

The Climate Crisis in Zambia: A Cross-Sectoral Situation Analysis of Agriculture, Poverty and Education

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ABSTRACT

Africa is warming faster than the global average, and Zambia exemplifies how the climate crisis is undermining development in countries that have contributed least to global emissions. This paper examines the impacts of climate change on agriculture, household welfare, and education in Zambia, and outlines priority actions to strengthen resilience. Zambia's climate is becoming hotter and more variable, with more frequent droughts, flash floods, and shifts in the growing season. These changes are acutely felt in a predominantly rainfed, maize-based agricultural system that provides livelihoods for over one-fifth of the labour force and supports more than half of the population. Climate variability has already contributed to crop failures, food insecurity, volatile maize prices, and reduced agricultural contributions to GDP, with Southern Zambia projected to be particularly hard hit.

The study highlights how climate shocks interact with existing vulnerabilities—high poverty, limited diversification, and dependence on hydropower—to deepen welfare losses and widen the poverty gap. Projections indicate declining yields of key staples in lowland areas, shortened growing seasons, reduced water availability, and potential declines in national GDP, alongside an increase in the number of people falling into poverty. At the same time, climate-related disasters are disrupting education systems across Eastern and Southern Africa, including Zambia, causing substantial direct loss and damage as well as non-economic impacts such as learning loss, psychosocial distress, and heightened protection risks for children. Yet, education attracts only a marginal share of global climate finance.

The paper argues that building resilience in Zambia requires integrated, evidence-based strategies that address both sector-specific and cross-cutting risks. Key recommendations include expanding irrigation and climate-smart agriculture tailored to agro-ecological zones, improving climate information and early warning systems, and systematically integrating climate risk into national development and agricultural policies. Additional priorities are climate-proofing education infrastructure and services, increasing climate finance for social sectors, strengthening social protection, and enhancing data and research to manage uncertainty. Pursued with urgency and equity, these measures can protect vulnerable households, safeguard human capital, and place Zambia on a more resilient and sustainable development trajectory in a rapidly changing climate.

Keywords: Climate change, Zambia, Agriculture, Climate resilience, Climate finance, Sustainable development, Food security, Climate-smart agriculture, Economic vulnerability, Education infrastructure, Adaptation strategies, Sub-Saharan Africa

Climate Crisis and Resilience in African Countries

As the world approaches the +2°C global warming threshold, Africa is heating even more rapidly (WMO, 2023a, p. 3). Although African countries have contributed relatively little to historical greenhouse gas (GHG) emissions, they face profound ecological, economic, and social consequences from climate change.

While the urgency of climate change in Africa is no less serious than elsewhere, it has received comparatively limited attention and support, despite the continent's distinct socio-economic and political realities.

Climate change affects African regions in diverse and uneven ways. Some areas are enduring recurrent, long-term droughts, crop failures, and famine, while others suffer from intense rainfall, sea-level rise, and both coastal and riverine flooding. Prolonged, severe heat waves have worsened these conditions and triggered heat-related health crises. Millions of people have been forced to leave their homes, driving internal displacement as well as cross-border and international climate-induced migration (WMO, 2023b, p. 2).

These challenges are compounded by health pandemics, economic decline, widespread poverty, gender inequality, rapid urbanization, violent extremism, military coups, and geopolitical competition. Together, they create a complex governance environment that makes it difficult to set and implement national priorities, especially in the context of Africa's constrained resources.

Climate Crisis the Zambian Context

The climate crisis in Africa, and in Zambia in particular, is already undermining livelihoods, food security, education, and long-term development, despite the continent's minimal contribution to global emissions. Zambia's heavy dependence on rainfed, maize-based agriculture and hydropower, combined with high poverty levels and limited adaptive capacity, makes its people especially vulnerable to rising temperatures, shifting rainfall patterns, and more frequent extremes. Building resilience will require coordinated action: scaling up climate-smart agriculture and diversification, strengthening early warning and risk mapping, climate proofing education and infrastructure, expanding climate finance for social sectors, and grounding national planning firmly in evolving climate data. If pursued with urgency and equity, these measures can help protect the most vulnerable households, narrow the poverty gap, and put Zambia on a more resilient, sustainable development path in the face of a rapidly changing climate. Hence the more such kind of study may be performed in the concern area.

PROBLEM STATEMENT

Despite contributing minimally to global greenhouse gas emissions, Zambia is already experiencing severe and escalating impacts of climate change, particularly in the agriculture and education sectors. The country's economy and rural livelihoods depend heavily on rainfed, maize-based smallholder agriculture and hydropower, both highly sensitive to rising temperatures, shifting rainfall patterns, and more frequent extreme events such as droughts and floods. These climate shocks are driving crop failures, food insecurity, income losses, electricity rationing, and widening poverty, with impacts varying across agro-ecological zones. At the same time, climate-related disasters are disrupting education for millions of children and generating substantial economic and non-economic losses, yet education receives a negligible share of climate finance. Although Zambia's policy frameworks acknowledge climate risks, there is still insufficient practical integration of climate projections into sectoral planning, limited investment in climate-resilient agriculture and social sectors, and inadequate systems for managing uncertainty. Understanding the scale, distribution, and cross-sectoral nature of climate impacts and translating this knowledge into targeted, climate-resilient development strategies remains an urgent but under-addressed challenge.

METHODOLOGY

Research design

This paper adopts a **qualitative, descriptive situation-analysis design** based on a **desk review of secondary data**. A desk-based approach was selected because the study seeks to synthesise and interpret an already substantial but fragmented body of evidence on Zambia's climate risks, rather than to generate new primary observations. Situation analysis is particularly suited to this objective, as it allows the study to characterise the current state of a problem, identify the drivers and distribution of vulnerability across sectors and populations, and derive policy-relevant recommendations from existing evidence. The design is **cross-sectoral and multi-scalar**: it examines climate impacts at the continental (African), national (Zambian), and sub-national (agro-ecological zone) levels, and across three interlinked domains — agriculture, household welfare and poverty, and education.

Sources of data

The study relied exclusively on secondary data drawn from the following categories of sources:

Source category	Examples used
Global scientific assessments	IPCC (2014, 2018, 2019); WMO State of the Climate in Africa (2023a, 2023b)
National policy and strategy documents	Seventh National Development Plan; National Policy on Climate Change; Second National Agriculture Policy (GRZ, 2016a, 2016b, 2017)
National statistical data	ZamStats Labour Force Survey and employment statistics (2019)
International organisation reports	World Bank (2019); OECD/FAO (2016); UNICEF & Dalberg (2026); Global Hunger Index (von Grebmer et al., 2019)
Peer-reviewed journal articles and working papers	Thurlow et al. (2012); Ngoma et al. (2017, 2019); Mulenga et al. (2017, 2019); Chisanga et al. (2017, 2018); Hamududu & Ngoma (2019); Mulungu et al. (2021); Azzarri & Signorelli (2020); Alfani et al. (2019), among others
Grey literature and technical reports	Braimoh et al. (2016); Verhage et al. (2018); De Pinto et al. (2019b); Fant et al. (2015)

Literature search and selection strategy

Relevant material was identified through purposive searching of academic databases, institutional repositories, and the official websites of the Government of the Republic of Zambia, UN agencies, and international financial institutions. Search terms combined thematic and geographic keywords, including climate change, climate variability, drought, flood, rainfed agriculture, maize, food security, poverty, hydropower, education, adaptation, and climate finance, paired with Zambia, Southern Africa, and sub-Saharan Africa. Reference lists of key documents were also snowballed to capture additional sources.

Inclusion criteria. Documents were included if they (i) addressed climate change impacts, vulnerability, or adaptation; (ii) were focused on Zambia, or on Southern/Eastern Africa where findings were reasonably transferable to the Zambian context; (iii) contained empirical data, projections, or authoritative policy positions; and (iv) were published by credible academic, governmental, or multilateral sources.

Exclusion criteria. Sources were excluded where they were opinion-based without an evidential basis, methodologically opaque, geographically irrelevant, or superseded by more recent data from the same institution.

Temporal scope. The review prioritised literature published from roughly 2007 onwards, with emphasis on the most recent decade, in order to capture contemporary climate observations, updated projections (to 2050), and current policy frameworks. Older foundational studies (e.g., Jain, 2007) were retained where they provide the analytical baseline against which later findings are interpreted.

Analytical framework

The analysis is organised around a simple **hazard – exposure – vulnerability – impact – response** logic, consistent with the IPCC risk framing:

- **Hazard:** observed and projected changes in temperature, rainfall variability, drought frequency, flash flooding, and growing-season length.

- **Exposure:** the share of the population and economy dependent on rainfed, maize-based smallholder agriculture and on hydropower, together with school-going populations and education infrastructure.
- **Vulnerability:** poverty levels, limited livelihood and dietary diversification, weak irrigation coverage, and constrained adaptive capacity.
- **Impact:** crop failure, food insecurity, price volatility, GDP and welfare losses, poverty deepening, electricity rationing, and disruption to schooling and learning.
- **Response:** existing policy provisions, adaptation and mitigation options, and financing gaps.

This framework guided both the extraction of information from sources and the structuring of the findings and recommendations.

Data extraction and analysis

Information was extracted into a thematic matrix and analysed using **qualitative content and thematic analysis**, supported by **descriptive interpretation of published quantitative statistics**. No new statistical modelling or econometric estimation was undertaken; reported figures for example, agriculture's approximately 6% to GDP, 22.3% share of employment, the projected 13% reduction in water availability by 2050, the estimated 4% decline in GDP, the additional 300,000 people pushed into poverty between 2007 and 2016, and the USD 1.3 billion in education-sector loss and damage are reproduced from their original sources and cited accordingly.

The analytical steps were:

- **Familiarisation and screening** of retrieved documents against the inclusion criteria.
- **Coding** of content against the analytical framework categories.
- **Thematic clustering** into the paper's substantive sections: continental context, national climate profile, agriculture and household welfare, and education.
- **Comparative and spatial interpretation**, particularly of differences between Southern and Northern Zambia and between lower- and higher-altitude zones.
- **Synthesis into policy recommendations**, derived by matching identified vulnerabilities and evidence gaps against documented adaptation and mitigation options and existing national policy commitments.

Validity, reliability and triangulation

To strengthen credibility, findings were **triangulated across source types** global scientific assessments, national statistics, peer-reviewed research, and institutional reports so that key claims rest on convergent evidence rather than a single source. Preference was given to peer-reviewed and officially published data. Where estimates diverged between sources, ranges were reported or the more recent and methodologically transparent estimate was preferred, and any residual uncertainty was stated explicitly in the text.

Ethical considerations

The study involved no human participants, no fieldwork, and no collection of personal or identifiable data; formal ethical clearance was therefore not required. Ethical rigour was maintained through accurate representation of source findings, full attribution and citation to avoid plagiarism, avoidance of selective reporting, and transparency regarding the study's evidentiary limits.

Limitations of the methodology

Several limitations should be borne in mind when interpreting the findings:

- **Dependence on secondary data.** The analysis inherits the assumptions, methodological choices, and any errors of the original studies, and could not independently verify underlying datasets.

- **Data gaps and lags.** Sub-national, sector-disaggregated, and up-to-date data particularly on education-sector losses and on livestock remain limited, and some national statistics predate the most recent climate shocks.
- **Projection uncertainty.** Climate and economic projections to 2050 are sensitive to emissions scenarios, model choice, and assumptions about adaptation, so quantitative estimates should be read as indicative orders of magnitude rather than precise forecasts (Fant et al., 2015).
- **Heterogeneity of sources.** Studies differ in scope, time period, and method, which constrains strict comparability across findings.
- **Absence of primary voices.** Without fieldwork, the study cannot capture the lived experience, indigenous knowledge, or adaptation practices of farmers, learners, and communities at first hand.

These limitations point to a clear direction for future work: primary, household- and school-level research within specific agro-ecological zones, combined with improved national monitoring systems, would substantially sharpen the evidence base for targeted adaptation planning in Zambia.

Zambia's Climate Crisis

Zambia is already experiencing serious climate impacts, including more frequent and severe seasonal droughts, intermittent dry spells, rising temperatures in low-lying valleys, flash floods, and shifts in the growing season. In response, the country is working to design sustainable and context-appropriate programmes for both crop and livestock sectors. Key adaptation measures include promoting irrigation and efficient water use, strengthening early warning and preparedness systems, and applying GIS/remote sensing to map drought- and flood-prone areas.

The 2023–2024 El Niño-induced drought in Southern Africa one of the most severe in decades highlighted the human cost of these trends, leaving nearly 10 million people without adequate food, water, or electricity.

Climate-related disasters such as floods and droughts have already imposed an estimated USD 1.3 billion in direct loss and damage on education systems in Eastern and Southern Africa, disrupting schooling for 130 million children. These interruptions are projected to translate into as much as USD 140 billion in lost future earnings, potentially rising to USD 380 billion by 2050 if climate impacts intensify and adequate actions are not taken (UNICEF Dalberg Report 2026).

Beyond physical damage, climate change is causing significant non-economic losses: reduced learning time, psychosocial distress, and heightened protection risks for children. Each missed day of school undermines future earning potential, compounding long-term setbacks for human and national development. Yet, education currently receives only about 0.5% of global climate finance, leaving education systems highly vulnerable to repeated climate shocks (UNICEF Dalberg Report 2026).

In agriculture, climate change is equally disruptive. Excessive rainfall in areas not typically prone to drought, more frequent droughts in traditionally dry regions, and a general shortening of the growing season are undermining agricultural productivity and food security. These impacts weaken livelihoods and erode the adaptive capacity of individuals and communities (Courouche Kalantary, 2010).

Agriculture remains a key sector in Zambia, contributing around 6% to national GDP (World Bank, 2019). It provides about 22.3% of total employment 4.3% in the formal sector and 18% in the informal sector (ZamStats, 2019). Smallholder farmers dominate production, which is heavily maize-based and predominantly rainfed (Libanda et al., 2016). This reliance on rainfed systems heightens vulnerability to climate variability and change, particularly among rural smallholders.

The IPCC's 2018 special report warns that a 1.5°C rise above pre-industrial temperatures will pose serious threats to food security, livelihoods, and economic growth (IPCC, 2018). Rural populations dependent on agriculture are especially at risk. Rainfed systems are highly sensitive to changing climate conditions, and more frequent and intense extreme events are expected to disrupt food systems, with negative consequences

for food availability, access, and nutrition (Meybeck et al., 2018). This context underscores the need to increase, not reduce, mitigation and adaptation efforts.

One of the greatest challenges in responding to climate change is uncertainty: future climate conditions and their precise impacts on specific economic sectors remain difficult to predict (Fant et al., 2015). Agriculture is a cornerstone of sub-Saharan African economies, providing livelihoods for more than 50% of the labour force (OECD/FAO, 2016), yet it is also the primary channel through which climate change exerts its impacts. In Zambia, agriculture employs over 22.3% of the labour force and supports more than half of the population (ZamStats, 2019; GRZ, 2016a, b). Its dependence on rainfall exposes rural households to climate shocks and deepens their vulnerability.

Zambian policy frameworks including the Seventh National Development Plan, the National Policy on Climate Change, and the Second National Agriculture Policy stress the importance of understanding where and how climate impacts will be most intense to guide adaptation strategies at national and subnational levels (GRZ, 2016b; GRZ, 2016a; GRZ, 2017). Current evidence indicates that climate change will widen the poverty gap, increase crop failures, alter the length of the growing season, and reduce water availability by about 13% by 2050 (Ngoma et al., 2019; Hamududu and Ngoma, 2019; Verhage et al., 2018; Mulenga et al., 2017).

Research further suggests that climate impacts will vary across Zambia's agro-ecological zones and may increase the need for crop diversification. Climate change could reduce national GDP by around 4% and is estimated to have contributed to an additional 300,000 people falling into poverty between 2007 and 2016 (Mulungu et al., 2021; Braimoh et al., 2016; Thurlow et al., 2012).

Impacts of Climate Change on Agriculture and Household Welfare in Zambia

Climate change affects agriculture mainly through more frequent and intense extreme events such as droughts and floods that directly reduce productivity and output (Jain, 2007; Thurlow et al., 2012). Because climate patterns are becoming less predictable, it is increasingly difficult for farmers, especially those in rainfed systems, to plan their activities (De Pinto et al., 2019b). Greater climate variability leads to higher uncertainty about the timing and intensity of rainfall, floods, and dry spells, as well as shifts in the start and end of the rainy season.

The effects on crop yields vary by region. For instance, yields of key staples such as maize and wheat are projected to decline in lower-altitude areas, while higher-altitude regions may experience yield gains for crops like sugar beet, maize, and wheat (IPCC, 2014; IPCC, 2019).

Zambia, like many of its neighbours, is already witnessing these consequences. Climate variability has contributed to crop failures, loss of livelihoods, increased food insecurity, and a smaller contribution of agriculture to GDP (Alfani et al., 2019; Chisanga et al., 2017; Chisanga et al., 2018; Mulenga et al., 2019). Southern Zambia is projected to be more severely affected than the northern regions, with rainfall becoming increasingly erratic and rainy seasons shifting in timing (Hamududu and Ngoma, 2019; Mulenga et al., 2017). Over 90% of smallholder agriculture is rainfed (GRZ, 2016a; GRZ, 2016b), making the sector particularly exposed to these climate shocks.

Additional impacts include prolonged electricity rationing sometimes up to 15 hours per day due to reduced hydropower generation, and high volatility in maize and maize meal prices driven by supply shortages and limited irrigation infrastructure (Mulenga et al., 2019; Chisanga et al., 2018; Ngoma et al., 2017).

These climate-related pressures have significant implications for food security. Recurring extreme events are undermining efforts to end hunger and achieve reliable food access (von Grebmer et al., 2019). The people most likely to be pushed back into poverty by climate change are those already marginalized, especially those living in the driest and wettest areas of sub-Saharan Africa (Azzarri and Signorelli, 2020; Olsson et al., 2014).

In Zambia, projected impacts on food security and nutrition are particularly severe due to high poverty levels and limited diversification in food production (Verhage et al., 2018; Alfani et al., 2019). Currently, cereals provide about 63% of the country's energy intake, with maize the staple food highly vulnerable to climate variability. Understanding the scale and distribution of climate impacts on agriculture is therefore essential for planning effective adaptation measures that can protect livelihoods, food security, and long-term development in Zambia.

Key recommendations:

a) Strengthen climate-resilient agriculture

- Expand irrigation and efficient water-use technologies, especially for smallholders.
- Promote crop and livelihood diversification beyond maize to reduce vulnerability.
- Develop and scale climate-smart agriculture practices suited to each agro-ecological zone.

b) Improve climate information and early warning systems

- Invest in robust, local early warning systems for droughts, floods, and heat waves.
- Use GIS and remote sensing more systematically to map and monitor risk-prone areas.
- Ensure timely dissemination of climate information to farmers and local planners.

c) Integrate climate risks into national planning

- Fully align development, agriculture, and climate policies (e.g., 8NDP, National Climate Policy, Agriculture Policy).
- Use climate impact projections to target resources to the most vulnerable regions and populations.
- Prioritize measures that reduce the poverty gap and protect rural livelihoods.

d) Protect and climate-proof education systems

- Treat education as a critical sector for climate resilience, not just an add-on.
- Invest climate finance in making schools safe, resilient, and able to continue operating during climate shocks.
- Address non-economic impacts (learning loss, psychosocial stress, protection risks) in education planning.

e) Expand climate finance and invest in human development

- Increase the share of global and national climate finance allocated to education and social sectors.
- Target support to marginalized communities in the driest and wettest regions.
- Build social protection systems that can rapidly respond to climate shocks.

f) Enhance data, research, and uncertainty management

- Support research on climate impacts by region and sector to refine adaptation strategies.
- Develop decision-making tools that account for climate uncertainty, especially for farmers.
- Continuously update policies and plans as new data and projections emerge.

g) Scale up mitigation alongside adaptation

- Pursue low-carbon pathways in energy (e.g., diversified generation to reduce dependence on hydropower alone).
- Promote sustainable land use and forestry practices that enhance carbon sinks and protect ecosystems.

CONCLUSION

In conclusion, the climate crisis in Africa, and in Zambia in particular, is already undermining livelihoods, food security, education, and long-term development, despite the continent's minimal contribution to global emissions. Zambia's heavy dependence on rainfed, maize-based agriculture and hydropower, combined with high poverty levels and limited adaptive capacity, makes its people especially vulnerable to rising temperatures, shifting rainfall patterns, and more frequent extremes. Building resilience will require coordinated action: scaling up climate-smart agriculture and diversification, strengthening early warning and risk mapping, climate-proofing education and infrastructure, expanding climate finance for social sectors, and grounding national planning firmly in evolving climate data. If pursued with urgency and equity, these measures can help protect the most vulnerable households, narrow the poverty gap, and put Zambia on a more resilient, sustainable development path in the face of a rapidly changing climate.

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