



GLOBAL
CENTER ON
ADAPTATION

State and Trends in Adaptation Report 2022

Adaptation at the core of a prosperous
Africa in an uncertain and warming world

Conference edition

This work is a product of the staff of the Global Center on Adaptation (GCA) with external contributions. The findings, interpretations, and conclusions expressed in this work do not necessarily reflect the views of GCA, its Executive Board, Supervisory Board, Advisory Board, or any of its donors. The individuals mentioned herein contributed to the production of the publication. Authors and reviewers contributed in their individual capacities and their affiliations are mentioned for identification purposes only.

GCA has taken all reasonable precautions to verify the information contained in this publication. However, the published material is being distributed without warranty of any kind, either expressed or implied. GCA does not guarantee the accuracy of the data included in this work. The responsibility for the interpretation and use of the material lies with the reader. In no event shall GCA be liable for damages arising from its use.

References to specific companies does not imply that they are endorsed or recommended by GCA, or that those companies are referred to in preference to others not mentioned.

The boundaries, colors, denominations, and other information shown on any map in this work do not imply any judgment on the part of the GCA concerning the legal status of any territory or the endorsement or acceptance of such boundaries.

The contributors have not endorsed nor are they responsible for the content of the full reports.

Report Direction and Preparation

The State and Trends in Adaptation 2022 report was co-directed by Ede Jorge Ijjasz-Vasquez (Senior Advisor) and Jamal Saghir (Senior Advisor). The reports were prepared with the support of numerous knowledge partners, institutions, researchers, and practitioners who brought their best expertise from diverse technical and policy perspectives. We wish to acknowledge their contributions.

The co-directors appreciate the support of Julia Eichhorn and Daniel Flores for report coordination; Chandrahas Choudhury, Marion Davis, and John Carey for report editing; and Green Ink for report design, layout, and proofreading.

We would like to thank Professor Patrick Verkooijen, CEO of the Global Center on Adaptation, for his valuable contribution and leadership.

Except otherwise noted,* the reuse of this document is authorized under a Creative Commons Attribution 4.0 International (CC-BY 4.0) license (<https://creativecommons.org/licenses/by/4.0/>). Users may copy, distribute, display, perform, and make derivative works and remixes based on it provided that appropriate credit is given and any changes are indicated. For any use or reproduction of elements that are not owned by GCA, permission may need to be sought directly from the respective rightsholders.

* Figures and tables sourced from other documents and all photographs are excluded from the CC-BY 4.0 licensing.

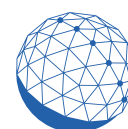
© Global Center on Adaptation (GCA) 2022 CC-BY 4.0

Suggested citation: Global Center on Adaptation. 2022. State and Trends in Adaptation Reports 2021 and 2022: Executive Summaries and Syntheses. Rotterdam and Abidjan.

ISBN (print): 9789083293370

ISBN (PDF): 9789083293387

Cover photo: Trials of CIAT-improved "magic beans" in Malawi, which have performed well despite the worst drought in three decades (Photo: CIAT/NeilPalmer)



Contents

Advisory Committee	2
Foreword	6
Executive Summary	8
Synthesis	24
Climate Risks in Africa	78
Section 1 – Economics and Finance	92
Overview	94
Adaptation Finance Flows in Africa	96
Insert – Fiscal Policies for Adaptation: IMF Perspective	120
Financial Instruments in North Africa	126
Climate Risk Regulation in Africa	142
Resilient Recovery – Senegal and Côte d'Ivoire	152
The Private Sector	166
Access to Global Climate Finance – The Technical Assistance Program	182
Section 2 – Sectors	196
The Africa Adaptation Acceleration Program (AAAP)	198
Livestock	224
Innovation in Agriculture	244
Urban Informality	266
City Resilience	286
Insert – Adaptation in the Desert to Power Program	306
Nature-based Solutions in Agroforestry	310
Blue Economy	320
Coastal Erosion	332
Insert – The World Bank's Country Climate and Development Report for the G5 Sahel Countries	354
Section 3 - Cross-Sectoral Themes	358
Locally Led Adaptation	360
Education	384
Institutional Arrangements for Adaptation	404
Youth and Entrepreneurship	418
Security	438
Insert – Migration and Climate Change	458
The Unfinished Research Agenda in Adaptation	470
Annexes	478
Country Profiles	480
Endnotes	500



Acknowledgements

THE ADVISORY COMMITTEE TO THE GLOBAL CENTER ON ADAPTATION

The Advisory Committee to the Global Center on Adaptation (GCA) provides guidance on issues, including the content of this report, and identifies and engages with partners. Advisors offer support in their individual capacities. The contents and recommendations of the report do not necessarily reflect their views or those of the organizations they represent. The Advisory Committee members for the State and Trends in Adaptation Report 2022 are, in alphabetical order:

Jean-Paul Adam, Director for Technology, Climate Change and Natural Resources Management, United Nations Economic Commission for Africa

Carol Chouchani Cherfane, Director, Arab Centre for Climate Change Policies; and Cluster Leader, Climate Change and Natural Resource Sustainability, United Nations Economic and Social Commission for Western Asia

Richard Damania, Chief Economist of the Sustainable Development Practice Group, World Bank Group

Rola Dashti, United Nations Under-Secretary-General; and Executive Secretary, United Nations Economic and Social Commission for Western Asia

Paul Desanker, Manager, National Adaptation Plans and Policy, Adaptation Programme, United Nations Framework Convention on Climate Change

Maxx Dille, Former Director of the Climate Programme, and Climate Coordinator and Deputy Director of Services, World Meteorological Organization



Photo: SilvaPinto1985/iStock

Mark Howden, Vice-Chair, Working Group II on Impacts, Adaptation and Vulnerability, Intergovernmental Panel on Climate Change

David Howlett, Advisor, Race to Resilience

Maarten Kappelle, Head, Thematic Scientific Assessments, United Nations Environment Programme

Kevin Kariuki, Vice-President, Power, Energy, Climate and Green Growth, African Development Bank

Rodolfo Lacy, Director for Environment Directorate, Organisation for Economic Co-operation and Development

Marcelo Mena Carrasco, Chief Executive Officer, Global Methane Hub

Alex Mung, Global Director, Water Sustainability, AB InBev

Jiahua Pan, Director, Research Centre for Sustainable Development, Chinese Academy of Social Sciences; and Advisor to the Ministry of Ecology and Environment of China

Sheela Patel, Founder and Director, Society for Promotion of Area Resource Centres; and Founding Member, Slum/Shack Dwellers International

Vera Songwe, Former Executive Secretary, United Nations Economic Commission for Africa

Nigel Topping, High Level Champion, Climate Action, United Nations Framework Convention on Climate Change COP26 Presidency

Elena Visnar Malinovska, Head of Unit A3—Adaptation to Climate Change, European Commission

Dominic Waughray, Senior Advisor to the CEO, World Business Council for Sustainable Development

REPORT DIRECTION AND PREPARATION

The State and Trends in Adaptation 2022 report was co-directed by Ede Jorge Ijjasz-Vasquez (Senior Advisor) and Jamal Saghir (Senior Advisor). It was prepared with the support of numerous knowledge partners, institutions, researchers, and practitioners who brought their best expertise from diverse technical and policy perspectives. We wish to acknowledge their contributions to this report.

The co-directors appreciate the support of Julia Eichhorn and Daniel Flores for report coordination, Chandradas Choudhury, Marion Davis, and John Carey for editing, and Green Ink for design, layout, and proofreading.

We would like to thank Professor Patrick Verkooijen, CEO of the GCA, for his valuable contribution and leadership.

REPORT AUTHORS

Chapters

Access to Global Climate Finance – The Technical Assistance Program: Maria Tapia, Dethie Ndiaye, Ali Hider (GCA)

Adaptation Finance Flows in Africa: Morgan Richmond, Bella Tonkonogy, Rajashree Padmanabhi, Angela Ortega Pastor, Neil Chin, Chetan Hebbale (Climate Policy Initiative [CPI])

Blue Economy: Pierre Failler, under the supervision of The United Nations Economic Commission for Africa (UNECA)

City Resilience: Christopher Chung, Ase Johannessen, Joep Verhagen (GCA)

Climate Risk Regulation in Africa: Maria Tapia, Dethie Ndiaye, Ali Hider, Jamal Saghir (GCA)

Climate Risks in Africa: Julia Eichhorn, Daniel Flores (GCA)

Coastal Erosion: Sergio Vallesi, Sam Paquier (Hydro Nexus), with support and review by Peter Kristensen, Nicolas Desramaut, Manon Pascale Cassara, Sarah Jung, Idriss Deffry, Sajid Anwar, Juan Jose Miranda Montero, Suiko Yoshijima, Pablo Ahijado Aparicio, Kanako Hasegawa (World Bank Group [WBG])

Education: Christina Kwauk, Ludwig Chanyau, Martina Grecequet, Liesbet Steer (The Education Commission)

Financial Instruments in North Africa: Katharina Lehmann-Uchner (United Nations Economic and Social Commission for West Asia [ESCWA]), Jamal Saghir (GCA)

Innovation in Agriculture: Jane Silverthorne, Marcus Glassman (Supporters of Agricultural Research Foundation [SoAR])

Institutional Arrangements for Adaptation: Daniel Flores, Julia Eichhorn, Ede Jorge Ijjasz-Vasquez (GCA)

Livestock: Polly Ericksen, Chris Jones, Karen Marshall, Isabelle Baltenweck, Rupsha Banerjee, Todd Crane, Bernard Bett, Steve Kemp, Iain Wright (International Livestock Research Institute [ILRI]), Alan Duncan (ILRI and University of Edinburgh), Paula Dominguez-Salas (ILRI and University of Greenwich), Charlie Pye-Smith, Philip Thornton

Locally Led Adaptation: Anju Sharma (GCA), Aditya Bahadur, Dave Steinbach (International Institute for Environment and Development [IIED])

Nature-based Solutions in Agroforestry: Ian Noble (GCA)

Resilient Recovery: Senegal and Côte d'Ivoire: Moulaye Bamba (under the supervision of The United Nations Economic Commission for Africa [UNECA]), Julia Eichhorn, Daniel Flores (GCA)

Security: Tom Middendorp (International Military Council on Climate and Security and European Defence Cooperation), Laura Birkman (The Hague Center for Strategic Studies), Elsa Barron (The Center for Climate and Security)

The Africa Adaptation Acceleration Program (AAAP): Charles Nhemachena, Amanda Archibong, Estelle Nikiema, Anthony Nyong, Oluyede Clifford Ajayi, Ajilore Oluwabunmi, Sèlidji Hermann Tossou, Danilo Cancado, Nitin Jain, Joep Verhagen, Christopher Chung, Aramide Abe, Adeyemi Onafuye, Daniel Flores, Julia Eichhorn, Maria Tapia (GCA); Aliou Gori Diouf, Fadekunayo Adeniyi, Joash Ntenga Moitui, Baba Mustafa Marong, Margaret Kamau, Edith Ofwona Adera (African Development Bank [AfDB])

The Private Sector: With input from: Romain Paniagua, Hauke Engel (McKinsey & Company), Marta Calore, Romana Pilepich, Sarah Lewis (Vivid Economics)

The Unfinished Research Agenda in Adaptation: Fleur Wouterse (GCA)

Urban Informality: Louise Fox (The Brookings Institution), Danielle Resnick (The Brookings Institution), Aba Amisshah Quainoo (Micro Enterprise Linkage [MEL] Consulting Ltd), Chris Heitzig, Susan Narthey

Youth and Entrepreneurship: Daniel Flores, Julia Eichhorn, Adeyemi Onafuye, Aramide Abe (GCA)

Synthesis

Jamal Saghir (GCA)

Annex

Country Profiles: Julia Eichhorn (GCA)

In memory of:

Our Advisory Committee member Raffaele Mauro Petriccione, and the author of the Agricultural Innovation chapter, Jane Silverthorne from SoAR, may this publication make them proud.

Donors that funded this report

Norwegian Agency for Development Cooperation (NORAD)

Swedish Ministry of Foreign Affairs

The Netherlands Ministry of Infrastructure & Water Management

Donors that support GCA

Multilateral and bilateral donor agencies

Agence française de développement

African Development Bank

Danish Ministry of Foreign Affairs

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

United Kingdom Foreign, Commonwealth & Development Office

Foundations

Bill & Melinda Gates Foundation

Gordon and Betty Moore Foundation

Other Institutions

City of Groningen

City of Rotterdam

CVF & V20 Joint Multi-Donor Fund

European Commission European Research Executive Agency

United Nations Environment Programme (UNEP-FI)

United Nations Office of Project Services

Organizations that provided support in the past

Minister of Environment and Climate Change Canada (ECCC) (prior to 2021)

International Development Research Centre (prior to 2021)



Photo: Stefano Barzellotti/Stock



Livestock

KEY MESSAGES

- Livestock accounts for around 55 percent of total household income in pastoral systems in Africa and 35 percent for mixed crop-livestock systems, it is also used for tasks like plowing.
- Rising temperatures, changing precipitation patterns, and an increase in extreme weather events mean there is an urgent need to develop adaptation measures for Africa's livestock farmers. Modeling studies suggest that under higher greenhouse gas emission scenarios, global cattle production losses from heat stress alone could amount to nearly US\$40 billion per year by 2085—equivalent to 9.8 percent of the value of production of milk and meat from cattle in 2005. Under lower emission scenarios, losses could amount to nearly US\$15 billion.
- Adaptation of livestock will require a combination of different interventions, some having to do with the animals themselves (breeding, pest management) and others about land management and the development of financial instruments to deal with climate risk.
- Although livestock is a key component of mixed crop-livestock systems, most climate change adaptation work has focused solely on the crop side. There is little direct information on the cost of implementing large-scale livestock adaptation programs in Africa. The research base required



Photo: Kandukuru Nagarjun

for building climate-resilient livestock systems is underdeveloped and needs greater support.

- A few adaptation actions of direct relevance to livestock systems include implementing early warning systems and adaptive safety nets for farmers in climate risk hotspots and taking climate services to scale by connecting millions of farmers and agribusinesses to ICT-enabled bundled advisory services by 2030.

“

I believe that the Africa Adaptation Acceleration Program is an important part of the solution to make the food systems more resilient and to make them better placed to cope with the next drought, or the next flood, or the next plague. At the same time, we can create jobs for new generations, based on strengthening African value chains.”

Anne Beathe Tvinnereim

Minister of International Development of Norway

INTRODUCTION

Livestock plays a crucial role in the economic and social life of Africa, supplying meat and milk for food and commerce, generating a large part of household incomes, fulfilling many functions, and occupying a range of niches within both pastoral and mixed-crop systems. Livestock is especially crucial to smallholder farming and therefore deserve a special focus when it comes to adaptation.

This chapter is organized into five sections. After a description of the importance of the livestock sector for Africa in Section 1, Section 2 presents the impact of climate change on livestock. Section 3 describes some of the most promising technical interventions to strengthen adaptation and resilience in the livestock sector. Section 4 presents estimates of the cost of adaptation inaction and action in livestock. Section 5 concludes with some policy recommendations.

WHY LIVESTOCK MATTERS

This introductory section presents the role of livestock in food and nutritional security, the economic and social importance of livestock in Africa, and the specific livestock systems in North and Sub-Saharan Africa.

The Role of Livestock in Food and Nutritional Security

Livestock products are a valuable source of proteins and micronutrients and play a key role in providing a balanced and healthy diet. However, meat consumption in Africa is modest and particularly low in areas where there is widespread malnutrition. In Southern Africa, it is around 80 kg per person per year, compared to over 400 kg in the United States. In Central Africa, per capita consumption is just over 20 kg. In West Africa, it is approximately 35 kg.¹

Between 1973 and 2013, per capita meat consumption in Sub-Saharan Africa rose from just 13.7 kg to 16.2 kg. But it is expected to increase over the next decades, driven by population growth, urbanization, and rising living standards.² One estimate suggests that the demand for meat in Africa will triple by 2050.³ This will have significant implications for production and trade.

The Economic and Social Importance of Livestock

A 2009 review of case studies in Sub-Saharan Africa and South Asia found that livestock accounted for around 55 percent of total household income in pastoral systems and about one-third in mixed crop-livestock systems, which also use the animals for tasks such as plowing.⁴ Livestock animals perform an essential function by converting plant biomass into nutrient-dense manure. They also play important cultural roles. For instance, sharing livestock can create or strengthen social relationships when used as a dowry or bride price.⁵

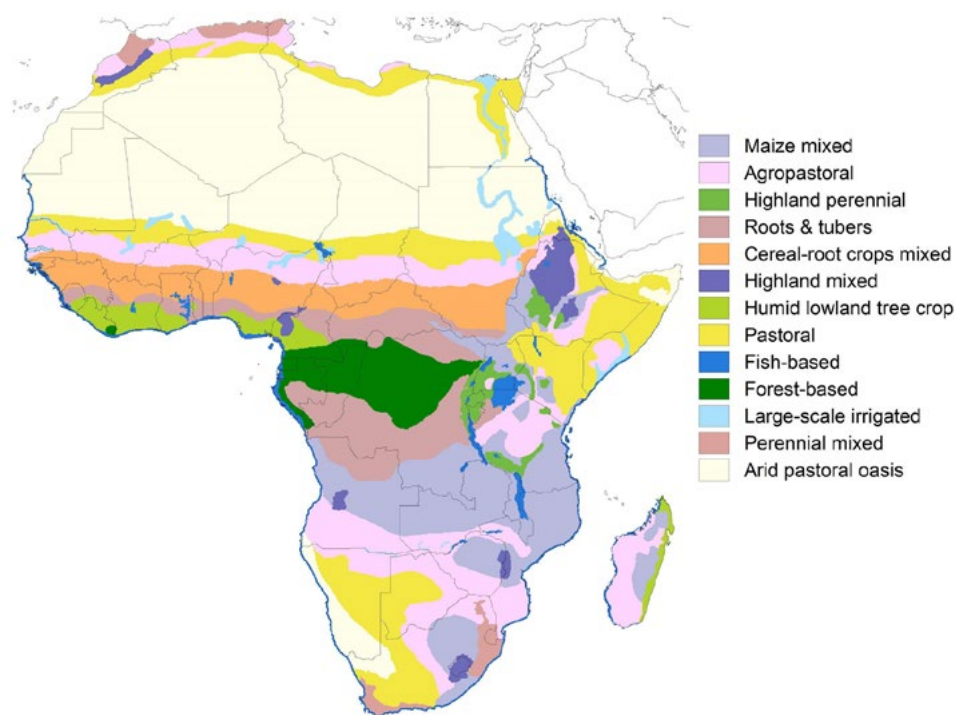
Over much of Africa livestock is one of the few assets that rural women can own.⁶ However, even within the sector women find themselves at a significant disadvantage. They tend to keep fewer animals than men, which are likely to be poultry and small ruminants rather than cattle or camels. While men dominate the more important and lucrative roles of herding and marketing, women are often left with the tasks of milking, feeding, and looking after sick animals.⁷

Trade in livestock and livestock products in Africa is hampered by modest production levels, the failure to achieve global Secure Beef Supply (biosafety) standards, poor infrastructure, and low investment. In 2020, Africa's livestock imports were worth over US\$10 billion, compared with US\$3.2 billion in exports. Of the latter, US\$1.3 billion of livestock products (mostly in the form of cattle, buffalo, and live animals) were traded within the continent, while US\$1.8 billion of products (primarily sheep and cheese) were exported elsewhere.

Livestock Systems in North and Sub-Saharan Africa

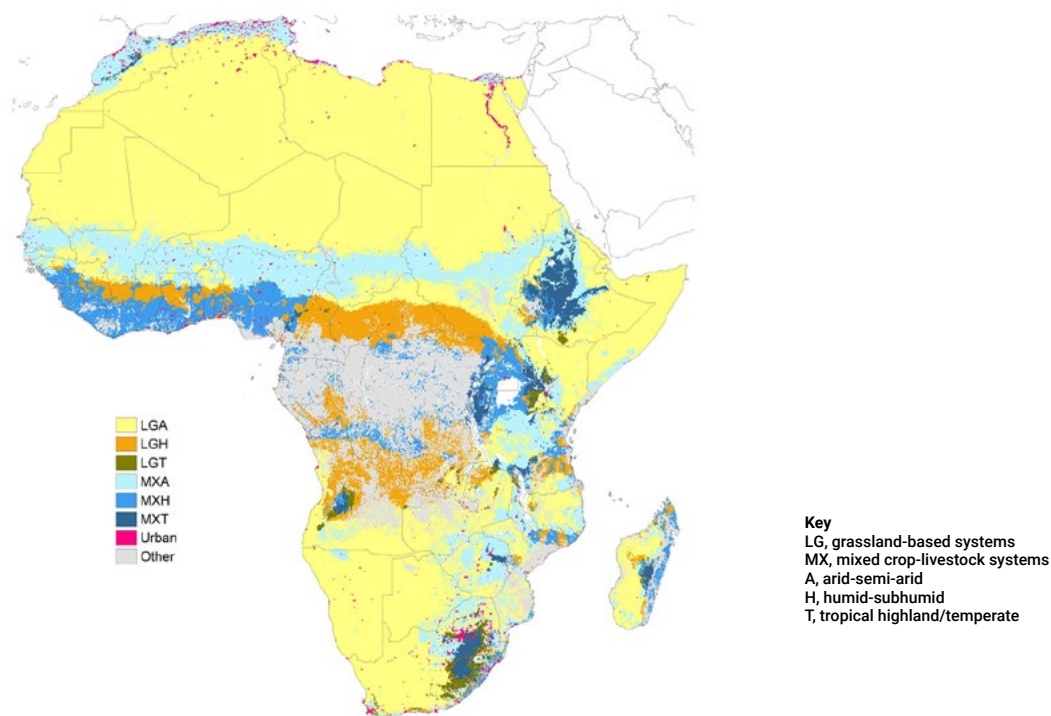
There are an estimated 46 million farms in Africa, the vast majority less than 2 hectares in size.⁸ They support an agricultural population of some 580 million people. No other continent possesses such a diversity of farming systems as Africa. Figures 1 and 2 show two approaches to mapping and characterizing African farming systems. The first defines 13 major farming systems, based mostly on access to resources and services.⁹ Livestock feature strongly in most of these farming systems. The second is a system of classification based on whether livestock is mostly kept in grassland-based systems or in mixed crop-livestock systems.¹⁰

Figure 1. Farming System Distribution in Africa



Source: Dixon et al., 2019¹¹

Figure 2. Livestock Distribution in Africa



Source: Robinson et al., 2011¹²

The variety of agroecological zones in Africa is mirrored by the diversity of livestock breeds.¹³ There are thought to be over 180 different breeds of cattle, each adapted to a particular environment and management system. Many local breeds are resistant to diseases that can otherwise cause huge economic losses. For example, N'Dama cattle do not suffer from trypanosomiasis. Most breeds of zebu cattle (*Bos indicus*) cope better with high temperatures than taurine cattle (*Bos taurus*) and exotic breeds. Unfortunately, poorly planned crossbreeding programs have led to genetic erosion and there is a serious risk that some breeds—and genes that favor, for example, heat tolerance and disease resistance—will be lost.

Livestock systems provide high levels of both formal and informal employment. A notable example of the former is the dairy sector in Kenya, which sustains some 3 million jobs, or 15 percent of the labor force.¹⁴ In areas where the agricultural systems are focused entirely on livestock the rearing of cattle, camels and small ruminants often provides the main form of

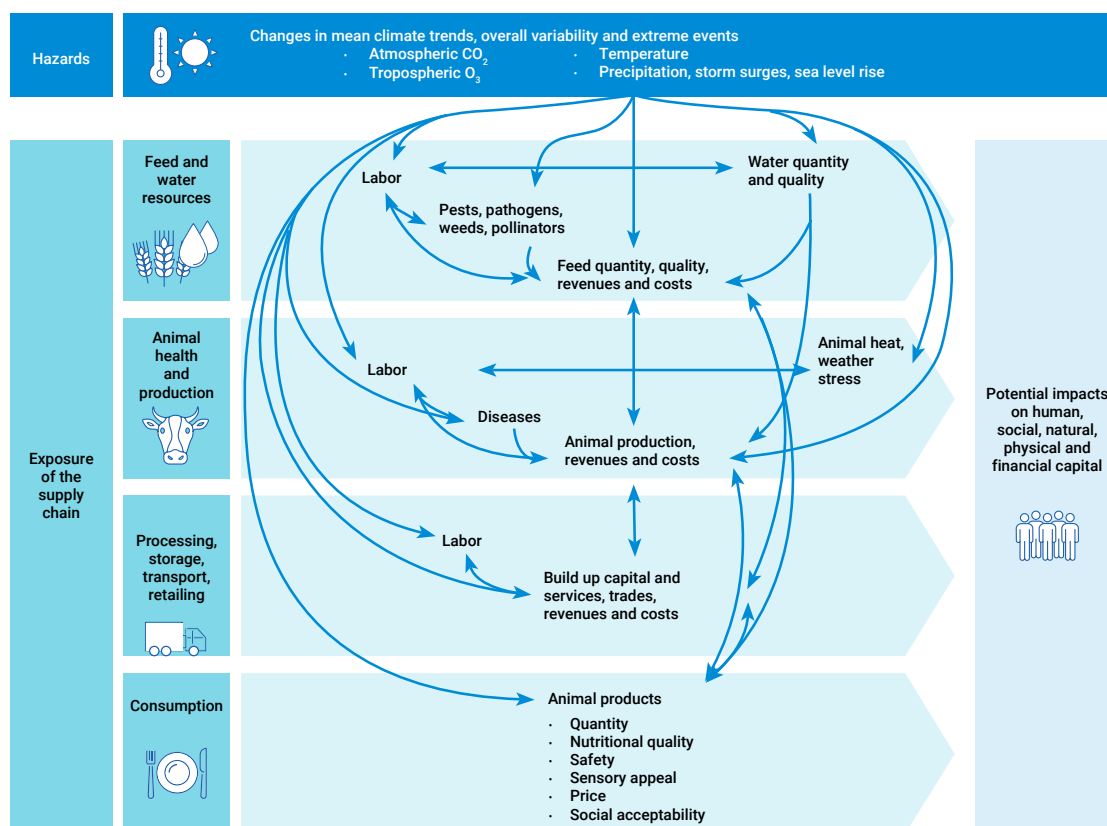
employment. About 40 percent of urban households in Africa are engaged in farming practice, often involving livestock.¹⁵

THE IMPACT OF CLIMATE CHANGE ON LIVESTOCK

The impact of climate change on livestock farming will have far-reaching consequences for national economies and the livelihoods and welfare of hundreds of millions of people in Africa. The impacts of climate change on livestock are presented in this section along five dimensions: heat stress, crops and grasslands, pests and diseases, food security, and household income.

Heat stress will have a major influence on productivity and changes in temperature, and rainfall will affect feed quantity and quality and the prevalence of livestock diseases. These disruptions will in turn have several knock-on effects, for example on gender differences in the way livestock and livestock products are owned and managed, or on the way mixed crop-livestock farming systems are run. Figure 3 summarizes the breadth of the impacts on livestock.

Figure 3. Potential Impacts of Climate Change on Livestock



Source: Godde et al., 2021¹⁶

Box 1. Livestock: Mitigation Co-Benefits of Adaptation



Mitigation as an issue preceded adaptation in the livestock sector, given northern donors' concern about greenhouse gas (GHG) emissions from livestock. This has slowed progress on adaptation to climate change for livestock production, as funding strategies for long-term adaptation in the sector have been slow to materialize. Critically, many countries have advanced targets for reducing GHG emissions but have very few specific targets for adapting their livestock sectors to climate change. As shown in this chapter, this bias toward mitigation actions poses major risks for the future

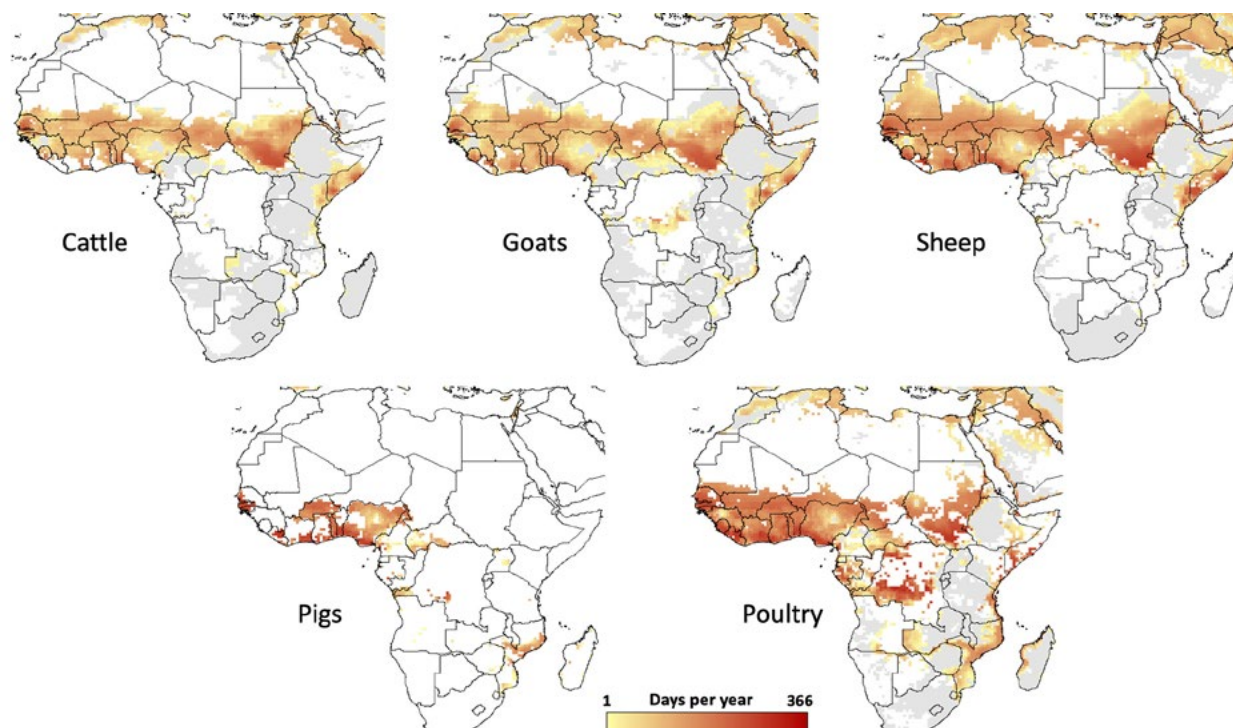
of the livestock sector. A different way to look at the solution is to understand that most adaptation interventions have mitigation co-benefits. This is because adapting livestock production to climate change will improve productivity, and improvements in productivity reduce GHG emissions intensities. For example, improved feed baskets that are adapted to hotter conditions will also reduce GHG emissions intensities. Helping to adapt livestock to new disease patterns will also reduce emissions intensities by maintaining productivity.¹⁷

Heat Stress

The effects of heat stress include reduced productivity, compromised animal welfare, reduced fertility, increased susceptibility to disease, and in extreme cases higher mortality. Heat stress affects all domesticated species, although different animals respond in different ways, depending on factors such as species, breed, age, genetic potential, physiological status, nutritional status, animal size, and previous exposure.¹⁸

Recent projections of changes in the Temperature Humidity Index (THI), a widely used proxy for heat stress in livestock, are shown in Figure 4 for the five major domesticated livestock species.¹⁹ Considerable increases are projected in the number of "extreme stress" days per year for cattle, chicken, goat, pig, and sheep populations in West and Central Africa. Projected changes in extreme stress in Southern Africa and substantial parts of East Africa are more muted. For North Africa, a large proportion of the cattle, goat and sheep populations will be affected by an increase in extreme heat stress.

Figure 4. Change in the Number of Days Per Year Above “Extreme Stress”: Values from 2000 to the 2090s for SSP5-8.5



Source: Redrawn for Africa from Thornton et al., 2021.²⁰ Data mapped for each species' current global distribution from Gilbert et al., 2018.²¹ Gray areas show no change from zero.

Possible economic losses in cattle meat and milk production in Africa are summarized in Table 1 and mapped in Figure 5. The losses projected for Africa

are about four times those of the global averages (red numbers in Table 1).

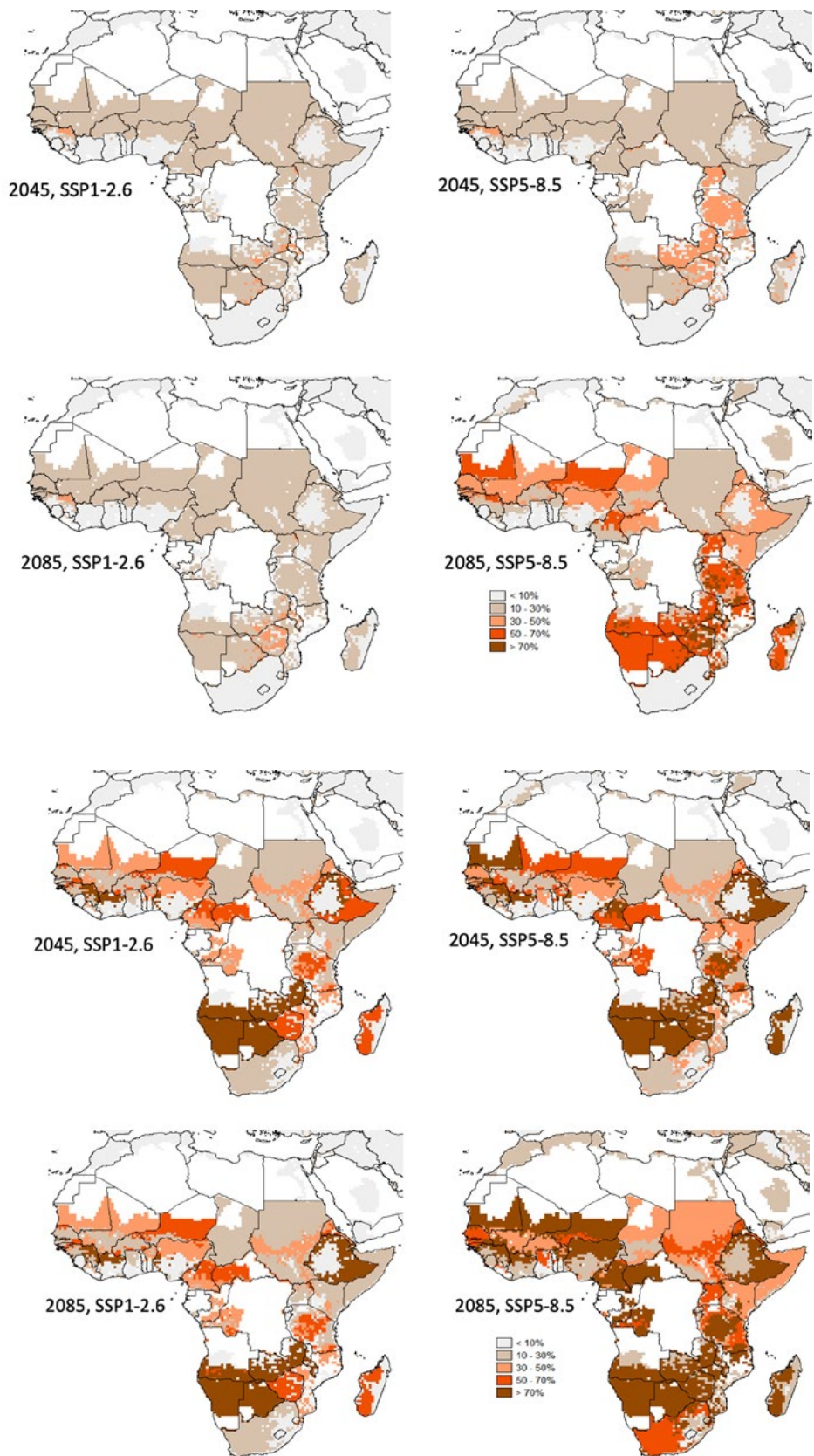
Table 1. All-Africa Losses in Cattle Milk and Meat Production Due to Heat Stress Compared with 2005 Production

Scenario and year	Milk losses		Meat losses	
	US\$ million	Percent	US\$ million	Percent
SSP1-2.6, 2045	708	9.3	2,508	20.8
		1.7		5.3
SSP1-2.6, 2085	725	9.6	2,561	21.2
		1.7		5.4
SSP5-8.5, 2045	942	12.3	3,255	26.8
		2.2		7.1
SSP5-8.5, 2085	1,773	22.3	6,146	46.0
		4.7		14.4

Source: Thornton et al., 2022.²²

Note: Costs are in constant 2005 USD. Percentages in red are the percentage of global losses.

Figure 5. African Country-by-System Value of Milk Production (left panel) and Meat Production (right panel): Loss Compared with 2005



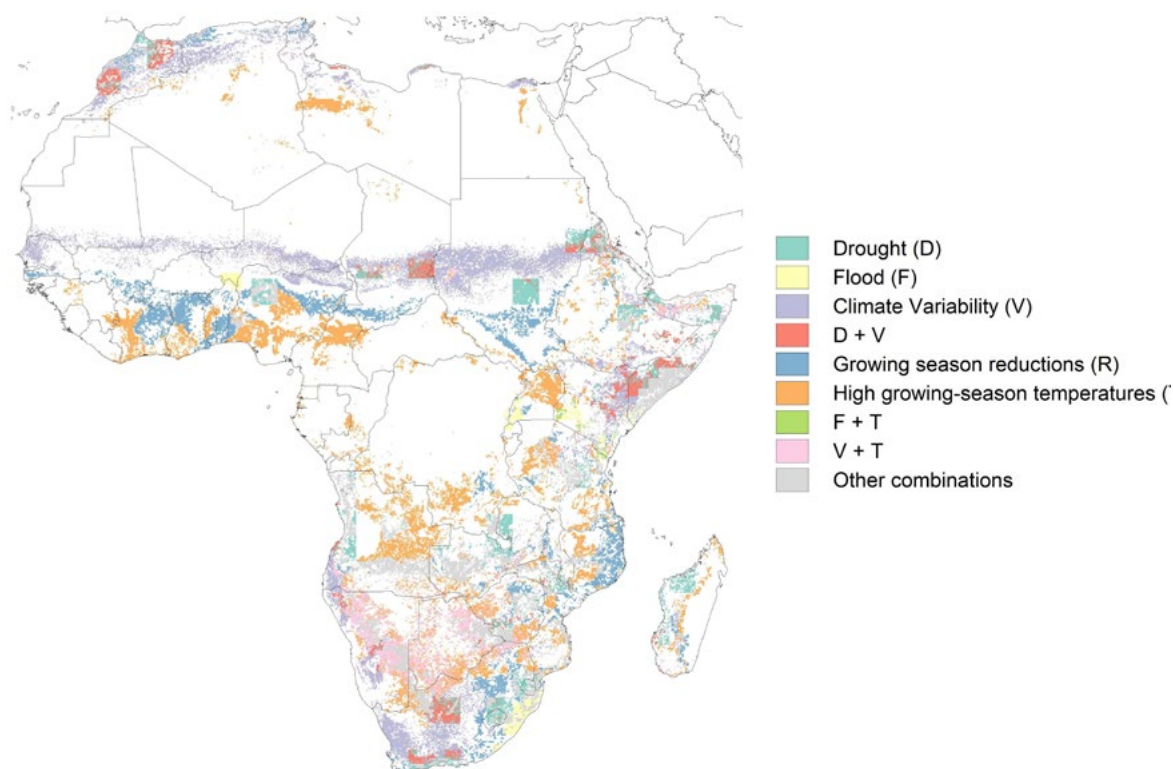
Source: Thornton et al., 2022.²³

Crops and Grasslands

Over large parts of Africa, climate change is already having a profound impact on the distribution and quantity of rain, on the timing of wet and dry seasons,

and on the frequency and severity of extreme events such as droughts and floods. The key climate hazards in Africa are shown in Figure 6.²⁴

Figure 6. Current and Future Climate Hazards in Africa



Source: Redrawn for Africa from Jarvis et al., 2021²⁵

Climate change is likely to have a significant impact on livestock feed availability through a range of mechanisms.²⁶ Higher concentrations of CO₂, in conjunction with increases in temperature and rainfall, may have a positive impact on productivity and could lengthen the growing season in temperate and tropical highland zones.²⁷ However, these positive effects are countered by climate change stresses such as increased temperature, and the increased scarcity of water during droughts and excess during floods. Because of the reliance of livestock on food crop by-products, such as straw and stovers, and on grains, the effects of climate change on livestock feed supply will largely mirror those for human

food supply. In general, the direction of change for growing food and feed crops is likely to be positive in temperate regions and negative in tropical regions.²⁸

As with food crops, the effect of climate change on grassland productivity relates to the balance between various competing factors. CO₂ fertilization could potentially enhance net primary productivity, but this will be countered by increasing aridity in some regions, including the Mediterranean and Sub-Saharan Africa. Grasslands are made up of diverse botanical assemblages and this lends them a degree of stability and resilience. Changing climatic conditions will doubtless influence their botanical

composition, without necessarily causing a decline in productivity.

Ruminant systems are inherently seasonal, transferring nutrients from periods of scarcity to periods of abundance, either through conserving nutrients such as hay, straw, or silage, or by storing energy in livestock animals themselves through fat deposition.²⁹ The efficiency of these systems varies by region. Those with the greatest seasonality of feed supply, especially in the tropics, are likely to be most vulnerable to changes in rainfall patterns and an increase in the incidence of drought.

Droughts lead to a decrease in productivity and longer herd-recovery times, and there is a strong relationship between persistent drought and animal deaths. The impacts of increasing seasonality and intra-annual variability of rainfall on animal stocking rates have not been widely studied, but these may be considerably greater than those caused by changes in mean rainfall.³⁰ Extreme climate events are also likely to disrupt trade patterns and damage infrastructure and transport.

Pests and Diseases

Climate change will affect the prevalence and damage caused by pests and diseases of livestock. The effects are likely to be location-specific and they will vary over time as climate change becomes more pronounced.³¹ Climate change is already having an impact. For example, changes in temperature and changing patterns of rainfall have increased the susceptibility of livestock to East Coast fever in the Northern and Eastern Cape of South Africa and in other areas south of the Democratic Republic of the Congo. Because of the links between Rift Valley fever outbreaks and El Niño–Southern Oscillation (ENSO) events, shifts are likely to occur in the range of outbreaks by mid-century as well as in its spread to new areas.

Climate change could have a significant impact on disease vectors such as the tsetse fly, mosquitoes, and midges, with changes in rainfall and temperature leading to a change in their abundance and distribution. For example, the geographical range of 50 percent of tick species in Africa could expand



in the future.³² Climate change could also alter the transmission rate of diseases either directly, by affecting the survival of pathogens and parasites, or indirectly, by affecting transport and trade patterns.³³

There is some concern that climate change could undermine existing biological control systems whereby one species helps to keep another at bay. The increase in extreme weather events could also have a significant impact. Recent outbreaks of the desert locust in East Africa were linked to a series of cyclones causing wet and warm conditions. The locusts destroyed some 200,000 ha of cropland in Ethiopia, leading to the loss of over 350,000 tonnes of grain. Their depredations also affected 1.5 million ha of pasture.³⁴

Food Security

The negative impacts of climate change on livestock production will translate into significant food and nutritional security issues. The loss of animal source foods (ASF) in diets will affect vulnerable and malnourished groups across Africa. As women play a critical role in ensuring equitable household nutrition,³⁵ they must be engaged in the development of adaptive strategies. The existing literature on coping strategies in times of food insecurity suggests that these (e.g. skipping meals, selling off assets) are often detrimental to long-run outcomes.

The quality of ASF may also decline with higher temperatures, as will overall food safety, as pathogens can multiply and food spoils more quickly.³⁶ Short-term solutions include more cold storage (although this is costly) and attention to good food hygiene practices by butchers and processors. Several authors also speculate that the price of ASF will increase if they become scarcer,³⁷ which will have implications for equity and access. The equity considerations that drive nutritional outcomes are considerable in this case, although there is not enough research on why inequity in food security persists, and how climate change may increase this unless deliberate attention is paid, for example, to securing women's economic independence.³⁸

Household Income

The biggest challenge to household incomes will come from the absolute loss of income from livestock production, followed by the increased volatility in prices and market access. The volatility will be due to the greater temporal and spatial variability of production, meaning markets have a much less stable supply. The impacts will play out differently by production system, but the severity really depends on the adaptation options made available.

Although pastoral systems have evolved over centuries to manage climate variability, more recent trends such as land fragmentation and loss of tenure, coupled with severe recurrent droughts, have eroded traditional coping mechanisms. Solutions include insurance and other financial safety nets and restoring rangeland integrity and mobility. In the past decade, investors have promoted livestock market development and schemes to better orient pastoral production toward markets,³⁹ but their long-term impact on climate resilience is still poorly understood.

Although livestock is a key component of mixed crop-livestock systems, most climate change adaptation work has focused solely on the crop side.⁴⁰ While we know that the income from livestock is important in times of shock, there has not been enough research on mixed systems to understand how household incomes may adapt. Some households may turn to keeping more livestock; others may diversify into different crops; others will leave agriculture altogether.



Photo: DisobeyArt/Shutterstock

Box 2. Will Climate Change Bring More Conflict to Dryland Systems?

Much has been written about the possibility that climate change will exacerbate conflict, as it increases weather shocks and extreme conditions.⁴¹ There is particular concern about “fragile” dryland systems with ongoing conflict, such as areas in northern Mali, Chad, Somalia and Sudan, given that competition for resources is one driver of these conflicts.⁴² However, the consensus of expert researchers is that climate change does not cause

conflict directly, especially when assessed against other drivers such as the presence of arms and local and international political events.⁴³ However, climate events are a multiplier or exacerbator of stresses and conflict. It is therefore simplistic to assume that climate change will necessarily increase violent conflict across the board, as conflicts are too embedded in other processes.

ADAPTING TO CLIMATE CHANGE: TECHNICAL INTERVENTIONS

Rising temperatures, changing patterns of precipitation, and an increase in extreme weather events mean there is an urgent need to develop adaptation measures for Africa’s livestock farmers. This will not be achieved by a single strategy, but a combination of different interventions.⁴⁴ These will include developing breeds that are better adapted to high temperatures, new disease threats and other challenges; matching stocking rates with pasture production; improving the quality of diet; and changing management practices.⁴⁵

This section presents adaptation solutions in seven categories: breeding, feed supply and seasonality, feed supply and demand, animal health and disease, rangeland management, climate information systems and financial solutions, and the critical role of women in adaptation solutions.

Breeding for the Future

Africa possesses a wealth of different agroecological zones, each directly influenced by climatic variation. Consequently, the livestock, with over 150 recognized local breeds of cattle, is highly diverse.⁴⁶ The genes responsible for traits such as heat tolerance, disease resistance, and an ability to cope with drought could play a key role in programs designed to develop breeds to cope with climate change.

These adaptation strategies could involve approaches like those used to establish disease resistance in dairy cattle, for example by crossing local zebu breeds resistant to trypanosomiasis with high-yielding exotic breeds. A good example of breeding for heat tolerance comes from the

Caribbean, where the introduction of a “slick hair” gene from indigenous Senepol cattle into Holsteins increased heat tolerance and productivity.⁴⁷

Breeding strategies need to consider how the environment will look in future to ensure that animals reproduce successfully under the new conditions. It will also be important to ensure that the breeds being promoted meet the needs and preferences of both women and men farmers. In some cases, breeding strategies will focus on general robustness, which can be defined as an animal’s ability to carry on doing the various things it needs to do to favor the ability to reproduce, rather than any one particular trait.

Of the 4,000 breeds of domestic livestock recorded in the 20th century, around 16 percent were extinct by 2000. One estimate in 2007 suggested that 20 percent of breeds were at risk, with almost one breed becoming extinct each month.⁴⁸ This genetic erosion needs to be countered urgently to ensure that the genes which could help adapt to climate change are conserved for future breeding programs. The loss of genetic diversity has been primarily caused by the marginalization of traditional farming practices and breeds. Climate change is also having a negative impact on rare indigenous breeds.

Such is the speed of climate change that traditional breeding methods will frequently be too time-consuming to enable breeds to adapt to, for example, rising temperatures or new disease threats. We need to take advantage of new genetic and informatics technologies to become more agile and responsive. Research priorities include identifying the genomic basis of resilience, constructing novel genotypes, and developing innovative reproductive technologies using informatics and highly targeted interventions.

Increasing Feed Supply and Reducing Seasonality Issues

The supply of livestock feed will need to adjust to a changing climate. As it is inherently adaptable, options do exist. The major macronutrients required by livestock can come from a range of sources and the feed industry is accustomed to adjusting based on the availability of different commodities. Changes in the climate will inevitably make such adjustments more commonplace in future. For example, shifts from maize to dryland crops such as sorghum and millet will lead to differences in the mix of crop residues available for livestock.

Recent advances in precise phenotyping, genotyping and related molecular technologies have huge potential to improve the yield and nutritional quality of livestock feed, enhance disease resistance, and improve drought tolerance of forage species. However, they have been minimally applied to date.⁴⁹ Ongoing breeding efforts are already targeting resilience, and these will need to be intensified. For example, breeding programs will increasingly need to focus on drought tolerance.

Breeding for greater water use efficiency (WUE)—defined as the ratio of forage biomass produced per unit of water used, to cope with water-limited

conditions—will be important. Trade-offs exist between WUE and biomass yield, and these will need to be considered. Breeding for pest and disease tolerance will also be important when it comes to maintaining and increasing the productivity of feed crops, not least because climate change is likely to lead to greater pest and disease pressure.

Livestock feeding systems that deliberately incorporate shade options are likely to become increasingly attractive.⁵⁰ Silvopastoral systems that combine pasture with trees are an obvious option. Trees provide shade and by reducing overall temperature also reduce the heat stress that can threaten the productivity and welfare of domestic livestock. Furthermore, deep-rooted trees can provide a source of fodder longer into dry spells than more shallow-rooted grasses and herbs.

Harvesting and managing rainwater can increase water availability and help to maintain feed and forage productivity during the dry season. Small-scale irrigation has enormous potential to smooth seasonal deficits in feed supply and increase overall feed availability in smallholder systems in tropical regions, provided such irrigation is managed sustainably.⁵¹

Matching Feed Supply with Feed Demand

The seasonal scarcity of feed supply already poses significant problems, particularly in tropical latitudes, and this is likely to intensify with the increasing incidence of drought and less certainty in growing seasons. To counter this, better feed conservation and storage methods are required, including better use of hay and silage. Creating denser feeds will facilitate storage and transport.⁵²

Feed production potential varies both temporally and spatially. It is influenced by agro-ecological conditions such as temperature and rainfall and this can lead to feed being abundant in geographic zones where livestock production is unimportant. Obvious solutions to this mismatch include the transportation of feed, and its storage for use in periods of scarcity. However, this can be challenging in places where there are poorly developed livestock feed value chains, a lack of business skills, and a lack of mechanization for processing feed. Interventions to enhance feed business development could significantly improve the resilience of livestock production systems to the effects of climate change.



Photo: GCA



Photo: Dieter Telemans/Panos Pictures

Animal Health and Disease

The most direct impacts of climate change can affect the capacity of animals to ward off infection. For example, heat-stressed animals are less productive and have weakened immune systems, although this varies by breed and species. With severe heat stress, mortality can increase. Heat stress can also decrease reproductive capacity and milk yields.⁵³ Simple interventions to keep animals cool include shelter from roofed sheds or trees; these can be easily incorporated into current mixed and extensive systems. Selective breeding to tolerate greater heat stress is a longer-term solution, as discussed above.

The distribution of disease vectors and pathogens will change significantly with new precipitation patterns and temperatures. Some geographical ranges will expand, and others decrease. Modeling these changes is extremely difficult and data-intensive, but investment in better prediction tools is critical. Disease surveillance systems are a “no-regret” option as early response is always more effective than interventions after disease outbreaks have occurred. Targeted responses are more effective and less costly. Some climate-sensitive diseases will occur in the same ecologies and so using vaccines or insecticides that respond to multiple vectors such as mosquitoes and ticks can be cost-effective. Selective breeding for disease resistance is a longer-term but ultimately necessary strategy, to reduce resistance to drugs.⁵⁴

Rangeland Management

Pasture and water availability in African arid and semi-arid rangelands are highly sensitive to climatic events and conditions.⁵⁵ Managing this variability has been central to pastoral production for centuries. Climate change will increase the variability of precipitation,⁵⁶ with likely significant consequences for rangeland vegetation. Net primary productivity and biomass in many areas of African rangelands is projected to decrease by 2050 due to climate change.⁵⁷ This comes against more than two decades of loss of mobility and increased fragmentation of rangelands,⁵⁸ which already make rangeland management harder.

Interventions to manage the increased uncertainty in pasture and water availability include land use planning at community, local and national government levels. This nested approach⁵⁹ is effective in ensuring pastoralists have access to traditional dry-season grazing areas, but this should also enable coordinated management in response to future change. This planning will need to be accompanied by better seasonal predictions of vegetation patterns. Further, with changes in temperature and precipitation, species suitability will change; ideally more heat- and aridity-tolerant species can be introduced.

Enhanced species diversity in pastures can improve yield performance and stability relative to simpler grass systems or grass-legume systems, and at the



Photo: GCA

same time increase resilience to extreme weather events. Improved grazing management is also a promising option. For example, WUE in pastures planted with tropical forage grasses can be enhanced through moderate rotational grazing.

Climate Information Systems and Financial Solutions

Climate predictions such as seasonal forecasts have been employed by early warning systems for decades, with significant improvements in their quality and interpretability.⁶⁰ The rapid expansion of mobile phone use and networks has created intense interest in the possibilities of sharing climate information widely with farmers who formerly have had limited access to such information. Digital technologies overcome information problems that hinder market access for many smallholders and herders, increase knowledge through new ways of providing extension services, and provide novel ways for improving agricultural supply chain management.⁶¹ Such technologies can catalytically improve agricultural efficiency and resilience to shocks by providing timely climate information

to aid in decision-making, reducing financial and labor costs, decreasing losses, improving quality, supporting sustainable use of resources, and increasing productivity.⁶²

Receiving information is helpful, but only if producers have access to inputs and financial services. Hence, several new projects funded by the World Bank and the OneCGIAR are exploring how to better combine climate information services with other inputs and information.⁶³

There are also two decades of experiments with financial instruments for climate risk management, including insurance against drought. The Index-Based Livestock Insurance (IBLI) program has been implemented in East Africa for more than a decade. While the payouts have been shown to buffer against climate shocks,⁶⁴ as with climate information, these payouts are most beneficial if other services are bundled with them—for example, information about diseases, livestock prices, and feed markets.

Box 3. Climate Service Information Initiatives in West Africa

The International Livestock Research Institute (ILRI) has explored options for bundling climate service information with other types of information in livestock value chains in Senegal, Nigeria, and Burkina Faso. There are relevant experiences in each country. In Burkina Faso, the development organization SNV has been leading initiatives such as the Mobile Data for Moving Herds Management and Better Incomes (MODHEM). The MODHEM project aims to enhance household-level food security in the agro-pastoralist areas by improving access and use of geo-satellite data. Additionally, in partnership with the Ministry of Animal Fisheries Resources (MoAFR) and Orange Mobile, SNV launched the GARBAL in 2019 to facilitate access to information for pastoral herd migration mobility, agro-meteorological data, agricultural commodities, and livestock prices for decision-making.

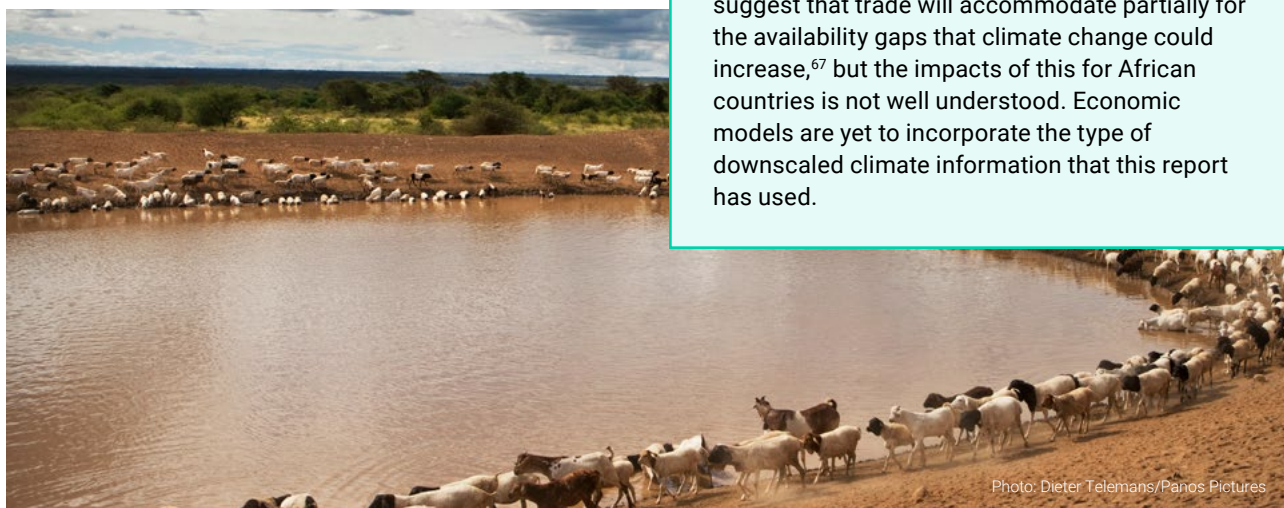
In Senegal, an initiative of the United Nations Capital Development Fund (UNCDF) and the Mastercard Foundation has promoted digital solutions, including the mAgri platform. The mAgri platform has been set up to communicate information and send alerts to farmers in rural areas. The mAgri is a private platform, which aims to provide farmers with real-time information on market prices of agricultural products via SMS. In addition, Action Against Hunger (ACF) and Agronome et Vétérinaires sans Frontières (AVSF) have been providing information related to changes in pasture, functioning of the boreholes, market information and so on.

Box 4. Maladaptation Risks in Livestock Systems

Maladaptation is a significant concern. Simply put, this is when an intervention to adapt to climate change makes people more vulnerable.⁶⁵ There are many examples of how this could occur in livestock systems. For example, exotic breeds have often been promoted as a pathway to improve productivity, yet these animals lack the traits that are better at coping with heat stress. Extensive pastoral producers need freedom of mobility to have secure access to water and pasture; interventions to secure land for irrigated agriculture in drylands threatens this secure mobility and makes pastoral producers vulnerable to climate change.

Box 5. Markets, Trade, and Climate Change

Regional and global trade is a mechanism that countries rely on for both filling food gaps and increasing income. In countries with large livestock populations (e.g. Sudan, Ethiopia, Niger) regional and international trade in livestock contributes significantly to economic growth. Models suggest that livestock production and trade will increase in Sub-Saharan Africa through 2050, although shocks such as disease outbreaks will constrain this episodically.⁶⁶ Increasingly variable or severe climate shocks could have the same effects, and the long-term production declines from heat stress may depress economic growth. Some authors suggest that trade will accommodate partially for the availability gaps that climate change could increase,⁶⁷ but the impacts of this for African countries is not well understood. Economic models are yet to incorporate the type of downscaled climate information that this report has used.





The Role of Women in Adaptation Solutions

The gender differences in women's and men's roles, participation, and benefits from livestock production mean that climate change will not affect genders in the same way, nor will men and women have the same choices regarding adaptation. Women have less adaptive capacity due to financial and other resource constraints, and less access to information and extension services.⁶⁸ Women are commonly perceived to be more vulnerable to climate shocks as a result.

Although we know that women are heavily involved in livestock management, their roles are often not recognized by researchers, extension workers, and NGOs seeking to improve livestock management.⁶⁹ This lack of attention has many unintended impacts. Many project interventions to improve farm management often increase women's labor burden.⁷⁰ Second, interventions that primarily focus on those who engage with formal markets will often disadvantage women: for example in the Kenyan dairy sector, most women sell in the informal, evening milk market.⁷¹

Despite their greater vulnerability and constraints, women can be agents of innovation in adapting to climate change with more deliberate policy and project support. With the recognition of the importance of women to livestock production and the urgent need to adapt to climate change,

several manuals have been published that explain best practices for ensuring that women's needs are addressed.⁷²

THE COSTS OF INACTION AND OF ACTION COMPARED

The Cost of Inaction

Climate change is already imposing serious costs on lives and livelihoods in Africa, both of which are closely tied to the stability and productivity of livestock. A portfolio of adaptation measures to counter the long-term effects of climate change will have significant costs, well in excess of the funds currently being made available for adaptation in Africa.

But as this section shows, these costs are far smaller than the estimated losses projected under different scenarios by modeling if no action is taken. Significantly, the costs of inaction only increase with time, meaning that immediate action and investment in adaptation is likely to be far more cost-effective, not to mention proactive and strategic, than piecemeal measures taken later in more challenging circumstances. This section gives the policy problem a quantitative dimension by setting out the projected costs of both inaction and action, while also noting the complexity of estimating costs for livestock adaptation, since many adaptation interventions in this realm also apply to agriculture in general. There is a need for more research on livestock-specific issues. Table 2 at the end of this section summarizes the costs of inaction analyzed.

Modeling studies suggest that under higher GHG emission scenarios, global cattle production losses from heat stress alone could amount to nearly US\$40 billion per year by 2085—equivalent to 9.8 percent of the value of production of milk and meat from cattle in 2005 (Figure 5). Under lower emission scenarios, losses could amount to nearly US\$15 billion.⁷³ For Africa, cattle meat and milk losses may amount to US\$4.2 billion per year by 2085—equivalent to 22 and 46 percent, respectively, of Africa's milk and meat production.

Changes in grassland productivity are projected to lead to an overall decline in livestock numbers ranging from 7 to 10 percent, representing economic losses in the range of US\$10–13 billion. Changes to African grassland productivity are likely to have

substantial, negative impacts on the livelihoods of more than 180 million people.

Invasive alien species are already having an adverse effect on African countries. The estimated annual cost of indigenous alien species to agriculture in Africa is about US\$66 billion.⁷⁴ Although just 0.26 percent of this is attributable to reductions in livestock income, livestock farmers also suffer from crop yield losses and the costs of weeding and management, which account for the rest of this estimate. The losses are modest in some countries—less than 1 percent of agricultural GDP in Algeria and Mauritania, for instance—but they account for over a quarter of agricultural GDP in many others, including Zambia, Niger, and Malawi. Climate change is likely to increase the spread and establishment of invasive alien species—in South Africa alone, 1,422 alien species have become naturalized—and in turn the costs of tackling them. Adapting to this possibility now, rather than waiting till it worsens, is therefore imperative.⁷⁵

Higher temperatures resulting from climate change could also have an impact on labor and labor performance.⁷⁶ This will be particularly important in Sub-Saharan Africa, where smallholder farmers and herders rely on outside human labor. According to the International Labour Organisation, labor

productivity begins to decline above 24–26°C. Once the temperature reaches 33–34°C there is a 50 percent decline in work capacity for moderate-intensity work tasks. Loss of labor capacity has critical implications for the livelihoods of households relying on subsistence farming and livestock. In rural populations exposed to temperature change, this capacity globally is estimated to have decreased by more than 5 percent from 2000 to 2016, but in large parts of West and Central Africa and coastal East Africa, observed losses were up to 30 percent more.⁷⁷ These losses will become greater and more widespread by mid-century, with increased morbidity and mortality and increased incidence of chronic kidney disease in agricultural populations. In hot regions, labor productivity could decline by 11 to 27 percent by 2080.

Finally, droughts, floods and storms regularly cause havoc in Africa, and they are likely to become more severe and more frequent in the coming decades. In general, the more severe a drought or flood, the greater the cost. For example, the estimated adverse impact of a 1-in-10-year drought in Malawi is 4 percent of annual GDP. This rises to 7 percent for a 1-in-15-year drought and 10 percent for a 1-in-25-year drought.⁷⁸ Nearly half of all the emergency multilateral food assistance to Africa is in response to disasters triggered by natural hazards.

Table 2. Estimates of the Costs of Adaptation Inaction in Livestock Systems in Africa

Element	Losses	Geography	Reference
Heat stress impacts on cattle milk and meat production	US\$4.2 billion annually by 2085	Africa	38
Impact of reductions in grassland productivity on livestock populations	US\$1.1 billion annually to 2050	Africa and Australia (most of the losses projected to be in Africa)	13
Loss of livestock income caused by invasive alien species	US\$0.2 billion annually	Africa	39
Reduction in human physical work capacity in livestock systems caused by drought and flood	5% reduction by 2050 under RCP2.6 8% reduction by 2050 under RCP8.5	Africa	79
	Currently US\$670 billion annually US\$1,600 billion annually in a +2°C world	Global, all sectors	80
	Currently, mean US\$0.8 billion per year	Africa, all sectors	43
Changes in pest and disease prevalence and severity	No data		

The Costs of Action

The size of the adaptation gap in general is both troubling and increasing. Adaptation finance for all sectors was about US\$20 billion per year in 2019. Annual estimates for the total costs of adaptation vary enormously: from US\$127 billion in 2030 and US\$295 billion in 2050,⁸¹ to 2–8 percent of GDP, or several trillion dollars each year.⁸² It is noteworthy that these estimates are increasing in new studies. Agricultural adaptation is estimated to need 26 percent of the total.⁸³ For the recent round of Nationally Determined Contributions (NDCs) up to December 2020, in the East African region as an example, estimates of climate finance needs for the livestock sector and related systems have averaged about US\$120 million per year. Most of this originates in the public sector and is directed to livestock system adaptation, with an emphasis on the most vulnerable populations.⁸⁴ Considering that the estimated cost of implementing the NDC of Ethiopia alone is US\$295 billion to 2030, and of Kenya, US\$62 billion, the finance currently available is clearly wholly inadequate—even with a doubling of adaptation finance, as outlined in a recent G7 statement.⁸⁵

There is little direct information on the cost of implementing large-scale livestock adaptation programs in Africa, at least as far as the levels of investment that are required. A recent Clim-Eat paper⁸⁶ estimated the cost of a few adaptation actions of direct relevance to livestock systems at the regional level, including:

- Implementing early-warning systems and adaptive safety nets for farmers in climate risk hotspots, US\$3.4 billion per year for Sub-Saharan Africa.
- Taking climate services to scale by connecting millions of farmers and agribusinesses to ICT-enabled bundled advisory services by 2030, US\$0.5 billion per year for SSA.

Other actions of indirect relevance to livestock systems were costed in the same study, such as climate-proofing investments in the agricultural sector and improving agricultural innovation systems, but these apply to agriculture in general rather than to just livestock.

The size of recent financial flows to the livestock sector directly are available for some countries.⁸⁷ For example, about US\$230 million was mobilized for livestock adaptation in Mali over the period 2015

to 2022, most of which was public finance targeting adaptation options such as improved water and feed management, improved livestock marketing methods and coherent land use planning processes. In East Africa, climate finance for the livestock sector amounted to just under US\$830 million between 2015 and 2022, again with most funds coming from the public sector and being targeted toward measures such as early-warning systems, feed and rangeland management, capacity development and marketing.

POLICY RECOMMENDATIONS

Some policy recommendations that emerge from the research synthesized and the analysis developed in this chapter are:

- Building climate-resilient livestock systems to cope with climate challenges requires concerted, coordinated action from investors and policymakers at the national and global levels. This will need to be informed by a solid research base,



which scientists have only started to assemble with the minimal funds allocated so far.⁸⁸

- Researchers need to develop a toolbox of effective adaptation practices, technologies and policies that are robust across different scales, priorities, and climate futures. They must also work with funders and governments to prioritize investments in the livestock sector. It is not just technical inputs that are needed, but institutional change in the way that livestock is viewed by funders and governments. This will require a considerable evidence base.⁸⁹ And this evidence and technical support are also needed to enhance monitoring and reporting for national, regional, and continental planning.⁹⁰
- Build capacity at national levels to understand how to prioritize interventions for the livestock sector across development and climate change planning.
- Develop policy to allow livestock development strategies that support rural development and contribute to a restoration economy, including the development of national policies and mechanisms to allow for carbon credit trading and benefit sharing for communities that implement rangeland restoration practices.⁹¹
- Design and update national and subnational animal feed strategic plans and strategic feed reserves; support predictive livestock early-warning systems and early-warning–early-action approaches, including for disease; establish feed inventories and feed stores; promote the establishment of intercommunity landscape-level grazing plans and natural resource management plans at community and farmer level.⁹²

