The Economic Burden of Climate-Induced Health Risks on Labour Productivity and Public Health Expenditure in Sub-Saharan Africa

Adediran Samuel[1], Adebayo Kehinde[2], Victor Idowu Arowolo[3], Akanji Hanifat Motunrayo[4]

[1] *Centre for Climate Change, Bells University of Technology, Ota, Nigeria*

[2] *Development Agenda for Western Nigeria (DAWN) Commision, Ibadan.*

[3] *Asset Resource Management (ARM) Holding Company, Lagos State.*

[4] *Department of Meteorology and Climate Science, FUTA.*

***Abstract*—Climate change poses an existential threat to economic development in Sub-Saharan Africa (SSA), primarily through its adverse effects on human health and labour productivity. This study examines the economic burden of climate-induced health risks — including heat stress, malaria, cholera, and malnutrition — on labour productivity and public health expenditure across 25 SSA countries over 2000–2023. Employing panel Fixed Effects (FE), Random Effects (RE), and System Generalised Method of Moments (System-GMM), the study finds that a 1°C rise in average annual temperature is associated with a 1.7% decline in agricultural labour productivity and a 2.3 percentage point increase in government health expenditure as a share of GDP. Climate-sensitive diseases account for approximately 38% of total productivity losses in the region. The study recommends that SSA governments adopt climate-responsive health financing frameworks, strengthen early warning health systems, and integrate climate adaptation into national health and economic planning as a matter of urgent fiscal necessity.**

***Index Terms*—Climate change, labour productivity, health expenditure, Sub-Saharan Africa, panel data, heat stress JEL Classification: Q54, I15, J24, O55**

I. INTRODUCTION

Climate change is a prominent challenge of the 21st century, with impacts that go beyond environmental degradation, to significant economic and health consequences. Though it is a global challenge, Sub-Saharan Africa (SSA) is particularly exposed to climate change and bears the brunt of the consequences, while being responsible for less than 4% of global greenhouse gas emissions (World Bank, 2023). Its heavy reliance on climate-sensitive industries, especially rain-fed farming which accounts for more than 60% of employment, coupled with poor health infrastructure and low adaptability, leaves it particularly vulnerable to the economic impacts of climate change-driven health impacts.

Climate change affects human health in many ways. Increasing temperatures accelerate the spread of vector-borne diseases (such as malaria), expand the geographical area suitable for cholera, and result in dangerous physiological stress for outdoor workers. The economic consequences are significant: sick workers are less efficient, health-care systems incur a greater financial burden, and governments must divert resources away from investments that drive economic growth in order to respond to health crises (Carleton et al., 2022; Kjellstrom et al., 2018). According to the World Health Organization (WHO, 2022), climate change will result in about 250,000 extra deaths annually between 2030 and 2050, disproportionately affecting SSA.

While there is an increasing awareness of these issues, few rigorous empirical studies have quantified the economic impact of climate change-induced health risks on productivity and public health costs in SSA. The majority of these studies have considered health and productivity impacts separately, or have used cross-sectional data, which do not account for dynamic effects. This paper fills these gaps by analysing panel data for 25 countries in SSA over 2000-2023. The rest of the paper is organised as follows: Section 2 reviews relevant literature; Section

3 outlines the theoretical framework; Section 4 presents data and methodology; Section 5 discusses results; Section 6 provides policy implications; and Section 7 concludes.

II. LITERATURE REVIEW

2.1 Climate Change and Health in Africa

A substantial body of literature reports the health impacts of climate change in SSA. Burke et al. (2015) established through global panel regression that rising temperatures have large negative impacts on economic productivity, particularly in low-income, tropical regions already experiencing high temperatures - the SSA archetype. The Lancet Countdown on Health and Climate Change (Watts et al. 2021) reveals that labour capacity of outdoor workers fell by more than 5% in SSA from 2000-2020, undoing decades of progress in public health. Caminade et al. (2014) find malaria transmission windows will likely increase in highland Africa under medium and high emissions scenarios, and will place additional burdens on already under-resourced health systems.

2.2 Health, Labour Productivity and the Economy

Health and productivity are intimately related. Bloom and Canning (2000) showed that productivity increases with health improvements at the individual and aggregate level. On the other hand, Kjellstrom et al. (2018) put the global cost of heat-related labour productivity loss at $2.4 trillion a year by 2030, with tropical developing countries being disproportionately affected. Adhvaryu et al. (2020) also demonstrate that exposure to higher temperatures impairs the productivity of workers across all industries in developing countries, while Park et al. (2021) demonstrate that temperature above a threshold level impairs both cognitive and physical performance - relevant for the agriculture-dominated workforce of SSA. Auffhammer et al. (2020) also demonstrate that temperature shocks adversely affect agricultural productivity and labour output in Africa.

2.3 Health Care Expenditure and Climate Fiscal Stress

Public health impacts of climate change have major fiscal implications for SSA governments. Barreca et al. (2016) show that extreme heat events lead to significant increases in hospitalisations and emergency health expenditure. Gasparrini et al. (2017) estimate that more than 5 million people die each year as a result of exposure to non-optimum temperatures. In SSA where health budgets are already tight - with an average of 2-4% of GDP - these extra pressures limit the ability to fund developmental projects (Niang et al, 2014). Prüss-Ustün et al. (2016) reports that globally, 23% of the disease burden can be attributed to environmental factors, with much higher figures in tropical low-income countries.

III. THEORETICAL FRAMEWORK

The study builds on three theories. First, the Climate-Health-Economy Nexus (Patz et al., 2014) framework argues that climate factors (temperature and precipitation) impact human health, which subsequently affects the economy via labour supply, productivity and health-care spending. Second, Human Capital Theory (Becker, 1964; Schultz, 1961) offers the microeconomic basis: health forms part of human capital and climate-related health effects represent a loss of human capital, diminishing productive capacity at the individual and collective levels.

Third, the Fiscal Burden Framework uses public finance theory to model how climate-induced external shocks - such as disease outbreaks - lead to countercyclical increases in government spending on health, crowding out productive investments. Together these frameworks capture the two-way link: climate change erodes health capital, productivity falls, and the government faces a greater fiscal burden, at the cost of productive investments.

IV. DATA AND METHODOLOGY

4.1 Data Sources and Study Area

We examine 25 Sub-Saharan African countries (Figure 1) from 2000-2023, leading to an unbalanced panel of 575-600 country-year observations. Selection of countries was made based on data availability. Data are taken from: the World Bank World Development Indicators (WDI); the Climate Research Unit (CRU TS4.06) gridded climate model; the WHO Global Health Expenditure Database (WHO-GHED); and the ILO ILOSTAT database.

The study covers 25 Sub-Saharan African countries (Figure 1) over 2000–2023, yielding an unbalanced panel of approximately 575–600 country-year observations. Countries were selected based on data availability. Data were sourced from: the World Bank World Development Indicators (WDI); the Climate Research Unit (CRU TS4.06) gridded climate dataset; the WHO Global Health Expenditure Database (WHO-GHED); and the ILO ILOSTAT database.

Figure 1: Study Area Map — 25 Sub-Saharan African Countries Covered (2000–2023)

Western Africa	Eastern Africa	Central Africa	Southern Africa
Nigeria, Ghana, Senegal, Mali, Burkina Faso, Niger, Côte d'Ivoire	Kenya, Tanzania, Ethiopia, Uganda, Rwanda, Somalia, Sudan, Madagascar	Cameroon, DR Congo, Chad, Angola	South Africa, Mozambique, Zambia, Zimbabwe, Malawi, Botswana

Note: The 25 sampled countries span all four SSA sub-regions, cover >85% of SSA population and GDP, and represent diverse climatic zones from the Sahel to humid tropics. Geographic coordinates sourced from GADM/World Bank (2024). Map represents administrative boundaries and does not imply any political endorsement.

Source: Author's compilation; World Bank GADM (2024)

4.2 Variable Description and Summary Statistics

The variables of interest are: (i) Agricultural Labour Productivity (ALP) - value added per agricultural worker in constant 2015 USD; and (ii) Government Health Expenditure (GHE) - as a share of GDP. Average Annual Temperature (TEMP) is the main independent variable measured in °C. Other variables include: (i) Yearly Precipitation (PRECIP) in mm; (ii) GDP per capita growth rate (GDPpcgr), (iii) Urbanisation rate (URI) and (iii) Malaria incidence per 1,000 people (MAL).

Table 1: Variable Descriptions and Summary Statistics (2000–2023, N = 25 Countries)

Variable	Definition	Source	Mean	Std. Dev.	Min	Obs.
ALP	Agric. value added/worker (USD 2015)	WDI	1,842	1,205	241	575
GHE (%GDP)	Govt health expenditure, % of GDP	WHO-GHED	2.87	1.23	0.72	590
TEMP (°C)	Mean annual temperature (°C)	CRU TS4.06	24.8	3.14	16.1	600
PREC (mm)	Annual precipitation (mm)	CRU TS4.06	897	412	112	600
GDP_GR (%)	GDP per capita growth rate (%)	WDI	2.31	3.87	-8.4	590
URB (%)	Urban population, % of total	WDI	36.4	14.2	11.3	600
MAL_INC	Malaria incidence per 1,000 pop.	WHO	187.3	142.7	0.8	570

Source: Author's computation from World Bank WDI, WHO-GHED, CRU TS4.06 (2024)

4.3 Model Specification

The empirical approach uses a three-pronged strategy. First, we use a two-way panel Fixed Effects (FE) model:

$$Yit = \alpha + \beta 1TEMPit + \beta 2Xit + \mu i + \lambda t + \varepsilon it \ldots\ldots\ldots\ldots\ldots(1)$$

Where Y is ALP or GHE for country i and year t; TEMP is the average annual temperature; X is a set of controls; μ_i are country fixed effects; λ_t are year fixed effects; and ε is the residual. To account for potential endogeneity, a robustness check is made using the System-GMM (Arellano & Bover, 1995; Blundell & Bond, 1998) and lagged temperature and precipitation as instruments. Hausman tests are used to choose between FE and RE.

V. RESULTS AND DISCUSSION

5.1 Descriptive Trends

Table 2 shows the trends in variables across selected years. The mean temperature across the 25 SSA countries rose from 24.1°C to 26.1°C between 2000 and 2023, a 2.0°C increase over 23 years, in line with the IPCC (2021) report on the increasing rate of regional warming. Agricultural productivity per worker increased slightly from USD 1,312 to USD 1,922 during this period, but with significant stagnation between 2010-2020, corresponding to the most pronounced warming. Public health spending as a percentage of GDP, increased from 2.31% to 3.41%, due to increasing climate-related health system burdens. Malaria cases, which have fallen slightly owing to control measures, still depend structurally on temperature-humidity.

Table 2: Trends in Key Variables across 25 SSA Countries (Selected Years, 2000–2023)

Year	Avg. Temp (°C)	Agric. Labour Prod. (USD)	Govt. Health Exp. (% GDP)	Malaria Inc. (/1,000)	GDP pc Growth (%)	Urbanisation (%)
2000	24.1	1,312.4	2.31	287.4	1.82	31.2
2005	24.4	1,498.7	2.54	251.6	3.41	33.1
2010	24.8	1,673.2	2.79	213.3	3.87	34.9
2015	25.3	1,791.5	3.01	194.7	2.12	36.6
2020	25.7	1,836.1	3.28	182.1	-1.43	38.4
2023	26.1	1,921.8	3.41	174.9	2.67	39.7

Source: Author's computation from WDI, WHO-GHED, CRU TS4.06 (2024)

5.2 Panel Regression Results

Table 3: Effect of Temperature on Agricultural Labour Productivity (ALP) and Health Expenditure (GHE)

Variable	FE — ALP	RE — ALP	GMM — ALP	FE — GHE
Temperature (°C)	-0.017*** (0.004)	-0.015*** (0.005)	-0.019*** (0.006)	0.023*** (0.007)
Precipitation (mm)	0.003** (0.001)	0.003** (0.001)	0.004** (0.002)	-0.001 (0.001)
GDP pc Growth (%)	0.082*** (0.018)	0.079*** (0.019)	0.091*** (0.021)	-0.014** (0.007)
Urbanisation (%)	0.011 (0.009)	0.014 (0.010)	0.009 (0.011)	0.008* (0.005)
Malaria Incidence	-0.006*** (0.001)	-0.005*** (0.001)	-0.007*** (0.002)	0.004*** (0.001)
Constant	4.812*** (0.423)	4.601*** (0.461)	—	0.714 (0.512)
Country FE	Yes	No	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	575	575	575	585
R^2	0.612	0.587	—	0.594

Hansen J-stat (p-val)	—	—	0.381	—
AR(2) p-value	—	—	0.214	—

*Note: ***, **, * denote significance at 1%, 5%, and 10% levels respectively. Standard errors clustered at country level in parentheses. ALP = log(Agricultural Labour Productivity); GHE = Government Health Expenditure as % of GDP. GMM instruments: lags 2–4 of TEMP and PREC.*

5.3 Discussion of Findings

The findings from Table 3 clearly demonstrate that temperature rises will have major economic impacts in SSA in two respects. First, a 1°C rise in annual average temperature leads to a 1.7% reduction in agricultural labour productivity (FE estimate), with similar results for RE and GMM. This finding is consistent with Burke et al. (2015) and Kjellstrom et al. (2018), who report productivity reductions in tropical regions. This reflects the impact of hot temperatures on the physical ability to work, mental alertness and days of good health to work (especially important in agriculture as more than 60% of SSA's working population are farmers).

Second, we find that a 1°C warming leads to a 2.3 percentage point growth in government health expenditure as a percentage of GDP. The additional public expenditure is driven by increased demand for health care for climate-sensitive diseases. The incidence of malaria also has independent negative impacts on labour productivity (-0.6%) and positive impacts on health expenditure (+0.4%), confirming that vector-borne disease transmission - worsened by rising temperatures - is a key economic burden. The GMM estimates, with acceptable Hansen J (p=0.381) and AR(2) (p=0.214) tests, indicate that the estimates are not plagued by reverse causality and dynamic panel bias, offering strong evidence of causality.

Table 4 breaks down the estimated economic costs, revealing that the annual productivity losses from climate-related health risks are estimated to be USD 47.3 billion on average in SSA, with annual additional health expenditures of USD 12.8 billion for governments (a combined total of USD 60 billion annually).

Table 4: Estimated Annual Economic Costs of Climate-Induced Health Risks in SSA (Average, 2018–2023)

Cost Category	Low Estimate (USD bn)	Central Estimate (USD bn)	High Estimate (USD bn)
Agricultural productivity loss (heat stress)	28.4	35.1	43.7
Productivity loss (malaria/disease absenteeism)	8.2	12.2	17.4
Additional government health expenditure	9.4	12.8	16.9
Total estimated burden	46.0	60.1	78.0
As % of SSA aggregate GDP	1.8%	2.4%	3.1%

Source: Author's estimates based on panel regression coefficients applied to World Bank GDP and ILO employment data (2024). Figures rounded to one decimal place.

VI. POLICY IMPLICATIONS

The analysis has profound policy implications for the governments of SSA, the African Union (AU) and development partners. First, SSA governments need to establish climate-responsive health financing. Existing health budgets are largely based on historical disease burdens and do not account for the likely climate-induced expansion of disease burdens. The creation of Climate Health Reserve Funds (using a combination of carbon revenues and international climate finance) would offer counter-cyclical fiscal stimuli to climate-related health spending.

Second, the research calls for climate adaptation in National Health Policies (NHPs). Heatwave and vector-borne disease outbreak risk models, along with heat-health action plans, should be integrated into health policy frameworks. Nations with progressive community health worker networks, such as Rwanda and Ghana, could be regional examples of climate-adaptive primary health care.

Third, because of the significant impacts on labour productivity in agriculture, investments in heat-adaptive agricultural practices (rest scheduling, provision of cooling stations in farming communities, shade infrastructure and heat-tolerant crop varieties) are co-investments in health and economic productivity. They should be prioritised in national climate adaptation plans (NAPs) and funded through the Green Climate Fund (GCF) and other multilateral funds.

VII. CONCLUSION

This research offers strong empirical evidence that climate change has a measurable and significant economic impact on Sub-Saharan Africa in two key ways: agricultural labour productivity losses and public health expenditure. The study employs a panel data set of 25 countries in SSA over 2000-2023 and estimates that a 1°C rise in temperature is associated with a 1.7% drop in agricultural labour productivity and a 2.3% increase in public health spending (as a share of GDP). Overall, the annual economic losses are estimated to be around USD 60 billion, or 2.4% of SSA's GDP.

The results demonstrate the need for SSA policymakers to consider climate change as more than an environmental problem but also a key economic and fiscal issue. Climate-sensitive health financing, integrated adaptation measures and regional cooperation on climate health data systems and monitoring are key priorities. Further studies should examine the distributional impacts across different income levels within the SSA region, and the cost-benefit of specific adaptation measures, such as conditional cash transfers tied to climate-health outcomes.

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