Scientific Knowledge Group

Research Article

Journal of Environmental Sciences and Plant Research

Climate Change, Hunger, and Extreme Poverty in Africa: A Case Study of Egypt

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ABSTRACT

The global crises of poverty and hunger, exacerbated by climate change, affect millions worldwide. This study investigates climate change's impact on achieving SDGs 1 and 2, focusing on hunger and poverty in Africa, with a specific focus on Egypt. Findings reveal that climate variability harms livestock, fisheries, and food security, while rising sea levels and melting ice increase land salinity, reducing agricultural productivity. In Egypt, rising sea levels threaten the Nile Delta, jeopardizing agricultural output. The study recommends infrastructure enhancements, international cooperation, and promoting heat-tolerant, water-efficient crops to address these challenges.

Keywords: Climate Change, Hunger, Extreme Poverty, SDGs.

Received: May 18, 2025;
Accepted: May 24, 2025;
Published: May 31, 2025

Introduction

Climate change intensifies hunger and extreme poverty in Africa. In 2022, over 282 million Africans faced severe food insecurity due to climate-related factors [1]. Climate disruptions lower agricultural yields, increase food prices, and deepen poverty [2]. Sub-Saharan Africa, with 433 million people living in extreme poverty in 2021, is highly affected [3]. In Egypt, 5.8 million people were food insecure in 2022, with climate impacts diminishing water resources and agricultural productivity [1].

Study Objectives

This study explores the relationship between climate change, hunger, and poverty in Africa and Egypt, assessing current and future impacts, and proposing mitigation strategies.

Study Methodology

A systematic review of 85 studies was conducted, with 63 selected based on relevance, reliability, quality, and recent publication [4, 5].

Literature Review

Climate Change and Agriculture in Africa. Climate change reduces agricultural yields and food security [6]. Vulnerable communities are at risk due to climate shocks [7].

Food Security in Africa. The FAO shows how climate change worsens food insecurity by impacting agricultural output and livestock health [8].

Poverty and Vulnerability. The World Bank states that climate change increases poverty risks by affecting food prices and productivity [9].

Climate Change in Egypt. Climate-related challenges in Egypt, including reduced water resources and rising temperatures, threaten food security [10, 11].

SDGs and Climate Change. Climate change impedes the achievement of SDGs 1 and 2 in Africa [12]. Adapting development policies to climate change is crucial.

Future Scenarios. Without significant adaptation, food insecurity and poverty will worsen in Africa [2, 13].

Climate Change, Hunger, and Extreme Poverty

The link between climate change, hunger, and

Citation: Khaled El-Sayed Hassan (2025) Climate Change, Hunger, and Extreme Poverty in Africa: A Case Study of Egypt. J Envir Sci Plant Res 1: 1-7.

extreme poverty is evident, as climate change worsens vulnerabilities in food systems and economies.

Definitions

Climate change refers to long-term shifts in temperature, precipitation, and extreme weather due to human activities like fossil fuel burning [14]. These shifts affect agriculture and livelihoods.

Hunger is the lack of sufficient food, while extreme poverty is living on less than $1.90 per day, leading to severe deprivation. Climate change worsens both by increasing extreme weather events and disrupting food production.

Manifestations

Climate Change Impact. Rising temperatures, sea levels, and erratic rainfall reduce yields. In Egypt, salinity from rising sea levels threatens the Nile Delta [15]. Droughts and unpredictable rainfall impact irrigation and food security [16].

Hunger Consequences. Food insecurity and resource shortages lead to conflicts. Climate change intensifies hunger, as seen in Egypt's declining agricultural productivity [17].

Extreme Poverty Effects. Agriculture-dependent communities suffer as climate change restricts resources. Water scarcity and dam projects worsen poverty in Egypt, with gender disparities amplifying economic hardships [18, 19].

Theoretical Frameworks

Climate Change and Hunger. Rising temperatures, erratic rainfall, and extreme weather impact African food production. In sub-Saharan Africa, where 60% rely on farming, droughts have left millions food-insecure [20].

Staple crops like maize face threats, with yields in the Arab African region projected to drop by 40% by 2050 [21]. In Egypt, rising sea levels may reduce arable land by 15% by 2050, harming rice and wheat production [22].

Framework Mechanisms

Declining Productivity. Climate shifts lower yields.

Rising Food Prices. Lower supply increases costs, limiting access.

Vulnerability of the Poor. Food costs consume a significant portion of low-income household budgets.

Regional Disparities. Sub-Saharan Africa, reliant on rain-fed agriculture, faces heightened risks.

Key Measures

Adaptation. Climate-resilient crops, improved irrigation, and heat-resistant agriculture.

Social Protection. Strengthening safety nets to protect vulnerable populations.

Climate change intensifies hunger and poverty, particularly in Africa, where agriculture and water resources are under strain. Addressing these challenges requires global cooperation, sustainable farming investments, and policy reforms.

Table 1 and Figure 1 illustrate undernourishment rates across continents and African regions (2005–2022). Africa accounts for 38.4% of the global undernourished population, second only to Asia (54.7%). Central Africa has the highest undernourishment rate (29.1%) due to conflicts affecting farming, particularly in the DRC. East Africa's rate (28.5%) stems from drought, conflict, and displacement in Somalia, South Sudan, and parts of Ethiopia and Kenya. Sub-Saharan Africa's rate was 22.5% in 2022, worsened by climate change, conflict, and weak agricultural infrastructure.

Table 1: Prevalence of undernourished by regions, 2005-2022

Regions	Years					
	2005	2010	2015	2020	2021	2022
World	**12.1**	**8.6**	**7.9**	**8.9**	**9.3**	**9.2**
Africa	**19.2**	**15.1**	**15.8**	**18.7**	**19.4**	**19.7**
Northern Africa	6.2	4.7	5.4	6.0	6.9	7.5
Sub-Saharan Africa	22.5	17.6	18.2	21.6	22.2	22.5
Eastern Africa	31.7	23.8	24.6	28.1	28.4	28.5
Central Africa	31.9	22.5	23.3	27.6	28.5	29.1
Southern Africa	5.1	7.2	9.3	9.5	10.0	11.1
Western Africa	12.2	10.8	10.6	13.7	14.5	14.6

The Global Distribution of Undernourished by Continents 2022.

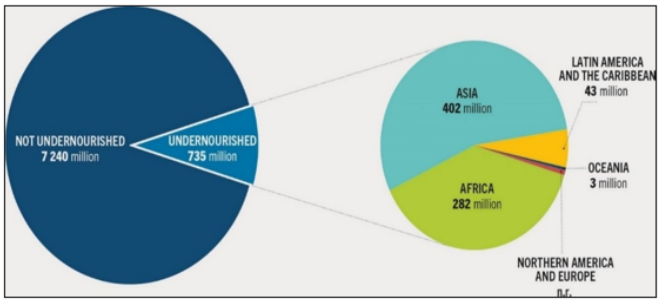

Figure 1: The Global Distribution of Undernourished by Continents 2022.
Sources: (IPCC, 2021) [14].

Climate Change and Poverty. Climate change worsens poverty in Africa, particularly due to agriculture's sensitivity to climate shifts. Over 60% of sub-Saharan Africa's population relies on agriculture (World Bank, 2020) [23]. Droughts, erratic rainfall, and extreme temperatures reduce crop and livestock productivity, heightening food insecurity in nations like Mozambique, Ethiopia, and Nigeria. In the Sahel, desertification shrinks arable land, triggering migration and conflict [24]. Egypt faces declining Nile water flow due to reduced Ethiopian Highlands rainfall, threatening agriculture and water security [25]. Rising sea levels further endanger Egypt's northern coast and Nile Delta, intensifying food shortages.

Framework Mechanisms

Higher vulnerability. Poor communities are most exposed and least equipped to adapt.

Economic instability. Climate events disrupt agriculture and infrastructure, weakening economies.

Resource competition. Scarcity fuels migration and conflict, exacerbating instability.

Displacement. Shrinking farmland forces migration to overburdened areas, deepening poverty.

Mitigation Measures

Resilience-building. Climate-smart agriculture, water management, and safety nets.

Global action. Support for adaptation policies to aid vulnerable populations.

Figures 2 & 3 illustrate Africa's extreme poverty trends versus global patterns and its share of global poverty from 1990 to 2020.

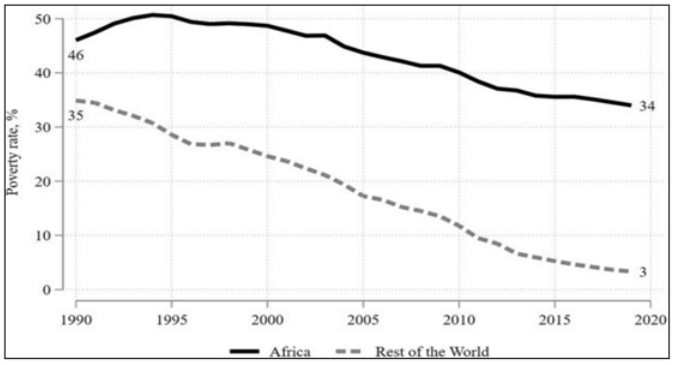

Figure 2: Trends in Extreme Poverty Rate in Africa, 1990-2020.
Source: (Abay, et al., 2023) [26]

Figure 2 highlights a slower decline in Extreme poverty in Africa than in the rest of the world. Between 1994 and 2019, Africa's poverty rate fell from 51% to 34%—a 33% drop. Meanwhile, global poverty fell from 35% in 1990 to just 3% in 2019, a 90% reduction. This contrast highlights Africa's persistent economic challenges despite global progress.

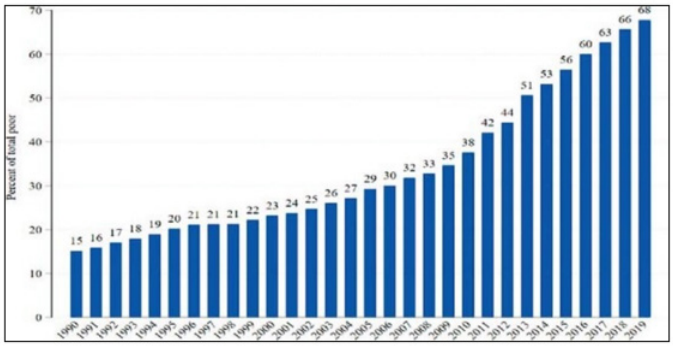

Figure 3: Share of Africa in the Global Extreme Poverty, 1990-2019
Source: (Abay, et al., 2023) [26]

Figure 3 shows Africa's increasing share of global poverty, rising from 15% in 1990 to 68% in 2019, largely due to stronger economic growth in other regions. East Asia, the Pacific, and South Asia, which had high poverty rates in 1990, experienced substantial income growth, with per capita income rising by 3.1% and 3.8% annually, respectively. In contrast, Sub-Saharan Africa saw only 1.5% growth, while the Middle East and North Africa recorded just 0.1% [23].

Impact of Climate Change on Hunger and Extreme Poverty in Africa

Current Impacts

Africa's reliance on rain-fed agriculture, weak adaptive capacity, and widespread poverty increase its vulnerability to climate change. Irregular rainfall, droughts, heatwaves, and rising temperatures disrupt food production, intensifying hunger and poverty.

In the Horn of Africa, recurring droughts have devastated farming and livestock. The 2017 drought in Somalia left 6.7 million people in need of food aid, triggering displacement and worsening poverty [27]. Similarly, the 2015–2016 El Niño drought slashed Zimbabwe's maize yield by 53%, affecting Malawi and Mozambique as well [28].

In the Sahel, desertification and unpredictable rainfall are shrinking agricultural output. Lake Chad has diminished by 90% since the 1960s, impacting over 10 million people in the region [29]. Climate-related food shortages are aggravated by poor infrastructure, governance issues, and conflict. In South Sudan and the Democratic Republic of Congo, climate and political instability have disrupted food supply chains, worsening hunger and poverty [30].

The following table (Table 2) highlights key climate change impacts on agriculture and food security in Africa.

It shows that climate change severely impacts African agriculture, reducing yields and worsening food insecurity. In the Horn of Africa, droughts have affected 6.7 million people in Somalia [31]. The 2015–2016 El Niño drought cut Zimbabwe's maize production by 53%, exacerbating food shortages [28]. In Southern Africa and the Sahel, desertification and erratic rainfall could lower yields by 20–50% by 2050 (IPCC, 2019) [32]. Ethiopia experienced a 90% crop loss due to severe droughts, while heatwaves in Kenya slashed maize and wheat output by 40%, inflating food prices [33, 34]. Rising sea levels in Kenya and Nigeria damaged rice farms, intensifying food insecurity [35]. Shrinking Lake Chad has affected 10 million people in the region [29].

Table 2: Current Impacts of Climate Change on Agricultural Production and Food Security in Africa

Region/ Country	Climate Impact	Effect on Agriculture	Impact on Food Security	Source
Horn of Africa	Recurrent droughts	Severe reduction in crop yield, loss of livestock	6.7 million people in need of food assistance (Somalia, 2017)	FAO, 2018
Southern Africa	El Niño-induced drought (2015-2016)	53% decline in maize production (Zimbabwe)	Widespread hunger, increased food imports, rising national debt	ReliefWeb, 2017
West Africa (Sahel)	Desertification, erratic rainfall	20-50% decline in crop yields by 2050	Increased food shortages, rural livelihoods threatened	IPCC, 2019
Ethiopia	Droughts, irregular rainfall	90% loss of crops during severe drought years	Displacement and food insecurity for millions	FAO, 2016

Kenya	Increased heatwaves and drought	40% reduction in maize and wheat production	Increased food prices, widespread hunger	World Bank, 2019
Nigeria	Sea level rise, floods	Rice farming areas flooded, leading to crop losses	Displacement and heightened food insecurity	UNEP, 2020
Lake Chad Basin	Shrinking water resources	Reduced agricultural land, depletion of fish stock	Over 10 million people facing food shortages	UNICEF, 2020

Future Impacts

Without urgent action, climate change will further worsen hunger and poverty in Africa. Temperatures are rising faster than the global average, with staple crop yields projected to decline by 50% by 2050 [14]. This will disproportionately harm the poorest, increasing food prices and malnutrition. In East Africa, shifting weather patterns could cut crop yields by 40% in some Kenyan regions by 2030, worsening hunger and mortality [36].

Water shortages will intensify, with reduced rainfall and rising evaporation in the Nile Basin threatening Egyptian agriculture [37]. In West Africa, sea-level rise will flood farmland, increase soil salinity, and drive migration [24]. Climate change could push 100 million people into extreme poverty by 2030, with Sub-Saharan Africa hit hardest [23]. Given that agriculture employs over 60% of Africans, urgent measures—such as climate-resilient farming, improved water management, and social protection—are essential to reduce risks.

Table 3: Future Impacts of Climate Change on Agriculture, Hunger, and Extreme Poverty in Africa by 2050.

Region/ Country	Projected Impact	Details	Source
Sub-Saharan Africa	Decrease in crop production	Up to 50% reduction in staple crops like maize, millet, and sorghum	IPCC, 2021
East Africa (Ethiopia, Kenya, Uganda)	Reduced growing seasons and crop yields	Maize and bean yields could decrease by up to 40% by 2030	Funk et al., 2019
Nile River Basin (Egypt, Sudan, Ethiopia)	Reduced water availability	Decreased rainfall and increased evaporation rates could lower water availability	Wheeler et al., 2020
West Africa (Nigeria, Senegal)	Rising sea levels and soil salinization	Inundation of farmland and increased soil salinization leading to reduced agricultural viability	Rigaud et al., 2018
Poverty Levels (Sub-Saharan Africa)	Increase in extreme poverty	An additional 100 million people could be pushed into extreme poverty by 2030	World Bank, 2020
Agricultural Sector (Sub-Saharan Africa)	Economic impact on smallholder farmers	Climate-related shocks could reduce income opportunities and exacerbate poverty	
Food Prices (Sub-Saharan Africa)	Increased food prices	Decreased production will drive up food prices, reducing access to nutritious food for many households	

Impact of Climate Change on Hunger and Extreme Poverty in Egypt

Current Impacts

Climate change has worsened hunger and poverty in Egypt, largely due to its dependence on the Nile River for agriculture. Reduced water availability, higher temperatures, and erratic rainfall have led to water shortages, lowering wheat and rice production in the Nile Delta and deepening rural poverty [15]. Rising temperatures also affect livestock, reducing milk and meat yields, increasing food prices, and exacerbating poverty, particularly in Upper Egypt [38]. Egypt's reliance on food imports makes it vulnerable to price shocks, as seen in 2020–2021 when wheat prices surged, straining food subsidies [17].

The Nile Delta faces flooding and saltwater intrusion due to rising sea levels, displacing farmers and fishers, worsening poverty [16]. Extreme weather events like droughts and heatwaves have damaged crops, increasing poverty in Upper Egypt [18]. Food shortages and higher prices have raised malnutrition, especially among rural children [39]. Overall, climate change is disrupting agriculture, water resources, and food imports, deepening economic hardship.

Future Impacts

Future climate change effects on hunger and poverty in Egypt will intensify:

Water Scarcity & Agricultural Decline. Egypt's water gap could reach 20–30% by 2050, reducing crop yields by 30% and worsening rural poverty [40].

Food Price Inflation. Declining domestic production will increase reliance on imports, driving food prices up by 20–30%, disproportionately affecting the poor [41].

Sea Level Rise & Displacement. A 1-meter rise in sea levels by 2100 could submerge parts of the Nile Delta, displacing millions and reducing food production [15].

Health & Malnutrition. Child malnutrition may rise by 20–30% by 2050 due to declining food supply and higher prices [42].

Extreme Weather Events. More frequent heatwaves, droughts, and floods will disrupt farming and infrastructure, raising food inse-

curity. By 2050, heatwaves up to 50°C could further reduce yields [16].

Coastal Vulnerability & Migration. Up to 10 million people in the Nile Delta may be displaced by 2050 due to rising sea levels and soil salinity, straining urban areas and increasing poverty [43].

Without urgent adaptation measures, climate change will escalate hunger and poverty in Egypt, worsening water scarcity, agricultural losses, and economic instability.

Table 4: Current and Projected Impacts of Climate Change on Hunger and Extreme Poverty in Egypt (2023-2050)

Indicator	Years				Source
	Current impact	Projected impact			
	2023	2030	2040	2050	
Prevalence of undernourishment (%)	8	10.5	12	15	FAO, 2023
Extreme poverty rate (%)	29.7	30.5	33	36.5	World Bank, 2023
Crop yield loss (%)	5	5	10	15	IPCC, 2022
Increase in food prices (%)	15	20	30	50	IFPRI, 2023
Vulnerable population (millions)	30	35	40	45	UNDP, 2023

Projection Classification, Assumptions, and Results

Classification. **2023 Baseline**: Represents current hunger and poverty levels as a reference point.
2030 Projection: Short-term outlook with partial adaptation, leading to moderate increases in food insecurity.
2040 Projection: Medium-term scenario showing worsening conditions due to limited adaptation.
2050 Projection: Long-term outlook predicting severe agricultural disruptions, escalating hunger and poverty.

Assumptions. Undernourishment: Declining agricultural productivity increases food insecurity (FAO).
Extreme Poverty: Agricultural losses worsen poverty, especially in low-income groups (World Bank).
Crop Yield Loss: Rising extreme weather events reduce yields (IPCC).
Food Prices: Declining production and higher demand drive price hikes (IFPRI).
Vulnerable Population: Population growth and climate stress increase risks (UNDP).

Main Findings. **Undernourishment**: Expected to rise from 8% in 2023 to 15% by 2050.
Extreme Poverty: Projected to increase from 29.7% to 36.5%.
Crop Yield Loss: Expected to grow from 5% in 2023 to 15%.
Food Prices: Predicted to rise by 50%.
Vulnerable Population: Estimated to increase from 30 million to 45 million by 2050.

Policies, Recommendations, and Successful Experiments

To address climate change threats to food security, urgent policy actions are required. This study recommends strategies backed by successful examples:
Climate-Resilient Crops: Promote flood-tolerant crops like those developed by IRRI [44].
Infrastructure and Land Use: Enhance infrastructure to counter climate disruptions, as seen in the Netherlands' water-absorbing urban planning [45].
Heat-Tolerant Plants: Support research on heat-resistant crops, following Jordan's example [46].
Water-Saving Crops: Encourage water-efficient crops like stevia in Egypt [47].
Saline Crops: Grow salt-tolerant plants, as the UAE does use seawater [48].
Targeted Food Policies: Implement food security programs for vulnerable groups, similar to Brazil's Zero Hunger Program [17].
Integrated Social Policies: Combine social and climate policies, as in Ethiopia's Productive Safety Net Program [49].
Carbon Taxes: Use carbon tax revenues to support low-income communities, as in British Columbia [50].
Fossil Fuel Subsidy Reform: Redirect fossil fuel subsidy savings to social programs, as done in Indonesia [51].
Regional Cooperation: Strengthen collaboration, following the African Union's CAADP model [52].

Postponing adaptation and social protection measures heightens risks. Immediate action is essential to secure food security and protect vulnerable populations [53-61].

References

1. Food and Agriculture Organization (2023) The State of Food Security and Nutrition in the World 2023. FAO, Rome. https://www.fao.org/publications/sofi/2023/en/.
2. Intergovernmental Panel on Climate Change (2022) Climate Change 2022: Impacts, Adaptation, and Vulnerability. IPCC, Geneva. https://www.ipcc.ch/report/ar6/wg2/.
3. World Bank (2021) Poverty and Inequality Platform (PIP). World Bank, Washington, DC. https://pip.worldbank.org/.
4. Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gøtzsche PC, et al. (2009) The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. PLoS Med 6: e1000100.
5. Moher D, Liberati A, Tetzlaff J, Altman DG, PRISMA Group (2015) Preferred reporting items for systematic reviews and meta-analyses: the PRISMA Statement. PLoS Med 6: 1000097.
6. Hallegatte S, Bangalore M, Bonzanigo L, Fay M, Kane T, et al. (2016) Shock waves: managing the impacts of climate change on poverty. The World Bank, Washington, D.C.
7. Schmidhuber J, Tubiello FN (2007) Global food security under climate change. Proc Natl Acad Sci USA 104: 19703-19708.
8. Food and Agriculture Organization (2015) The state of food insecurity in the world 2015. FAO, Rome.
9. The World Bank (2015) Climate change complicates efforts to end poverty. World Bank, Washington, D.C.
10. Abdelaal HS, Fathy S, Abdelaal HM, El-Ramady H (2019) Grains production prospects and long-run food security in Egypt. Sustainability 11: 4457.

11. Nassr S (2021) Analysis of climate change effects on food security in Egypt using IMPACT model. Egypt J Agric Econ 31: 743-755.
12. Hassan K (2022) Climate change and the global sustainable development goals. LAP LAMBERT Academic Publishing GmbH & Co., Germany.
13. Béné C, Newsham A, Davies M (2021) Resilience and food security: a review of the evidence. Food Security 13: 425-439.
14. Intergovernmental Panel on Climate Change (2021) Climate Change 2021: Impacts, Adaptation, and Vulnerability. IPCC, Geneva. https://www.ipcc.ch/report/ar6/wg2/.
15. Ghoneim E (2020) Rising sea level and its implications for Egypt's Nile Delta. Climatic Change 162: 437-449.
16. Waha K, Krummenauer L, Adams S, Aich V, Baarsch F, et al. (2017) Climate change impacts in the Middle East and Northern Africa (MENA) region and their implications for vulnerable population groups. Regional Environmental Change 17: 1623-1638.
17. FAO (2019) Zero Hunger Program: A pathway to ending hunger and poverty in Brazil. Food and Agriculture Organization. https://www.fao.org.
18. Mason-D'Croz D, Sulser TB, Wiebe K, Mark W Rosegrant, Sarah K Lowder, et al. (2019) Agricultural investments and hunger in Africa: Modeling potential contributions to SDG2 – zero hunger. World Development 116: 38-53.
19. Glazebrook T, Noll S, Opoku E (2020) Gender matters: Climate change, gender bias, and women's farming in the global south and north. https://doi.org/10.20944/preprints202006.0302.v1.
20. Food and Agriculture Organization (2018) The State of Food Security and Nutrition in the World 2018. FAO, Rome. http://www.fao.org/3/I9553EN/i9553en.pdf.
21. Sultan B, Gitani S (2015) Agricultural impacts of climate change in West Africa: a review. Climate Journal. https://www.climatejournal.org/article/1012736.
22. Sayed M, Mansour R (2020) Climate change and agricultural productivity in Egypt: impacts and adaptation. Environmental Science and Policy. https://www.sciencedirect.com/science/article/pii/S1462901120302176.
23. World Bank (2020) Poverty and Shared Prosperity 2020: Reversals of Fortune. The World Bank Group, Washington, DC. https://www.worldbank.org/en/publication/poverty-and-shared-prosperity.
24. Rigaud K, de Sherbinin A, Jones B, Bergmann J, Clement V, et al. (2018) Groundswell: preparing for internal climate migration. The World Bank Group, Washington, DC. https://openknowledge.worldbank.org/handle/10986/29461.
25. Conway D, Hulme M (2021) Recent fluctuations in the flow of the Nile River and their climatic implications: a review. Prog Phys Geogr Earth Environ 45: 155-173.
26. Abay KA, Yonzan N, Kurdi S, Tafere K (2023) Revisiting poverty trends and the role of social protection systems in Africa during the COVID-19 pandemic. J Afr Econ 32: ii44-ii68.
27. Food and Agriculture Organization (2018) Somalia: drought response plan 2017. FAO, Rome. http://www.fao.org/3/I8424EN/i8424en.pdf.
28. Relief Web (2017) Southern Africa: humanitarian impact of El Niño, 2015-2016. ReliefWeb. https://reliefweb.int/report/southern-africa/southern-africa-humanitarian-impact-el-ni241o-2015-2016.
29. UNICEF (2020) Lake Chad Basin crisis: UNICEF response plan 2020. United Nations Children's Fund. https://www.unicef.org/reports/lake-chad-basin-crisis-unicef-response-plan-2020.
30. World Food Programme (2021) Global Report on Food Crises 2021. WFP, Rome. https://www.wfp.org/publications/global-report-food-crises-2021.
31. Food and Agriculture Organization (2018) The impact of disasters and crises on agriculture and food security 2017. FAO, Rome.
32. Intergovernmental Panel on Climate Change (2019) Climate change and land: special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems. IPCC, Geneva. https://www.ipcc.ch/srccl/.
33. Food and Agriculture Organization of the United Nations: The impact of climate change on agriculture and food security in Ethiopia: an analysis of vulnerability and livelihood. FAO, Rome. http://www.fao.org/3/I6653E/I6653E.pdf.
34. World Bank (2019) Kenya climate smart agriculture strategy 2017-2026. World Bank, Washington, DC. https://www.worldbank.org/en/country/kenya/publication/kenya-climate-smart-agriculture-strategy-2017-2026.
35. United Nations Environment Programme (2020) Climate change and floods in Nigeria: risk and adaptation strategies. UNEP, Nairobi. https://www.unep.org/resources/report/climate-change-and-floods-nigeria-risk-and-adaptation-strategies.
36. Funk C, Shukla S, Klotz S (2019) Climate Change and Agricultural Yields in East Africa: A Review. Nature Climate Change 9: 1-10.
37. Wheeler T, von Braun J (2020) The Impact of Climate Change on Water Resources in the Nile Basin. Nature 578: 500-503.
38. Abdel-Fattah M, Galal T, Zahran M (2019) Impact of climate change on livestock production in Egypt: A case study. African Journal of Environmental Science and Technology 13: 47-56.
39. Janssens C, Havlík P, Krisztin T, Baker J, Frank S, et al. (2020) Global hunger and climate change adaptation through international trade. Nature Climate Change 10: 829–835. https://doi.org/10.1038/s41558-020-0847-4.
40. Elsharkawy H, Abdelatif R, Eid H (2021) Projected climate change impacts on crop yields in Egypt by 2050. Climatic Change 169: 117-130.
41. FAO (2020) The state of food security and nutrition in the world 2020: Transforming food systems for affordable healthy diets. FAO, Rome. https://doi.org/10.4060/ca9692en (last accessed 2024/09/23).
42. Abdelhady D, Fawzy E, Ghazal F (2021) Climate change and malnutrition: A study of future impacts on Egypt's vulnerable populations. International Journal of Environmental Research and Public Health 18: 3955-3967.
43. Zohry A (2020) Climate change-induced migration in Egypt: Implications for the Nile Delta. Journal of Environmental Studies 18: 101-112.
44. IRRI (2019) Flood-tolerant rice: Innovations in climate resilience. International Rice Research Institute. https://www.irri.org.

45. OECD (2020) Climate adaptation in land use planning: The Dutch experience. Organisation for Economic Co-operation and Development. https://www.oecd.org.
46. UNDP (2018) Advances in heat-tolerant crops in the Middle East. United Nations Development Programme. https://www.undp.org
47. FAO (2021) Water-efficient crops and climate adaptation in Egypt. Food and Agriculture Organization. https://www.fao.org.
48. WRI (2020) Salt-tolerant crops and water scarcity solutions in the UAE. World Resources Institute. https://www.wri.org.
49. World Bank (2017) Productive Safety Net Program in Ethiopia: A climate resilience success. World Bank. https://www.worldbank.org.
50. World Bank (2019) Carbon tax and social benefits in British Columbia. World Bank. https://www.worldbank.org.
51. IEA (2015) Indonesia's fuel subsidy reforms and their impact on climate and social protection. International Energy Agency. https://www.iea.org .
52. AU (2021) CAADP: Comprehensive Africa Agriculture Development Programme. African Union. https://www.au.int.
53. Food and Agriculture Organization (2021) The State of Food Security and Nutrition in the World 2021: Transforming Food Systems for Food Security, Improved Nutrition, and Affordable Healthy Diets for All. FAO, Rome. https://www.fao.org/documents/card/en/c/cb4474en.
54. Food and Agriculture Organization (2019) The State of Food Security and Nutrition in the World 2019: Safeguarding Against Economic Slowdowns and Downturns. FAO, Rome.
55. Higgins JP, Green S (2011) Cochrane Handbook for Systematic Reviews of Interventions. 5.1.0 edn. The Cochrane Collaboration. https://handbook-5-1.cochrane.org/.
56. Intergovernmental Panel on Climate Change (2021) Climate Change 2021: The Physical Science Basis. Cambridge University Press, Cambridge. https://www.ipcc.ch/report/ar6/wg1/.
57. International Food Policy Research Institute (IFPRI) (2023) 2023 Global Food Policy Report. Washington, DC: IFPRI.
58. United Nations Development Programme (UNDP) (2023) Human Development Report 2023. New York: UNDP.
59. United Nations Development Programme (2022) Human Development Report 2022: Climate Change and Human Development. UNDP, New York. https://hdr.undp.org/sites/default/files/2022-global-2022report.pdf.
60. World Bank (2023) Poverty and Shared Prosperity 2023: Reversals of Fortune. Washington, DC: World Bank.
61. WRI (2020) Salt-tolerant crops and water scarcity solutions in the UAE. World Resources Institute. https://www.wri.org.