.033544	0.137606	0.158384	0.210494	0.196371
	(0.012490)	(0.003694)	(0.002537)	(0.004482)	(0.025885)
	0.0075***	0.0000***	0.0000***	0.0000***	0.0000***
GHEEX.	0.104460	0.142293	0.193826	0.208285	0.133893
	(0.059992)	(0.013573)	(0.011838)	(0.010780)	(0.018716)
	0.0823	0.0000***	0.0000***	0.0000***	0.0000***
GEDUEX.	0.009009	0.011269	-0.026216	0.001026	0.141417
	(0.019435)	(0.007271)	(0.005741)	(0.005303)	(0.009817)
	0.6432	0.1219	0.0000***	0.8468	0.0000***
Sample (adjusted):	13	13	13	13	13
Cross sections	35	35	35	35	35
Observations	455	455	455	455	455
Instrument Overidentification- Hansen J Test					
Model	Model-1	Model-2	Model-3	Model-4	Model-5
Instrument variable	L2_SED	L3_SED	L4_SED	L5_SED	L6_SED
Mean dependent var	-0.133171	-0.133171	-0.133171	-0.133171	-0.133171
S.E. of regression	0.202744	0.229999	0.246223	0.285904	0.286523
J-statistic	28.69944	34.43131	30.91463	33.46597	32.47295
Prob(J-statistic)	0.533424	0.263919	0.419613	0.302682	0.345864
Instrument Relevance- F Test					
Coefficient	0.785715	0.619834	0.415687	0.274769	0.121265
R-squared	0.655878	0.409791	0.183804	0.079739	0.013730
Adjusted R-squared	0.655118	0.408379	0.181673	0.077095	0.010578
F-statistic	863.3925	290.2232	86.25000	30.15369	4.357158
Prob(F-statistic)	0.000000***	0.000000***	0.000000***	0.000000***	0.037662**
Arellano–Bond Serial Correlation Test					
AR (1) - m-Statistic	-3.697039		-2.475873	-3.595137	-9.641252
(SE (rho))	(3.245242)	NA	(4.006162)	(2.566370)	(1.078139)
Prob.	0.0002		0.0133	0.0003	0.0000
AR (2) - m-Statistic	2.285936	0.000870	2.016884	1.571282	1.058409
(SE (rho))	(1.341813)	(3216.685)	(1.130005)	(1.298140)	(1.914150)
Prob.	0.0223	0.9993	0.0437	0.1161	0.2899

Source: (Authors' computation by-EViews 10)

Note: Dependent variable=SED, * & **, denote statistically significant variables at the 1% and 5% levels of significance, respectively.**

Table 11 supports the robustness(stability) of models tested in above table 10. The Robust Least Squares estimation reveals that the coefficients and sig of all

explanatory variable remain the same as the valid models in difference and Two-step system GMM.

Table11: Robust Least Squares estimation

Dependent Variable: SED
Method: Robust Least Squares: Sample (adjusted): 2009 2022
Included observations: 490 after adjustments: Huber Type I Standard Errors & Covariance

Variable	Coefficient	Std. Error	z-Statistic	Prob.
L1. SED	0.964869	8.11E-05	11898.37	0.0000
GMILEX.	0.004773	3.06E-05	155.9886	0.0000
GAGREX.	0.017255	4.16E-05	414.4205	0.0000
GHEEX.	0.000259	3.60E-05	7.204554	0.0000
GEDUEX.	0.000018	0.000032	0.553846	0.0534
	Robust Statistics			
R-squared	0.732887	Adjusted R-squared		0.730684
Rw-squared	0.928881	Adjust Rw-squared		0.928881
Akaike info criterion	866.5818	Schwarz criterion		897.5682
Deviance	5.139003	Scale		0.077007
Rn-squared statistic	4.33E+08	Prob(Rn-squared stat.)		0.000000

Source: (Authors' computation by-EViews 10)

Table 12: Optimal Model - Arellano-Bond Dynamic Panel Estimations

	(Difference GMM)	(Two-Step System GMM)
	SED (Outcome Variable)	SED (Outcome Variable)
L1. SED	0.395228	0.399333
	(0.010622)	(0.004824)
	0.0000***	0.0000***
GMILEX.	0.228025	0.229190
	(0.006752)	(0.005685)
	0.0000***	0.0000***
GAGREX.	0.213451	0.210494
	(0.005523)	(0.004482)
	0.0000***	0.0000***
GHEEX.	0.205980	0.208285
	(0.015249)	(0.010780)
	0.0000***	0.0000***
GEDUEX.	0.005536	0.001026
	(0.005279)	(.005303)
	0.2948	0.8468
Sample (adjusted): 2010 2022(Min.obs.)	13	13
Cross section (Number of countries) included	35	35
Observations	455	455

Source: Authors' computation: Note: * & **, denote statistically significant variables at the 1% and 5% levels, respectively.**

5. Results and Discussion

Table 11 presents the results from the different GMM and two-step system GMM methods. We focused on the coefficients obtained from two-step system GMM, as it is more efficient than the difference GMM is, as stated in the model comparison results of Table 9, although the sign and significance of the coefficients of the explanatory variables are the same under both difference GMM and two-step system GMM. Econometricians state that the regression results from optimal GMM estimators are invariant to the transformation method (i.e., orthogonal transformation in system GMM differencing in difference GMM) (Blundell, & Bond, 1998; 2000). In this study, the coefficients of all explanatory variables are consistent in both the difference GMM and two-step system GMM). The results indicate that the coefficient of military expenditure is positive, indicating that military expenditure positively and significantly affects sustainable environmental development in SSA. In sub-Saharan Africa government expenditure in % of GDP on average accounts 1.54% is larger than spending in agriculture which critical need in SSA. The results revealed that a 1% increase in military expenditure led to a [0.229190 units] increase in the minmax standardized value of the SED outcome in the study area. This positive impact of military expenditure might have varied across a country in the study area due to differences in governance, infrastructure, and policy implementation among a country.

Sustainable development theory claims that when government military expenditure is not aligned with SDGs goals, it damages SED. The theory argues that the plants that are used to produce guns, ship them, and extraction of minerals for their manufacture all cause massive harm to energy and natural resources and are key suppliers of pollution and environmental worsening (WCED., 1987). Fortunately, in Africa, there are no massive weapon factories that can trigger environmental pollution or natural resource destruction. In Africa, there are no massive weapon factories that can trigger environmental pollution or natural resource destruction. In addition, the military sector in many countries in Sub-Saharan Africa links military activities with ecological development. For instances, growing investment in South Africa in solar energy and electric vehicles for military operations to reduce its CO_2 emissions (Defense Web.,2017), extensive investments by

Uganda in ecofriendly military training infrastructures since 2017 (Uganda Vision 2040., 2018), defense force deployment in Kenya and Tanzania to defend national parks and woodlands from illegitimate hunting and gathering activities, strong participation and rapid response of the military to natural disasters such as heavy erosion, and wildfires in Ethiopia (UNEP & UNHCR. 2017).

The result confirm that sustainable development theory does not hold true in SSA, where as the result is consitent with ecological modernization theory (Mol & Spaargaren, 2000), stating that government expenditures in the military can support environmental development and improve SED is valid. This finding contradicts the findings of (Isiksal, 2021; Tarczyński et al., 2023), who stated that government expenditures in the military increase Co_2 emissions, thereby negatively affecting environmental development. Additionally, Habibullah et al. (2023) noted that an increase in defense spending deepens the depletion of biodiversity, and in Next eleven (N-11) countries, militarization worsened environmental degradation (Zhu et al., 2023). This is most likely due to those studies conducted in developed states where weapon manufacturering are considered equal to or more important than other factories and studies that consider a single goal or target of SED by overlooking goals such as living on land, engaging in climate action, and cleaning water and sanitating. Nevertheless, the findings are consistent with those of a previous study in which government expenditures on the military have a crowding-in effect on green capital (Das & Hussain., 2023); the study by Saba. (2023) determied that military expenditure reduces CO_2 emmisions in long-run. Additionally, Solarin et al. (2018) argued that technological investment in the military reduces the threat of environmental development. In addition researcher noted that investment in military research and development can lead to improvements in environmental technologies and advance environmental development (Radelet & Sachs,1998), and Smith (2016) argued that when investment strategies incorporate environmental development, valuable ecological outcomes can result.

In addition, Sustainable development theory argues that increased public expenditure on agriculture promotes sustainable farming practices, a farming activity aimed at meeting the nutrition needs of the current generation deprived of compromising the capacity of coming generations to satisfy their

own needs unlike conventional farming system which less efficient in land management, low access of modern agricultural technologies and results soil depletion. sustainable farming practices links environmental conservation, economic efficiency, and social justice. In sustainable farming practices, water conservation, use of carbon-based inputs(low carbon emitting), and soil management practices and enhanced farmers' awareness of overall natural resource management, brings environmental development (WCED., 1987; FAO, 2016; OECD, 2020). The coefficients from both difference and system GMM revealed that the effect of agricultural expenditure on SED is positive and significant at the 1% level. A 1% increase in agricultural expenditure leads to a [0.210494units] increase in the standardized value of SED in SSA. Thus, the study failed to reject sustainable development theory. However, the magnitude of effects of agricultural expenditure on sustainable might be different from state to state due to differences in agricultural policies and infrastructures.

Moreover, the study results are inconsistent with the findings of earlier studies. For example, Kelsey and Rudd (2021) noted in their study that government expenditures on the production of certain crops, corn, rice and wheat, can lead to biodiversity forfeiture and degradation of the environment. Zhao et al. (2022) also reported that the intensification of public spending on water-intensive crops has increased water contamination and reduced resource use. Public investment in traditional farming practices contributes to environmental quality deterioration (Ghosh & Ranjan, 2023), whereas the findings are consistent with the findings of Gurr et al. (2016) in Brazil, who concluded that public agricultural spending reduces land degradation and increases water quality. Moreover, research by the FAO (2013) revealed that in Bangladesh, public funds help farmers adjust to variable climate conditions, which can lessen the risk of ecological degradation.

Additionally, the results in Table 12 show that health expenditure has a positive and significant effect on SED at the 1% level of significance. This is true for both the difference and system GMM. The coefficient from the system GMM shows that a 1% increase in health expenditure leads to a [0.208285 units] increase in the minmax standardized value of the SED outcome in SSA. Hence, the study confirmed that sustainable development theory upholds in points of view of this expenditure. The theory posits that

the government should invest in housing, health, and food security to improve natural resource quality. These findings are in line with those of previous studies. They reported that government expenditure on health is important determinant of achieving sustainable development goals (Meiling et al. 2022) that healthier people are usually more capable of contributing to environmental initiatives, leading to improved environmental resilience (WHO, 2020), and environmentally unified government expenditures on health increase ecological development (Khan & Kumar, 2021). On the other hand, Ganada (2021) reported that domestic general public health spending intensifies carbon emissions in BRICS countries. However, this study used a modified ordinary least square model, whose static model cannot consider the effects of lagged development and endogeneity problems because lagged dependent variables are included as regressor variables.

Finally, the study tests whether government education expenditures affect SED in SSA. In difference and system GMM, education spending has a positive but insignificant effect on SED in SSA, though Public expenditure in education in SSA on average accounts more than 4 percent of GDP which is determined to have the largest of all expenditures considered in this study. This indicates that spending in education in the study area failed to significantly considered environmental education viz., effect of human actions, and the role of caring and sustaining the natural capitals and fostering the consciousness and understanding of ecological matters. Nevertheless, sustainable development theory, which argues that government investment in education improves the awareness and skills of people, enables them to participate in sustainable environmental development activities such that the benefits of environmental development fail to be rejected based on the positive coefficient of the study result. Earlier researchers have argued that trained and equipped people are more likely to implement eco-friendly actions, such as recycling, saving energy, and supporting natural resource protection efforts (Orr, 2004; Sterling, 2004; Tilbury, 2011). A lower educational level significantly intensifies CO2 emissions and vice versa (Ozbay et al, 2022), and environmental education can advance ecological importance via green consumption and reduce pollution (Wu et al. 2023). Spending on education can produce long-term benefits for ecological sustainability (Bowers, 2020). Nevertheless, Gough and Scott (2007), in their

study, argued that schools need energy for light, laboratories (heating and freezing), and electronic devices. Although renewable energy sources can deteriorate environmental quality, the most important problem in these studies was their failure to consider a broad range of sustainable environmental development proxies. To sum up, public spending in military, agriculture, health, and education in SSA can improve sustainable environmental development when the expenditures are directed towards improving the targets of SDG6 such as drinking water, and sanitation services, waste water treatment, water management services, reducing carbo-dioxide emissions (using renewable energy source), and effective carbon pricing, caring terrestrial and freshwater sites, and reforestation

5. Conclusion and Policy Recommendations

In this research, dynamic panel estimates for Sub-Saharan African countries for the time period of 2008--2022 revealed that government military expenditure has a positive and significant effect on SED, suggesting a possible intersection between state security and environmental development sustainability. To improve environmentally sustainable development in sub-Saharan African countries, policy makers have suggested intensifying military expenditures (expenditures in defense technologies) those improves environmental development sustainability, such as the use of green technologies those conserve natural resources and helpful to manage them. Moreover, investment on solar energy and electric vehicles for military operations, increasing training and participation of military force in environmental protections. The empirical results of this study show that high agricultural expenditure may contribute to ecological quality improvement through sustainable (eco-friendly farming) or organic farming practices, which can lead to high quality of life on land, good climate conditions and clean water and sanitation. Public investment in agriculture needs to target sustainable farming practices, promoting organic agricultural practices that lessen waste, pollution, and the use of energy-intensive technologies and invest in training programs for farmers to encourage eco-friendly systems. Public expenditures on health increase public health, which can lead to more fruitful inhabitants and a reduced burden on natural resources through enhanced public health practices. Governments in SSA have to increase their investment in healthcare, which consists of environmental health, considering

issues such as environmental pollution and the impacts of climate shock on the health of people. Additionally, programs that increase public awareness of the relationship between health and ecological quality should be incentivized. Moreover, in this study government expenditures are measured by percentage of GDP. To increase these expenditures the regimes in the region are required to increase the share of tax revenues to GDP.

6. Research implications

This study was carried out to examine the impact of public expenditures on sustainable environmental development to fill the existing knowledge vacuum for policy makers and practitioners in scarce public resource allocation. Military expenditures, agricultural expenditures, and health expenditures significantly contribute to SED. This confirms that sustainable development theory is valid for government agricultural and health expenditures, but the theory is refuted in the case of public military spending. However, ecological modernization is valid for public military spending. Policymakers should redirect spending education to those significantly contributing to SED. In addition, policy makers must not look militarized as a curse for SEDs; rather, they must pay attention to the types and contributions of the military equipment to be acquired.

7. Limitations and Suggestions for Future Research.

In this study we have used three out of four sustainable environmental development goals. Specifically, sustainable environmental development index computed might have been inflated due to SDG14 is not considered because of lack of data. Moreover, this study examined only short-run effect of government expenditure on SED in SSA. Therefore, we suggest that future research should be carried at global level, consider SDG14, and employ long-run effect estimation techniques.

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c. the titles(s), academic position(s), address (institutions of their affiliation, postal address, telephone, e-mail etc., for correspondence) of the author(s) footnoted at the bottom of the page with the use of asterisks;

d. other relevant information such as name and address of a corresponding author, if the paper was presented at a meeting or is part of a series study, should be noted at the end of the manuscript.

1.2. Information on authorship and degree of authors' contribution. It is the responsibility of the authors to list their names according to the degree of contribution made by each of them, in a decreasing order of contribution. Normally, the following rules apply:

- ☞ Equal contribution is presumed when the names are written in alphabetical order; or
- ☞ The degree of contribution shall be determined by the order in which the names appear, unless indications are given by the authors to the contrary.

1.3. All correspondences will be made with the author whose name appears first (unless otherwise specified).

2. Abstract

The manuscript should have an abstract:

- not exceeding 250 words;
- that briefly introduces the problem, research gaps and the study area;

- that outlines the methodology, mainly the study design, approaches, sampling strategies, materials used and methods of data collection and analysis;
- containing the key findings of the study, their implications and conclusions or key recommendations.

3. Introduction

In this section, the author(s) should:

- give background to the study problem and the rationales;
- present statements of the problem, setting the contexts, the nature and extent of the problem studied;
- indicate the study area and objectives of the research;
- introduce the research questions or hypotheses;
- present adequate review of the literature (both conceptual —including theoretical and conceptual frameworks— and empirical) related to the research;
- do all these in no more than five pages.

4. Materials and Methods

In here, authors are required to present clear account of:

4.1. the philosophical underpinnings, study design, approaches, sampling strategies, and methods of data collection and analysis. In so doing,

- ☞ standard methods need only be mentioned, or may be described by reference to the literature as long as it is readily available.
- ☞ modifications of standard techniques should be described.
- ☞ if the method is new, it should be described in detail.

4.2. design of the experiment, including the number of replications (if the article results from experimental or quasi-experimental research);

4.3. materials used, including:

- ☞ chemicals, laboratory equipment with the necessary technical specifications; standard units of measurement;
- ☞ any plants or animals involved, with exact descriptions of genus, species, strain, cultivar, line, etc.);

4.4. justifications as to why the materials and methods used were chosen over others.

5. Results and Discussion

Depending on the craft and choice of authors, as well as on what the subject matter warrants, results and discussion can be either intertwined together or presented under separate sections. In any case,

- present only results that add new insights to existing knowledge;
- only results based on data and information scientifically-drawn from sources, but free from authors' personal dispositions and biases.
- results should be simply and clearly stated;
- reduce large masses of data to means, along with the standard error or standard deviation;
- include only tables, figures and graphs that are necessary, clear and worthy reproducing;
- repeat in the text only the most important findings shown in tables and graphs;
- refer in the text each table and figure by its number;
- include negative data—what was not found— if they affect the interpretation of results;
- give only data that relate to the subject of the paper (in other terms, include concomitant/related findings only if they are important);
- provide adequate answers to all the research questions or pursue all the hypotheses/assumptions made at start of the study.

6. Interpretation of the Results

This section, which should preferably be embedded with the 'Discussion' section, should:

- not repeat what has already been said in the review of literature;
- show significance of the results;
- relate the results to the initially-stated objectives and research questions or hypotheses that were set out in the introduction;
- show how the results and their interpretations relate to (agree or disagree with) previous findings and their interpretations.

7. Conclusion and Implications/or Recommendation

This is the section where,

- the author(s) draw, based on the findings and discussions of their implications, logical conclusions about each research question or hypothesis;
- nothing (methods, observations or results) should come as a surprise (should not be mentioned for the first time);
- authors should avoid unnecessary detail or repetition from preceding sections;
- show implications for theory, policy, practice, and/or further research to follow up the results.

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8.1. All materials, referred to or quoted must be acknowledged properly. Plagiarism is a serious academic dishonesty, which is unethical and illegal.

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8.3. Citation and referencing should be complete according to this Style Guide, which is adapted with modifications from the Chicago Manual of Style 16th Edition.

The author-date citation in a running text or at the end of a block quotation consists of the author's/editor's last name, and the year of publication. Examples:

- Author, year, page no.: (Johnson 1987: 22–25).
- Two sources, with one author having two works: (Sen 1999; Jenden 1978a&b).
- More than three authors/editors: (Kassoguè *et al.* 1996).
- Organisation, year, volume, page no.: (World Bank 1988, 2:47).

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- ☞ Long quotations should appear indented and centered in the text without quotation marks.

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* Brown (1975: 63) has argued that the ...

OR

* One economist (Brown 1975: 63) has argued that...

Use "*et al.*" when citing work by more than two authors. Example: A new treaty (Goody *et al.* 1976) suggests...

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Numbered notes should be used to denote clarifications about the references used, to include points left out in the text, to add some items which readers may want to know. If the citations or references in the text are too long, or consist of more than three names, it may be advisable to put them in the ***Notes*** at the end.

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Alemayegu Lirenso. 1988. Food Aid and Agricultural Production in Ethiopia. *Ethiopian Journal of Development Research,* 10 (1): 59–90. (The last parts of the Journal can also be given as *Ethiopian Journal of Development Research,* Vol. 10, No 1, pp. 59–90.)

Cowley, R. 1967. The Standardization of Amharic Spelling. *Journal of Ethiopian Studies,* V. 2: 1–8.

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Clapham, C. 1988. *Transformation and Continuity in Revolutionary Ethiopia*. Cambridge: Cambridge University Press.

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Wood, A.P. 1982. Spontaneous Agricultural Resettlement in Ethiopia, 1950–1974. ***In***: J. Clarks and L. Konsinski (Eds.), *Redistribution of Population in Africa,* pp. 1150–82. London: Heinemann.

☞ ***Contributions in proceedings***

Taddesse Tamirat. 1984. Feudalism in Heaven and on Earth: Ideology and Political Structure in Mediaeval Ethiopia. ***In:*** *Proceedings of the Seventh International Conference of Ethiopian Studies, University of Lund 26-29 April 1982,* pp. 195–200, Edited by S. Rubenson. Addis Ababa: Institute of Ethiopian Studies.

☞ ***Conference papers***

Hyden, H. 1990. 'Ideology and the Social Sciences: The African Experience'. Paper presented at the OSSREA Social Science Conference, 8–10 May, Kampala, Uganda.

☞ ***Unpublished works***

Messing, S. 1957. 'The Highland-Plateau Amhara of Ethiopia'. Ph.D. dissertation, University of Pennsylvania.

Alula Abate, *et al.* [these should be listed]. 1986. Evaluation of the Impact of UNICEF-Assisted Water Supply Projects in Bale, Harerge, Shewa and Wello- Ethiopia. Programme Cycle 1980–1983. *Research Report No. 30,* Institute of Development Research, Addis Ababa University, Addis Ababa.

☞ ***Official publications***

Central Statistical Office. 1975. *Results of the National Sample Survey Second Round, Vol. V. Land Area and Utilization*. Addis Ababa: CSA.

World Bank. 1973. 'Agricultural Sector Survey, Vol. I, The General Report. Report no. PA-143a.' Washington: World Bank.

_____. 1989. *Sub-Saharan Africa: From Crisis to Sustainable Growth*. Washington: World Bank.

☞ ***Online sources***

Further to the details in the above categories, include the date of access and the URL of the site whereat the material was accessed.

9. Format

A4 paper size with 2.5cm margins shall be the standard page size.

9.1. Title

Titles should be set in title case, NOT in all caps and should not contain acronyms and abbreviations.

9.2. Endnotes

Authors are advised to use endnotes instead of footnotes.

Endnotes should be numbered consecutively throughout each chapter or article, and placed at the end of a work, in a section titled "Notes", after any appendix and before the reference list.

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These should be placed at the end of the text next to the appendix but before the endnotes.

9.4. Headings

Major chapter headings must be in Title Case and centered on the page. Sub-headings must also be in Title Case but aligned with the left margins. A manuscript with subsections should be presented as follows:

10.	1.	2.	3.
1.1	2.1	3.1	
1.2	2.2	3.2	

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Text should be set in Times New Roman, 12pt font size, double-spaced. Block quotes should be indented from both sides and set in 11pt font.

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- Tables should be used only where the data requires at least 2 rows/columns by 3 rows/columns. Shorter details shall be presented in text form.
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Avoid use of dots in all familiar abbreviations, such as CSA, EEC, FAO, UNESCO, USA. However, dots should be placed at the end of the followings: e.g., etc., *et al.*, and other similar entries.

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- English is the medium of the Journal. Use one form of spelling, preferably the UK English (English English), throughout the article. Do not mix or switch between the two forms.
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