Food and water security, early warning, early action and response in Western Province, Zambia

CGIAR
INITIATIVE ON
Fragility, Conflict, and Migration

Retrospective analysis of the 2018-2020 humanitarian food and water crisis in Western Province, Zambia

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IWMI
International Water Management Institute

Climate Centre

Executive Summary

The food and water crisis that affected Zambia due to prolonged dry spells between 2018 and 2020 is an example of how natural, socioeconomic, and political drivers can produce compounding impacts with long-lasting implications for development. This retrospective disaster analysis explores the risk interactions and early warning early action functioning before and during the event, to draw lessons for anticipation and response to future crises of a similar nature. Combined, the findings feed into the understanding of risk and impacts, which is crucial for improving impact-focused early warning and implementation of early actions. The Government of Zambia's Disaster Management and Mitigation Unity (DMMU) and Zambia Red Cross Society (ZRCS), key stakeholders in the research, indicated a gap in knowledge of the drivers and impacts of the food and water crisis in Western Province and EWEA functioning at the time, especially the more remote border areas located near the border with Angola and Namibia. No retrospective analysis of the 2018-2020 crisis event has so far included a review of the functioning of the EWEA components at the time at the national and local levels. Therefore, this analysis focuses on Western Province of Zambia, specifically the Sioma, Sesheke and Shang'ombo border districts.

The research provides an in-depth perspective on one of the most recent food security crises in Zambia to inform localization and strengthen early warning and early action efforts at the national and community levels. The 2023 drought event in Zambia underscores the critical need for enhanced preparedness for similar crises. This research complements ongoing initiatives for early warning for drought (e.g. through the AWARE project) and efforts within the National Technical Working Group for Forecast-Based Financing, chaired by DMMU, on drought trigger and early action protocol development. This research's focus on hazard and vulnerability interactions aligns with the move to multi-hazard contingency planning in Zambia, led by DMMU.

The mixed-methods forensic analysis builds on key informant interviews, focus group discussions, peer-reviewed literature, publicly accessible data and geospatial analysis **to consider compounding and cascading risk interactions in 2018–2020 in Zambia, their attendant impacts and risk drivers, and available warnings as well as the communication and early actions associated with them**. Complementing ongoing initiatives to strengthen EWEA activities in Zambia for food- and water-related impacts, this study provides contextual information that can support improved targeting, early action selection, warning system design and coordination.

Findings:

Between 2018 and 2020, multiple hazards and risk factors converged, leading to severe food insecurity and water access challenges in Western Province, Zambia. While the main trigger for food insecurity was prolonged dry spells in the 2018/2019 rainy season, this was compounded by the impacts of COVID-19, inflation, and various crop and livestock pests. While local rainfall dynamics were the main driver of the food insecurity, low river flows and diminished water access in 2019, the crisis was deepened and elongated due to local occurrence of fall armyworms, locusts, wildlife damage of crops and later in 2020, the onset of COVID-19. In particular, the unsafe working conditions for migrants seeking employment elsewhere and wildlife attacks near water sources and crop fields were significant local impacts. The findings also highlight the variation in the onset and experience of impacts: where across Western Province, the 2018/2019 rainy season resulted in loss of harvests. In the case study area at the border of Western Province, the rainy season of 2019/2020 was considered more challenging, which resulted in prolonged impacts on food security. At the end of this second failed season, the onset of COVID-19 further influenced food security and coping mechanisms, such as migration for piecework. This highlights the need for further localization of the national early warning systems, accounting for micro-climatic variation and socio-economic and biological influences on food production and security.

This study concludes that early action to address impacts on food and water access was possible based on available early warnings, yet this opportunity was missed. Despite the first early warning signals indicating a potential below-average rainy season in August 2018, and the Zambia Meteorological Department (ZMD) confirming this in their 2018/2019 seasonal outlook in September 2018, the national response by the government and humanitarian actors only began in December 2019. Although Zambia has a comprehensive Disaster Risk Management (DRM) framework, the primary challenge to early action at the national level was the mobilization of financial resources, with limited options for scaling awareness and farmer support before a disaster declaration. The lack of pre-agreed financing led to a reliance on humanitarian appeals. At the community level in the case study area, there were practical and cultural barriers to accessing early warning information and agricultural advice from ZMD and the Ministry of Agriculture. Structural barriers included poor road access, limited coverage of telecommunication and radio networks, and distance from markets. However, communities did recognize traditional early warning signs of potential drought conditions through ecological and meteorological indicators. Despite these warnings, limited knowledge of early action options and resource constraints meant communities could do little to mitigate the negative impacts on harvests during the 2018/2019 and 2019/2020 rainy seasons. While Early Warning Early Action (EWEA) would not have entirely prevented the crisis, given the large-scale food insecurity, it could have alleviated the impacts for the most vulnerable households in a more timely and dignified manner, reducing reliance on food aid.

Recommendations:

A robust Disaster Risk Management (DRM) framework is necessary for averting crises and effectively handling residual risks by proactively anticipating and responding to emergencies, especially when long-term investments in resilience are constrained. The event studied in this retrospective study is an example of other socioeconomic and biological crises compounding food and water-related impacts triggered by dry spells. Encouragingly, the government has recently demonstrated progress through initiatives such as multi-hazard contingency planning, fortification of local DRM committees, and bolstering response structures. Additionally, the Technical Working Group on Forecast-based Financing, under the leadership of DMMU, has been instrumental in advancing early warning and action strategies for droughts in Zambia following the studied event. The government could consider the recommendations below in advancing national early warning systems, annual contingency planning and coordination of local capacity for DRM, as well as data collection and analysis during and after future crisis events. The recommendations can also be integrated into the ongoing work on drought anticipatory action for humanitarian partners to the Zambia government.

1. **Improve national-level analysis of local food insecurity and water access risks through enhanced monitoring and evaluation before, during, and after crises.** The study underscores the importance of considering factors beyond hydro-meteorological hazards, such as micro-climatic conditions, food prices, exposure to wildlife, access to agricultural inputs, and mobility, as significant determinants of food insecurity. The findings also highlight a gap in data availability regarding the impacts of the crisis on rural water access, malnutrition, and other health concerns before, during, and after the crisis. Furthermore, the findings explore the connection between microclimates, food insecurity outcomes, and indigenous knowledge for early warning systems. These factors should be considered for risk assessments that inform annual contingency planning for government and humanitarian response plans. Improved risk information can inform more impact-based early warning and better targeted early action.
2. **Focus on the last mile in early warning dissemination and communication by expanding dissemination channels and localizing warning messages based on forecast impact information and feasible early actions.** Diversifying communication methods such as cross-border radio channels, free SMS messages, or the local chief system would be beneficial, especially in remote areas like Mbao and Imusho, which rely on extension worker visits for advisories. For future dry spell events, more cross-sectoral early warning communication is recommended – bringing together agriculture, health and water resource management departments to develop communications. Actionability of advisories should be improved in dialogue with at-risk communities, identifying viable alternative varieties to plant, strategies to protect from wildlife damage and health impacts, and recommendations for timing of activities – integrating trusted traditional early warning signals.
3. **Promote and support Early Action at household, community and national scale.** Early action by the government and humanitarian/development partners could have made a difference for communities in the window between the first warnings and the start of the response through livelihood support, rehabilitation of water services, sensitization to potential health risks and active monitoring of vulnerable groups for health issues (between August-December 2019), and this should be strengthened in future crises (for suggested early actions, see Figure 1). To enable early action at scale, this will need to be embedded in the standard operating procedures of DMMU and other DRM actors, ideally with a common national-level trigger for early action responsive to different types of drivers of food and water-related impacts.
4. **Strengthen Mechanisms for Pre-Crisis Funding Access: Enhance efforts to access funds before crisis impacts occur**. There is a need to enable early action in the Zambian disaster funding structure. Expanding access to trigger-based pre-agreed financing, coordinated through DMMU with support from the broader government, can support more proactive early action in the window between forecasts and peak impacts. Furthermore, the extensive social protection system in Zambia has the potential to offer support to farmers ahead of harvest failure, as some pilots are already underway, which could be further scaled up if accessibility, timeliness and affordability issues are addressed.
5. **To effectively address the impacts of future events and reduce long-term risks, measures must also target the root causes of vulnerability and exposure.** Disaster Risk Management (DRM) and Climate Change Adaptation (CCA) initiatives should address underlying vulnerabilities related to poverty, education, livelihoods, and accessibility. Communities often struggle to access the essential resources and information needed to implement early actions based on warnings, such as agricultural tools and knowledge of drought-tolerant crops like sorghum and cassava. Limited telecommunication and media coverage restrict access to vital information, while poor road conditions impede access to essential services and markets. Therefore, improving early warning systems at both national and local levels must be coupled with early action-focused support to achieve a lasting positive impact.

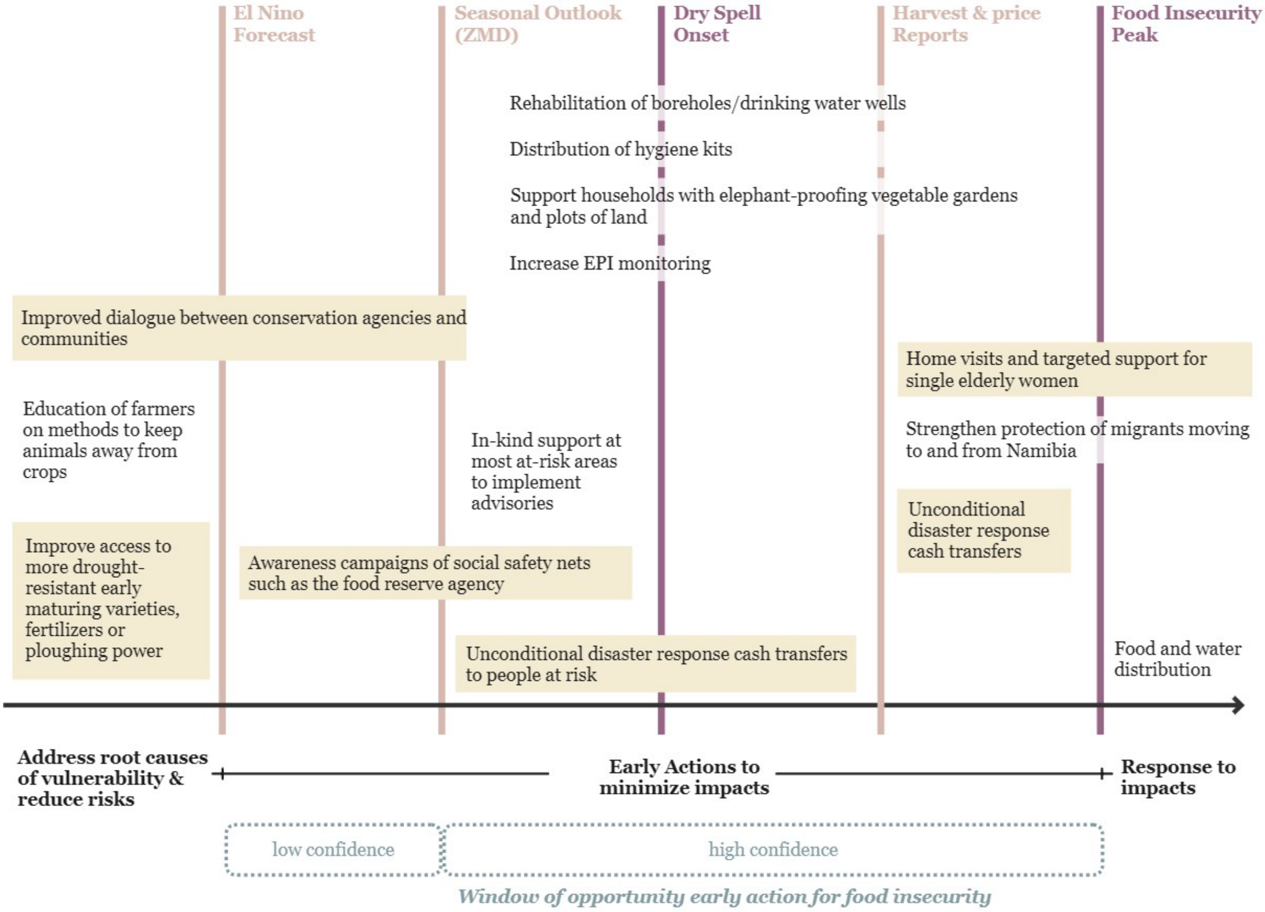

Figure 1. Overview of potential windows of opportunity for early action in the case of similar events in the future, focusing on food insecurity impacts.

In conclusion, tackling the diverse challenges of food insecurity and water access in Zambia's Western Province requires, across timescales, the involvement of local communities. Recognizing the interconnected nature of risks is key to effective disaster risk management. The retrospective analysis of the 2018-2020 food insecurity crisis in Zambia demonstrates how early warning systems can be designed to be more impactful, how community participation can be made effective, and how multi-risk strategies should be implemented. Strengthening capacity, ensuring that funding reaches local communities, and addressing the underlying causes of vulnerability are crucial for building resilience and preventing future crises. Cooperation among government entities, humanitarian organizations, research institutions, and donors is crucial to executing these recommendations and securing food and water resources in Zambia's Western Province.

For an interactive visual summary of the research, please see the online StoryMap accessible through this link: https://arcg.is/1aP4vb0

About the Institutions

CGIAR is the largest agriculture innovation network with a research portfolio of US $900 million, over 3000 partners and clients in 70+ countries focused on enhancing food and nutrition security through a science-based approach to emerging development issues. The main scientific areas of focus include supporting food systems transformation, driving sustainable land and water use, supporting resilient agri-food systems, and creating genetic innovation through crop breeding and seed systems for adaptation of food and farms to meet goals for poverty reduction, gender equality, nutrition, climate, and the environment. Its research is carried out by 13 CGIAR Centers/Alliances in close collaboration with hundreds of partners, including national and regional research institutes, civil society organisations, academia, development organisations, and the private sector.

The International Water Management Institute (IWMI) is an international, research-for-development organization that works with governments, civil society and the private sector to solve water problems in developing countries and scale up solutions. Through partnership, IWMI combines research on the sustainable use of water and land resources, knowledge services and products with capacity strengthening, dialogue and policy analysis to support implementation of water management solutions for agriculture, ecosystems, climate change and inclusive economic growth. Headquartered in Colombo, Sri Lanka, IWMI is a CGIAR Research Center with offices in 16 countries and a global network of scientists operating in more than 55 countries.

The Red Cross Red Crescent Climate Centre (RCCC) is a technical reference centre that supports the Red Cross Red Crescent Movement and its partners in reducing the impacts of climate change and extreme weather on vulnerable people, working at the intersection of science, policy and practice. Hosted by the Netherlands Red Cross in The Hague, the Climate Centre operates with a mostly virtual team spanning more than 30 countries, as well as affiliations with universities, foundations, UN agencies, and professional associations. A core objective is to make the best global scientific insights operable at local level. Key elements include support for awareness-raising and capacity-building, especially in developing countries where people are especially vulnerable to climate change. Our focus areas include anticipatory action, heat, the intersection between climate and conflict, climate-smart disaster risk reduction, health, and social protection.

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The report is informed by the collaboration between the CGIAR Initiative on Fragility, Conflict, and Migration (FCM). The CGIAR Research Initiative on FCM aims to enhance the resilience of food, land, and water systems in fragile and conflict-affected settings, where migration-related challenges are prevalent. By taking a systems approach and working in partnership with local stakeholders, the Initiative seeks to generate evidence to inform effective policies and programs that promote social and gender equity, climate resilience, conflict mitigation, and peace building in these settings. More information can be found at https://www.cgiar.org/initiative/fragility-conflict-and-migration/

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Foreword

Our changing climate poses unprecedented threats to humanity, not only due to the increasing frequency and intensity of hazards but also because of deeply rooted vulnerabilities that make certain populations particularly susceptible to these dangers. In Zambia, these vulnerabilities are exacerbated by factors such as poverty, fragile infrastructure, and unsustainable use of natural resources, creating conditions where the compounding effects of climate change can have devastating impacts on communities.

The 2018-2020 food and water crisis in Zambia's Western Province serves as a distressing example of how multiple hazards can converge, leading to significant human suffering, economic hardship, and instability.

This report, produced through the collaboration between the International Water Management Institute (IWMI), the Red Cross Red Crescent Climate Centre (RCCC), and the Disaster Management and Mitigation Unit (DMMU) of Zambia, provides critical insights into the underlying drivers of the 2018-2020 crisis. It highlights the importance of learning from past events to enhance our preparedness and mitigate the impacts of similar future crises. At DMMU, we firmly believe that a comprehensive, systems-based approach is essential to address the interlinked factors contributing to such complex situations. Understanding the root causes and interactions between various risk factors allows us to build a more resilient disaster management system.

At the core of this partnership, lies the shared belief that anticipatory action—taking proactive steps to address risks before they fully manifest,- can be a powerful tool for mitigating the impacts of disasters and protecting vulnerable populations. By focusing on early identification of risks and implementing targeted interventions, we have the opportunity to break the cycle of crisis and response that has often characterized traditional disaster management. This report's findings and recommendations emphasize how investing in anticipatory measures, such as early warning systems and community-based risk assessments, can significantly reduce the impact of crises and build resilience at both community and national levels.

The lessons from the Western Province's experience highlight the need to enhance local early warning dissemination, fortify response structures, and address financial barriers that delay timely interventions. By integrating scientific data with traditional knowledge and encouraging community participation, we can ensure that early warning systems are effective and accessible to those who need them most. The adoption of anticipatory action strategies in Western Province, a region historically at the epicenter of food and water crises, could be particularly transformative, helping us to protect lives, improve livelihoods, and reduce reliance on emergency aid.

Moving forward, our collective efforts must focus on co-creating context-specific, scalable, and sustainable solutions. Collaboration among government entities, humanitarian organizations, academic institutions, and local communities is vital to driving climate resilience and proactive disaster risk management. This report is a step towards a more resilient Zambia, offering a roadmap for how anticipatory action can be integrated into broader efforts to address the challenges of climate change and fragility.

We hope that the findings presented here will inspire stakeholders at all levels to take action, ensuring that together, we can move beyond reactive responses and build a more resilient, just, and equitable future for all.

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List of Acronyms

AA	Anticipatory Action
ADBG	African Development Bank Group
AML	African Migratory Locust
CERF	Central Emergency Response Fund
DMMU	Disaster Management and Mitigation Unit
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
ENSO	El Nino Southern Oscillation
EWEA	Early Warning Early Action
EWS	Early Warning System
FAO	Food and Agriculture Organization of the UN
FAW	Fall Army Worm
FCAS	Fragile and Conflict-Affected Settings
FCM	Fragility, Conflict, and Migration
FCV	Fragility, Conflict, and Violence
FGD	Focus Group Discussion
FLWS	Food, Land, and Water Systems
FMD	Foot and Mouth Disease
FMECD	Federal Ministry for Economic Cooperation and Development Zambia
GBV	Gender Based Violence
GRZ	Government of the Republic of Zambia
IOD	Indian Ocean Dipole
IFRC	International Federation of Red Cross and Red Crescent Societies
IPC	Integrated Food Security Phase Classification
IWMI	International Water Management Institute
MOA	Ministry of Agriculture
MTENR	Ministry of Tourism, Environment & Natural Resources
NGO	Non-governmental organization
NOAA	National Oceanic and Atmospheric Administration
OCHA	Office for the Coordination of Human Affairs
PIN	People in Need
RCCC	Red Cross Red Crescent Climate Centre

SADC	Southern Africa Development Community
SADRI	Southern Africa Drought Resilience Initiative
SARCOF	Southern Africa Regional Climate Outlook Forum
SASSCAL	Southern African Science Service Centre for Climate Change and Adaptive Land Management
SMS	Short message service
UN	United Nations
USAID	United States Agency for International Development
WBG	World Bank Group
WARMA	Water Resources Management Authority
WFP	World Food Programme
WPA	Western Province Provincial Administration
WWF	World Wildlife Fund
ZMD	Zambia Meteorological Department
ZRCS	Zambia Red Cross Society
ZSA	Zambia Statistics Agency
ZVAC	Zambia Vulnerability Assessment Committee

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Chapter 1: Introduction

There is growing recognition among emergency responders, policy makers and donors of the value of early action to reduce the humanitarian impacts of disasters in Zambia. An in-depth contextual understanding of risk factors, their root causes, and drivers can support effective strategies to respond to disasters, including government, development, and humanitarian partners' ongoing efforts for early warning and early action (EWEA). Early warning early action, also called Anticipatory Action, is one element of the disaster risk management (DRM) continuum. It refers to actions taken to reduce the humanitarian impacts of a forecast hazard before it occurs or before its most acute impacts are felt. The decision to act is based on a forecast, or collective risk analysis, of when, where and how the event will unfold (IFRC 2020c). However, EWEA is designed to manage residual risk[1]. Addressing the root causes of vulnerability[2] necessitates a broader strategy involving disaster risk reduction, climate adaptation, and other interventions across longer timescales (Wilkinson et al., 2020). Building on successful initiatives in the humanitarian sector, there is now a growing call in the EWEA/AA community to integrate EWEA into both national and local DRM frameworks, led by national governments to ensure sustained implementation and scale (GRC, IFRC, ICRC, 2024; Anticipation Hub, 2022).

Between 2018 and 2020, triggered by extensive dry spells, Zambia experienced a food security crisis and diminished water access, primarily affecting the Southern, North-Western and Western regions. Impacts included crop failures, food and water shortages, livestock deaths and reduced GDP, amongst others (IPC, 2019, 2020). As a result, in September 2019, 1.7 million people out of the total 18.4 million inhabitants in Zambia at the time, faced severe food insecurity (IPC class 3+) and a year later, by September 2020, 1.42 million people were still classified as at this level (IPC, 2019, 2020). IPC data shows that Western Province had the highest percentage of the population facing severe food insecurity (IPC class 3 or higher): up to 34% in 2019 and 40% in 2020 (IPC, 2019, 2020). Humanitarian needs were higher across the province than other affected areas (OCHA, 2019). Furthermore, the Government of Zambia's Disaster Management and Mitigation Unity (DMMU) and Zambia Red Cross Society (ZRCS), key stakeholders in the research, indicated a gap in knowledge of the drivers and impacts of the food and water crisis in Western Province. Given the recurrence of drought conditions in Zambia due to El Nino, addressing drought-related impacts on food and water access is considered a high priority by DMMU and humanitarian partners. Located near the border with Angola and Namibia, the remoteness and diversity in local climatic conditions make this a helpful case study focused on supporting the localization of EWEA and broader DRM approaches. The 2018-2020 event is Zambia's most recent example of a food security crisis. Yet, no retrospective analysis of the event included a review of the functioning of the EWEA components at the time at the national and local levels. Therefore, the focus of this analysis is Western Province of Zambia, specifically the border districts Sioma, Sesheke and Shang'ombo – with specific attention to Sesheke district (Figure 1).

While extensive dry spells in the rainy season of 2018/2019 and 2019/2020 were the main triggers for the crisis, a dynamic interplay of connected risks and societal responses converged to produce severe humanitarian impacts. Recognizing the risk interactions that result in disaster impacts, early warning early action systems and broader disaster response frameworks are increasingly trying to address risk interactions (e.g. compounding or cascading relationships). Analysing such events can improve disaster risk management planning and response (GAR, 2022). Integration of compound risk in EWEA is recognized as a challenge, and current EWEA systems typically focus on single natural hazard events. Recent examples from the global pandemic COVID-19 have revealed the inherent complexity and interconnections of risk, preparedness and response, and challenges for early warning, early action systems (de la Poterie et al., 2022; Kruczkiewicz et al., 2021). There is also an increasing recognition of the importance of a shift from hazard- to impact-based forecasting and action (RCCC, 2020; WMO, 2021), which considers economic, political, conflict, violence, migration and other elements of fragility as risk drivers (Jaime et al., 2024). During the 2018-2020 crisis, Zambia lacked a formal system for early action triggers, financing, and implementation, though some EWEA components were operational. Currently, under the leadership of the government, stakeholders are developing such a system. With ongoing initiatives to enhance early warning and action for food and water security, understanding historical risk drivers, interactions, impact pathways, and EWEA capacity is crucial.

This study follows a mixed-methods retrospective approach to analyze the food and water crisis event and EWEA functioning during 2018-2020. It combines the methodology of forensic investigation of disaster events (FORIN) (Oliver-Smith et al., 2016) with a focus on cascading and compounding hazards and impacts analysis (Cavallo & Ireland, 2014; de Ruiter et al., 2020; Pescaroli & Alexander, 2016; UNDRR, 2022), and EWEA systems design (GRC et al., 2020). The study combines secondary literature and data analysis with primary interviews and focus group discussion data. We examine the role of EWEA as a key part of the process to address residual risks. Combined, the findings feed into the understanding of risk and impacts, which is crucial

[1] Defined by UNDRR as "the disaster risk that remains in unmanaged form, even when effective disaster risk reduction measures are in place, and for which emergency response and recovery capacities must be maintained" (UNDRR, 2022).

[2] This study differentiates between root causes of vulnerability and drivers of risk. Drivers of risk are dynamic - specific time-bound events influencing elements of disaster risk over years or decades and are the triggers of disaster events. These include climate, weather (physical drivers), biological and socio-economic (societal drivers) processes. Root causes of vulnerability involve social and economic structures, such as the characteristics of power, wealth and resources distribution, as well as ideologies and historical heritage. Such root causes may change, albeit slowly, and help explain how events result in impacts on specific people (Marchezini & Wisner, 2017).

for selecting early warning sources and theory of change for potential early actions. It also suggests areas for further strengthening of the EWEA system in Zambia based on a counterfactual approach. The results of the study will inform recommendations for long- and short-term investments in disaster risk management in Zambia, as well as climate change adaptation, including early warning/ early action. These measures aim to support the resilience of the population in the long term, and at the same time aim to support institutions and communities in anticipating unprecedented extreme events that are more likely to occur in our changing climate. The insights from 2018-2020 can be applied to anticipation of and response to future crisis events. The following research questions guide the analysis:

1. What were the underlying drivers of risk that led to the disaster event (including relevant natural, socio-economic, and political factors), and how did the various drivers interact over time in the years before the event?
2. To what extent were elements of an EWEA system in place and operational during the event? (Including understanding risks, forecast availability and monitoring, warning dissemination and communication, early action planning, and financing)

The report first outlines the methodology (Chapter 2) before outlining the findings relating to drivers of risk (Chapter 3) and EWEA functioning during the event (Chapter 4). The discussion further contextualizes the findings (Chapter 5), and the report concludes with recommendations for future EWEA and DRM investments in Zambia (Chapter 5).

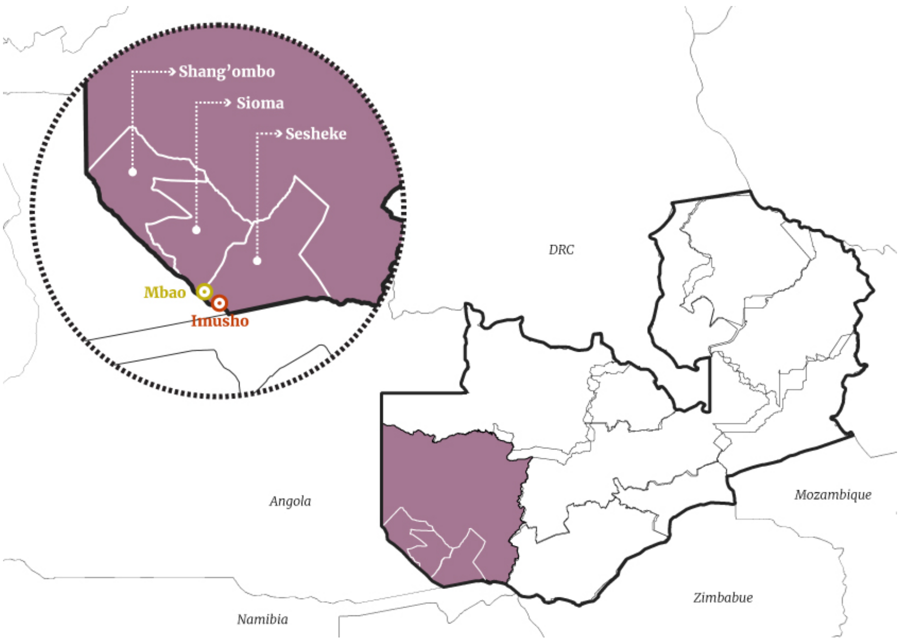


Figure 2. Analyzed districts within the Western Province.

Chapter 2: Methodology

To address the research questions, a longitudinal retrospective disaster analysis of the 2018-2020 food security crisis in Zambia was conducted, specifically focusing on early warning early action. The study explored the triggering event (dry spell occurrence between 2018 and 2020), the risk drivers before, during, and after the main physical triggering event, and how early warning, early action, and response were implemented.

The longitudinal retrospective disaster analysis approach builds on the Forensic Investigations of Disasters (FORIN) framework (Oliver-Smith et al., 2016). FORIN is a structured approach to understanding crisis events. It emphasises the importance of understanding the context leading up to a disaster, including the events that acted as risk drivers and the root causes (social, economic, and political conditions) contributing to vulnerability and resilience. However, FORIN does not explicitly cover a systematic and integrated approach to analysing compounding or cascading risks or any early warning or early action. Therefore, this study complements the FORIN historical framing with an in-depth assessment of early warning signals for the dry spell and food insecurity impacts, building on the Forecast-based Financing manual methodology (GRC et al., 2020). The retrospective review of the EWEA functioning at the time is structured along critical elements of the EWEA value chain: understanding risks, forecast availability and monitoring, warning dissemination and communication, early action planning, and financing. The study integrates primary qualitative data from key informant interviews and data from secondary sources (literature, geospatial and time series data), covering both research questions. The methodological framework is summarised in Figure 2 and the definitions of the terminology used are listed in Annex 2. The sections below describe the methods used.

2.1 Desk-based review

First, a comprehensive literature review was carried out to identify the events, responses, and impacts that occurred before and during the crises experienced in 2019-2020 in Zambia. This review included peer-reviewed and grey literature sources selected based on their relevance and alignment with the research questions, along with stakeholder suggestions and interviews. Grey literature included humanitarian reports and appeals, research reports, governmental websites, and newspaper articles. Through the literature review, we identified the spatiotemporal occurrence of events and their interactions, and these templates formed the basis for the analysis of the event's evolution.

1. Initial literature review of academic and grey literature to populate an **event/impact and EWEA timelines**. The first captures the main impacts, the number of people affected, and the timing and locations affected. The second documents early warning signals and early actions and responses.
2. **Impact/Driver Interaction Matrix** with an overview of linked events, or drivers of risk, mentioned in the literature, which influenced the hazards, exposure or vulnerability during 2018-2020 of the affected population (Tilloy et al., 2019). The relationship between the event (triggers/direct causes; increases exposure/vulnerability; reduces impacts) with each of the impacts from the impacts calendar was noted, along with the locations affected, and short description and sources.
3. For each of the identified drivers, we summarized identified **root causes of vulnerability** that were highlighted in the literature.

For the main physical triggers (dry spells) and impacts (food insecurity, limited water availability) of the event identified through the literature review, we further reviewed available reports and forecast information to inform the *forecasts* section of the EWEA system overview. For details on the hydro-meteorological forecasts assessed, see Annex 3.

The main impacts and drivers of the event were then summarized geospatially, using the GIS weighted overlay approach (RCCC, 2021b), which further showed the geospatial occurrence of the drivers identified in the literature review. For details on data processing for the different layers, please refer to Annex 5.

2.2 Data collection

Primary data was collected in November and December 2023 to explore the event and EWEA experience in Western Province more specifically.

1. Four semi-structured focus group discussions (FGD) on the experiences of rural communities in Mbao (2) and Imusho (2) villages, before and during 2018-2020. The FGDs focussed on the impacts during the event, the triggers for the events experienced and the access to timely and reliable early warning information and implementation of action. During the FGDs, note takers captured the information in Lozi and later translated this to English. Community members who directly or indirectly experienced the impacts of the events participated in a discussion on general conditions and context during research on the timeframe and EWEA. They were specifically asked to reflect on access and understanding of information, actions taken, challenges, lived experience of the event, and connected risk drivers. FGD

were separated by gender (one FGD for women and one for men per community) and constituted of 6-12 people, one facilitator and two note-takers.

2. Fourteen semi-structured key informant interviews with government, NGO, research/academia and humanitarian sector experts in Western Province and Lusaka. Interview questions focused on the same topics as the FGDs. Interviews were conducted in English, both online and in-person. Fourteen key informant interviews were conducted with government, humanitarian, NGO and development key actors at the national and provincial levels.

Findings from the research were then shared back with community members in Mbao and Imusho villages, and key informants in Mongu during a validation research visit in March 2024, yielding additional insights and refining conclusions. Findings were also shared with national key informants to validate the findings.

2.3 Data analysis

Literature, FGDs and interview data were coded in NVIVO and organized according to the following categories: event evolution and description; disaster impacts; drivers of risk/linked events; exposure and vulnerability; root causes; early action; forecast; warning dissemination; financing; response; recommendations. Interview and FGD data were then added to the impact, EWEA timeline, and impact/driver matrix.

Event evolution, risk drivers and root causes of vulnerability

This research combines community-based research with various desk-based methods to create an interdisciplinary historical systems perspective on the event. The emphasis is on exploring the interconnectedness of various factors contributing to the crisis at the local, district, provincial and national scales. Risk drivers are typically dynamic and can interact with each other (Wisner et al. 2014; see Annex 2 for a full glossary). To better understand the interactions between various events and processes, the analysis adds to FORIN a specific focus on cascading and compounding hazards and impacts by mapping out risk interactions (Cavallo & Ireland, 2014; de Ruiter et al., 2020; Pescaroli & Alexander, 2016; UNDRR, 2022).

Based on the impact/driver interaction matrix (Tilloy et al. 2019), for the event and driver analysis (research question 1), the mixed data sources supported the creation of a timeline, cognitive map and geospatial overlay of key events identified. These were iteratively improved through stakeholder consultations and expert review. The cognitive map served as a visual representation of the interactions between the detected elements identified in the literature and interviews, providing a comprehensive overview of the complex risk dynamics at play (Bakhtavar et al., 2021; Matanó et al., 2022). Risk drivers are dynamic events influencing elements of disaster risk over years or decades and are the triggers of disaster events. These include climate, weather (physical drivers), and biological and socio-economic processes. Root causes of vulnerability involve social and economic structures, such as power characteristics, wealth and resource distribution, ideologies, and historical heritage. Such root causes may change, albeit slowly, and help explain how events result in impacts on specific people (Marchezini & Wisner, 2017). The root causes of vulnerability for each identified driver were summarized in an adapted alluvial diagram. Only linkages supported by the primary data or multiple sources in the literature were included, while other linkages with little evidence were deprioritized.

EWEA functioning

For the overview of EWEA functioning during the 2018-2020 period in Zambia, an integrative approach was used to synthesize the findings from the desk-based analysis (literature and forecasting data) and primary data collection. This analysis was split up following the core elements of the EWEA value chain: understanding risk, forecast availability and monitoring, warning dissemination and communication, early action planning and implementation, and financing. Based on the coded literature and primary data, the different sections synthesize the functioning of the different core elements during the 2018-2020 crisis. Understanding risk and financing was not covered extensively in the primary data, and therefore, the analysis relied mainly on the literature review for these core elements.

The available forecasts and the qualitative re-analysis of timeliness and accuracy of the forecasts were based on the criteria used for early action protocol development for anticipatory action (GRC et al. 2020) and built on the ongoing drought early action protocol scoping conducted in October 2023 by ZRCS supported by the Climate Centre and 510 (ZRCS, forthcoming). For the analysis, the study used the same trigger levels as the EAP to determine whether action would have been triggered hypothetically (as no early warning early action system existed officially). Based on the analysis of available early warning information for the identified drivers of risk that triggered impacts, several windows of opportunity for early action were determined. This hypothetical overview of early warnings and early actions was then compared to information communicated and actions implemented to identify key areas for further improvement.

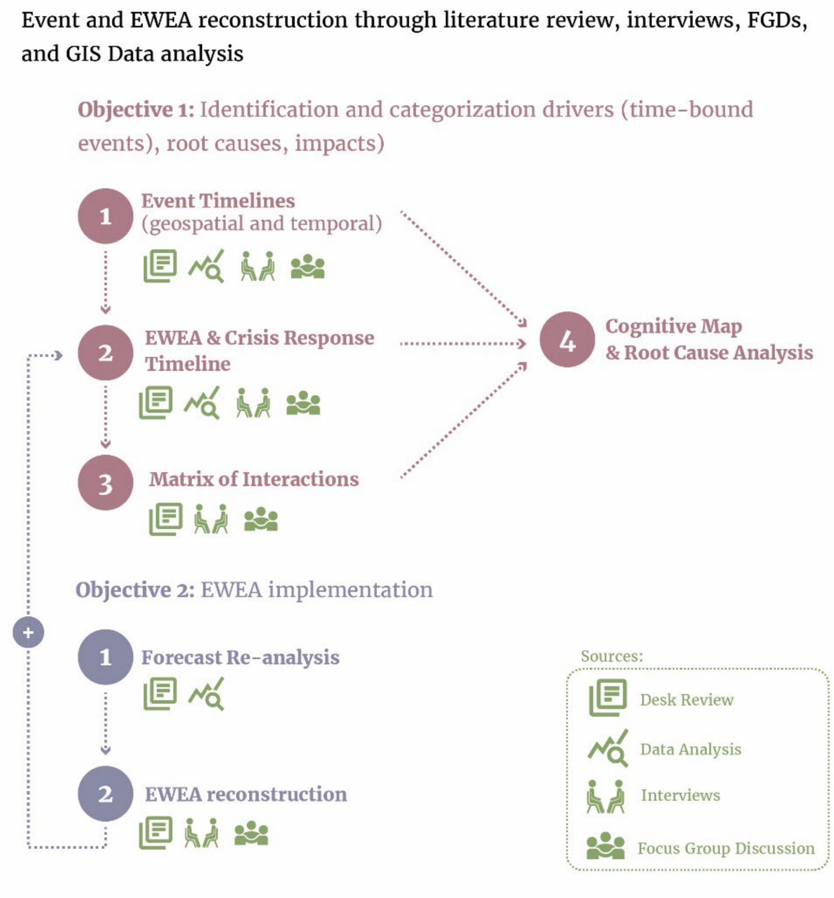


Figure 3. Methodology overview

2.4 Study limitations

This study design and implementation faces various limitations that should be considered when interpreting the findings. First, the literature review has inherent challenges in ensuring information accuracy, especially when incorporating grey literature, such as media articles and humanitarian reports, as verifying the reliability of sources can be difficult. Similarly, while interviews and FGDs provide a unique perspective on the events under analysis, they introduce subjectivity to the narrative and only cover a small sample and geographical area. To mitigate these limitations, we systematically compared information from the literature review with data gathered through stakeholder interviews, FGDs, and time series data analysis. This triangulation of diverse evidence types, aimed to alleviate inherent uncertainties in each research method.

In addition, stakeholder interviews and FGDs introduce a potential source of cognitive biases. Individual motivations, personal emotions, and experiences may influence stakeholders' recollections of the period under analysis. At the time of data collection, 5 years had passed since the onset of the event. To overcome these limitations and enhance the quality of elicited information, (Browne & Rogich, 2001) suggest the use of context-dependent questions. In alignment with this, our interview questions were context-specific, focusing on the events within the period under analysis. This approach aimed to minimize cognitive biases and ensure a more accurate understanding of the stakeholders' perspectives. Furthermore, sample selection bias from the literature review and focus group interviews can yield a partial representation of the system under analysis. Recognizing this challenge, we incorporated diverse data from various geospatial and time-series sources to capture various perspectives. We also endeavoured to clarify the spatial scale findings, as some were very localized for the FGDs locations, while others applied more generally to Western Province.

Chapter 3: Event evolution and riskdrivers

The following chapter covers the crisis impacts in Zambia from 2018-2020 (section 4.1) and the identified drivers that either directly triggered the event or altered the exposure or vulnerability of populations (4.2).

3.1 Crisis impacts

The section below outlines the major humanitarian impacts during 2018-2020 in Western Province, summarized in Figure 3. The period between 2018 and 2020 was characterized by food insecurity for households dependent on subsistence farming and fishing and a severe reduction in water availability and drinking water access in Western Province.

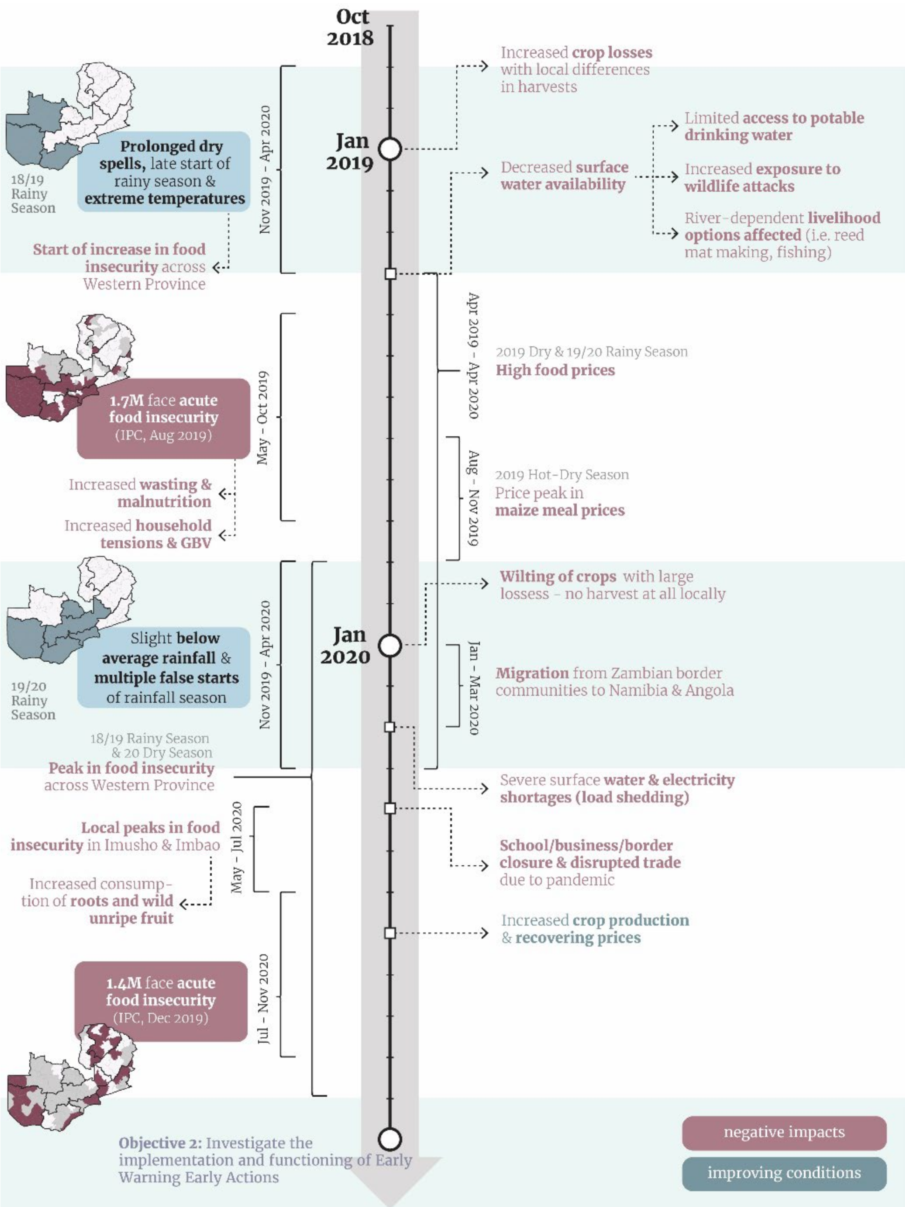
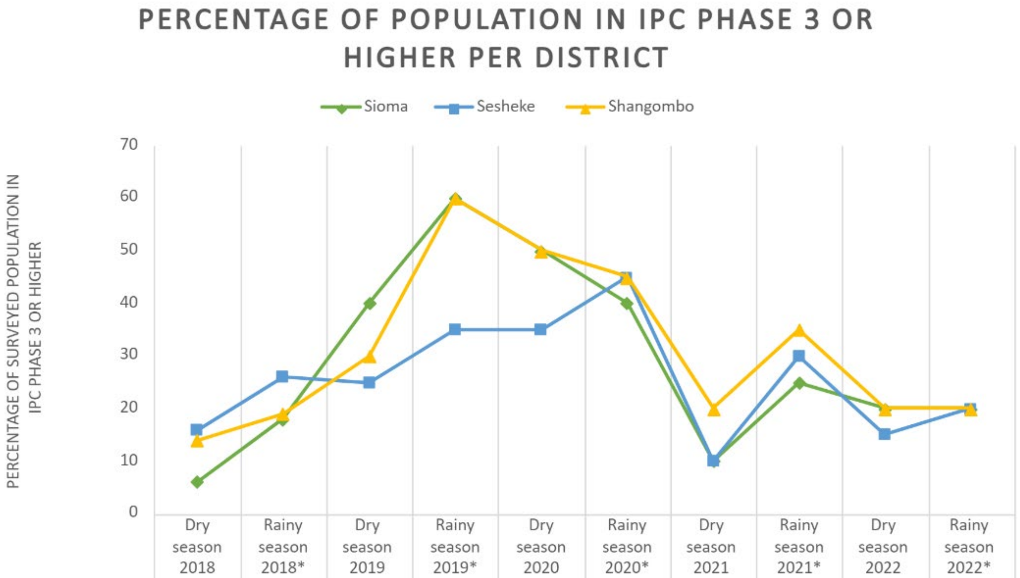


Figure 4. Overview of impact evolution over time, summarizing findings from desk review, interviews (across Western Province), focus group discussions (in the villages of Mbao and Imusho specifically) and data analysis, focusing on Western Province. Figure summarizes the main findings described in 4.1-4.3.

Food security impacts

Western Province, North-Western, Southern, and Eastern provinces in Zambia saw a rapid deterioration in food security from 2018 onwards. Although the rainy season (November-March) is generally considered the lean season, most of the Western Province recorded a steep increase in food insecurity during the dry season of 2019, reaching a peak of 60% of people in extreme food insecurity (IPC phase 3 or higher) during the 2019 rainy season in some districts (Sioma and Shang'ombo notably) (IPC, 2020; Figure 4). Food insecurity impacts in Sesheke were delayed compared to Sioma and Shang'ombo, peaking in 2020. This aligns with findings from focus group discussions, where communities experienced 2020 as the most problematic year with local variation in dry spell occurrence, availability of food from the market and coping capacity, as will be discussed in the following sections.



	Dry season 2018	Rainy season 2018*	Dry season 2019	Rainy season 2019*	Dry season 2020	Rainy season 2020*	Dry season 2021	Rainy season 2021*	Dry season 2022	Rainy season 2022*
Sioma	6	18	40	60	50	40	10	25	20	20
Sesheke	16	26	25	35	35	45	10	30	15	20
Shangombo	14	19	30	60	50	45	20	35	20	20

SEASON IN ZAMBIA

*Figure 5. Food insecurity in Zambia, showing the percentage of surveyed population in IPC food security classification 3 or higher, indicating severe food insecurity, in the districts Sioma, Sesheke and Shang'ombo in Western Province. Note that seasons marked with an * are projected data by the IPC 2019, 2020, not actual observations.*

> " [During the drought period of 2018-2020, red.] farmers who had planted crops experienced complete crop loss, and at the community level, the impact translated into heightened levels of hunger. This period marked a time when the country recorded significantly elevated hunger levels, accompanied by various other challenges. People became malnourished due to a lack of sufficient food.*]*

KI14

Food production decreased substantially in the 2018-2020 period, affecting food availability for subsistence households and households dependent on the markets. All FGDs highlighted the lack of harvests in 2018/2019 and 2019/2020 and the depletion of food stocks early in the rainy seasons. There were differences in the reported harvests in the two villages where FGDs were conducted, which also deviated from the findings based on the interviews.

Across Western Province, interviews and literature underline the high crop losses during the 2018/2019 season due to prolonged dry spells. The 2018/2019 dry spell affected 72% of fields in Western province (Mpundu & Sichilima, 2020). The main staple crop production of maize decreased by 16.3% nationally in 2019 compared to the previous season, reflecting a 31.6% decrease from the 5-year average (2014-2018) (FAO, 2019). Similarly, rice production (paddy) also decreased by 18.7% nationally compared to the previous season (FAO, 2019). FGDs in Mbao indicated that 2018/2019 already came with poor harvests and food shortages, worsening over 2019/2020. In Imusho most impacts were experienced in 2019/2020, considered a worse season, as illustrated by the quote below. Harvests were better for those who could plant earlier, as rains stopped very early in 2018/2019 and

2019/2020 (KI03). The main reason for the low yields was dry spells[3], which affected staple crops in the crucial flowering stages, resulting in high crop losses. Furthermore, according to some women in focus group discussions, remaining crops, such as more drought-resistant sorghum and millet, were eaten by wildlife or affected by locusts.

> “ *No one harvested anything. The only people that had food are those that reserved maize from the previous growing season, and they were selling it at very high price.*
>
> *FGD1*

May 2019, the Ministry of Agriculture communicated an overall expectation of reduced production compared to the 2017/2018 season of key staple and cash crops, specifically: season rice (-31%); sorghum (-49%); millet (-23%); maize (-16%) (MoA, 2019). The 2019/2020 season National Food Balance Sheet reported a deficit of 354,930 megatons of maize for human and industrial consumption, mainly due to the decrease in crop production of the 2018/2019 season, according to the Ministry of Finance (2019). Nationally, the improved rainfall conditions in 2019/2020 were reflected in the improvements in production for key staple crops such as maize (+69%), sorghum (+200%), rice (+17%) and millet (+81%) (MoA, 2020). This is at odds with the local experience in Imusho and Mbao, as discussed above.

Access to food from the market was also greatly hindered by high food prices, up by 15.9% from February 2019 to February 2020 (IMF, 2019; Open Zambia, 2020), impacting household expenditures. In the Western Province, household cereal stocks had already dwindled over the first three months of the 2019–2020 season, and FGDs also underlined the early onset of hunger (IFRC, 2021b; FGD1-4). Due to the decrease in staple crop production, various affected households were left to turn to the market to access food (OCHA, 2019), as these ran out of their produced stock earlier than normal (ZVAC, 2019). Across Zambia, high household expenditure on food was reported, with 39% of drought-affected households nationally spending over 65% of their income on food (OCHA, 2019). Food prices are further explored in Section 4.2.

“There was crop failure due to high temperatures and insufficient moisture, also, due to a few people that managed to harvest, there was the high food price, especially for maize grain … The prices of maize grain were high just across the country, not really attributable to one geographical location, but it was just at a general level across the country” (KI01).

As a result of the low yields and high food prices, high rates of **wasting and undernutrition** were reported, particularly affecting young children and the elderly (KI04; KI03; ZVAC, 2019). Severe acute malnutrition levels were already increasing in the year before the dry spells – showing a particularly large prevalence of wasting in Western Province (GRZ, 2019). The most recent 2018 Demographic and Health Survey (ZSA, 2020) found stunting in 35% of children below the age of 5, with 4% stunting and 12% underweight nationally. In July 2019, the Zambia Vulnerability Assessment Committee developed an in-depth vulnerability and needs assessment that supported these values as high levels of under-nutrition and stated that Zambia is one of the countries with the highest burden of under-5 malnutrition in Africa (ZVAC, 2019). In the Western Province, the assessment found many districts with a prevalence of wasting above the national average (4%), with a provincial average of 6%. Shang’ombo (33%) and Sioma (29%) were the most affected districts. In 2019, across Western Province, 65,254 children under five were screened, finding 1,539 children aged 6 to 59 months with Severe Acute Malnutrition (SAM) and 1,320 Moderately Acutely Malnourished (MAM) (CERF, 2020). The impacts in Shang’ombo district were also observed by humanitarian actors and similar experiences were recorded for other districts in Western Province:

[3] Dry spells are periods of interrupted rainfall within the rainy season, which can have a significant (often disastrous) impact on livelihood activities. In agriculture, for example, a dry spell lasting more than three weeks is commonly regarded as a climatic event with a major impact on the crop cycle. Dry spells can also occur either at the beginning of the season, with the effect of delaying the start-up of agricultural activities, or at the end of the season, with the effect of penalizing the harvest. Consequently, it is important to anticipate these dry spells and to have an efficient system for monitoring the season. Droughts, on the other hand, are measured over a relatively longer period (than dry spells), often from a few months to a few years.

“ *2019 was bad for Shang'ombo district. When we went on the ground, we found people had not eaten for more than a week. They were surviving on a wild tuber called Ndowa. This root if eaten too much, you die in your sleep, if you eat little your feet swell. Many people especially the elderly and young ones had died of hunger. Villages were empty, everyone went to dig the tubers.*

KI13

Faced with challenges in accessing food from subsistence production or markets, communities resorted to other **coping mechanisms**. Many focus group discussions mentioned a shift to gathering wild fruits and tubers/roots. However, for communities living in or near national parks, the search for edible roots was restricted in 2020 by the Zambian Wildlife Protection Authority, according to focus group discussion participants. Elderly people were found to have the lowest coping capacity, as they were less mobile and could not venture out to collect food. Some participants recalled instances where elderly people living alone passed away from hunger. While these stories cannot be verified directly, the increased malnutrition rates by official sources, as described above, underline the severity of this issue.

Negative coping strategies were also employed, increasing vulnerability over time. Overfishing of the rivers was discussed, which had implications for fish stocks in the subsequent years. Fishing exposed people to detainment by border soldiers along the Cuando River bordering Angola (KI03; KI05). Based on interviews, focus group discussions and reports, **school drop-out rates** also increased as families could not afford school fees anymore (Rosen et al., 2021; Focus Group Discussions; Bank of Zambia, 2020). Some community and primary schools had to close since students were forced to abandon school in search of other sources of income to alleviate food insecurity (CERF, 2020).

“ *As a result of food insecurity, young marriages dissolved, people skipped meals for two days, and people gathered wild fruits, tubers, vegetables, and fish for survival. Twenty percent of the schoolchildren dropped out of school.*

FGD2; FGD4

As a result of the socio-economic impacts of the high food insecurity and lack of livelihood options, various **cascading impacts and (negative) coping strategies** were mentioned that influence the long-term vulnerability of communities (Figure 5). All focus group discussions mentioned that early marriages became more frequent and that tensions increased between men and women in the household. Some community members mentioned an increase in theft and an increase in teenage pregnancies as well. This aligns with findings from Rosen et al., 2021. Several interviewees mentioned a local increase in gender-based violence (KI01; KI04; KI08). However, these incidents were not reported in focus group discussions.

In the border districts of Western Province, such as Sesheke, migration to Namibia and Angola was a commonly reported coping strategy. Estimates of the number of people who moved away range from 75-90% based on focus group discussions and interviews, of which a sizable portion relocated permanently (up to 90% of those who migrated, according to the Mbao focus group discussions). Women (mainly middle-aged) moved to Namibia for piecework. These women faced mistreatment and underpayment and were sometimes detained because they lacked travel documents (FGD1; KI07). The impacts on the village due to the migration of some of its inhabitants were evident from focus group discussions, which emphasized the large number of people who had not yet returned. The departure of the young working population and parents was described as having left the elderly and children more vulnerable to future shocks.

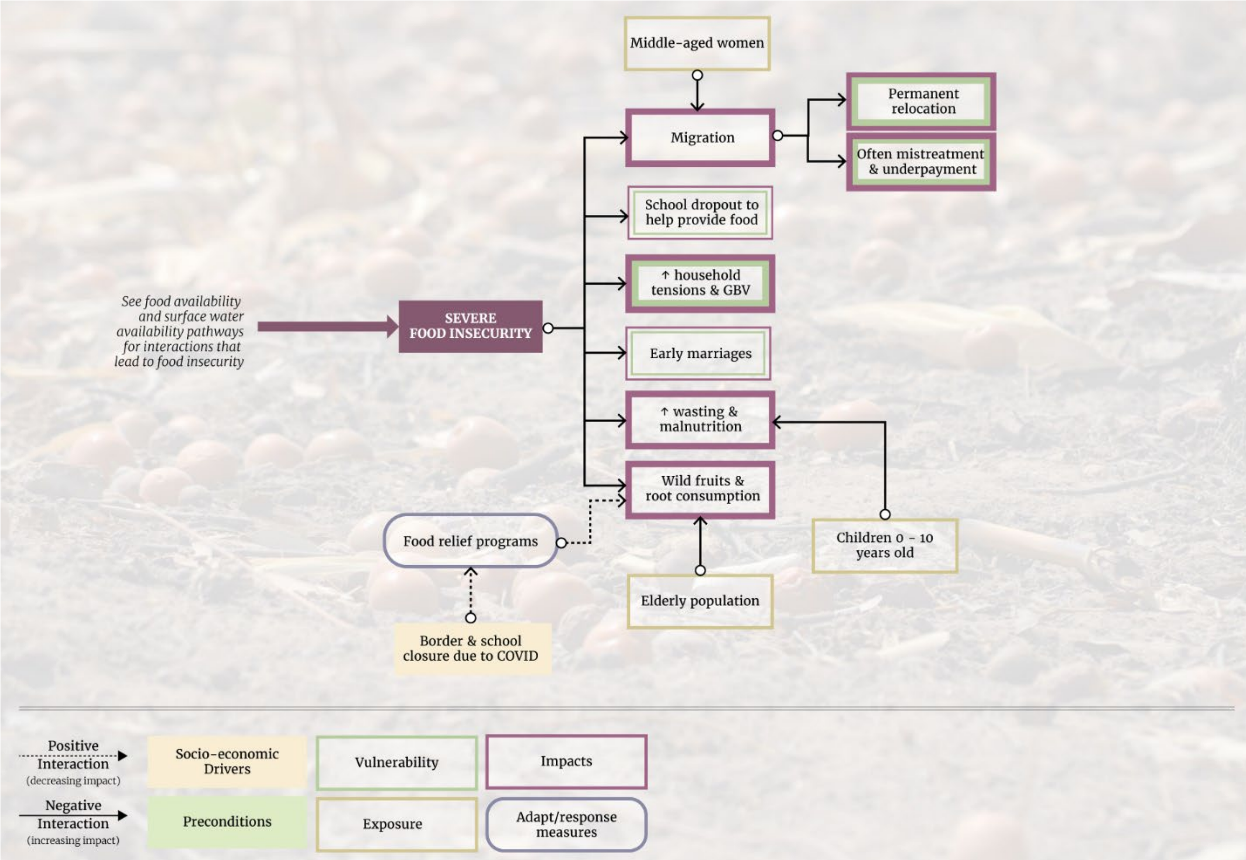


Figure 6. Overview of cascading impacts from food insecurity during 2018-2020 reported in Western Province. Background image credit (edited transparency): Will Roberts CC-BY-SA-4.0, Via Wikimedia Commons.

Impacts on water resources

Rural communities in Western Province are highly reliant on rivers, streams, wells and boreholes for their own drinking water, water for livestock for fishing and other water-based livelihood strategies such as reed-mat making. Between 2018 and 2020, underground and surface **water resources were reduced drastically** in the province, leading to water shortages in which most traditional water sources dried up. The Barotse floodplains, for example, which form the main economic water source in the Western Province, were highly affected (see Figure 6 for an illustration). The floodplains provide favourable land for fish breeding, and farmers are also highly dependent on the flooding season for farming (Chihango Kabanda & Mapanza Sikananu, 2021).

While the Western Province is among the areas receiving the lowest rainfall per year in Zambia, floods are an annual recurrence due to the proximity to the Zambezi River and tributaries as well as the Cuando River. Floods in the Barotse floodplains are celebrated each year at the start of the rainy season with the Kuomboka ceremony, one of the most famous traditional ceremonies which signals the period when people move from the floodplains to the uplands with their livestock. Several interviews highlighted the importance of floods for the local economy and traditional ceremonies, as floodwaters support the fish population (a significant source of livelihood) and replenish soil moisture. However, in 2019, the ceremony was cancelled due to **low river levels**, and in 2020 due to COVID-19 (Lusaka Times, 2019b, 2020).

> “ *Perennial rivers dried up, patches in the rivers with water were not healthy for drinking and boreholes dried up by May 2020. Men accompanied women to fetch water 5-10km away to protect women from wildlife (jackals, lions, leopards, elephants, and crocodiles).*
>
> *FGD1*

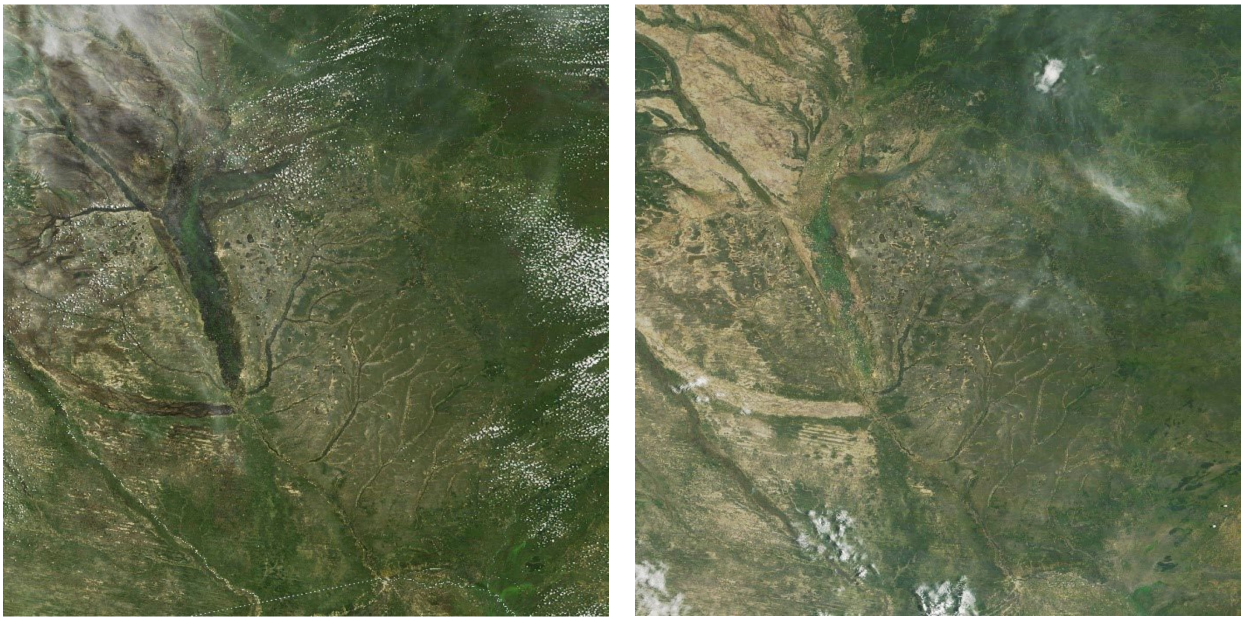
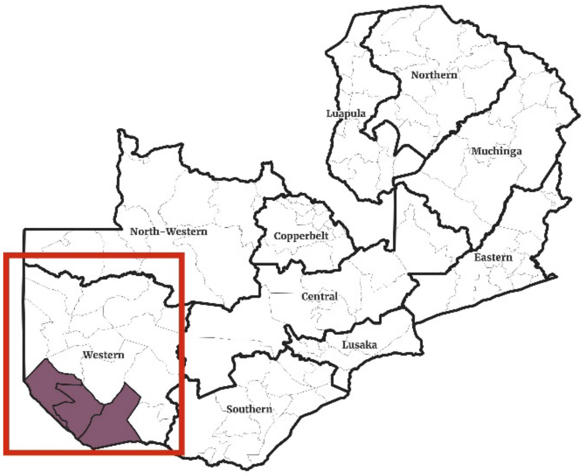


Figure 7. Satellite imagery of Western Province of Zambia on 15.3.2017 (top left) and 5.3.2019 (right). The comparison highlights the extent of dried-up areas around the Zambezi River after the extremely low rainfalls during rainy season November 2018 to March 2019. Imagery Source: Terra MODIS – NASA WorldView 2023.

Image (down right): Reference map of above imagery extent (red rectangle).



Impacts in Western Province, where people are strongly connected to and dependent on the rivers that flow through the province, are not only driven by rainfall dynamics locally. Basin-wide dynamics related to rainfall, evaporation and water abstraction determine river flows, which sometimes have a time lag compared to local rainfall dynamics. Local dry conditions reported for the 2019-2020 rainy season and the following months are supported by satellite imagery of the study sites (Figure 7). While there is limited data for the Cuando River, such information exists for the other major river system passing through Western Province, the Zambezi River. Across the Zambezi basin, the year 2019 (including the tail-end of the 2018/2019 rainy season) was characterized by **deficient rainfall**, which slightly recovered in 2020, in line with earlier mentioned local observations (Hulsman et al., 2021). According to a press statement released by the Zambezi River Authority, the Zambezi River flows monitored at Victoria Falls were at 800m3/s in March 2019, greatly below the 2,522m3/s long-term average (Zambezi River Authority, 2020). These values continued to decrease, reaching 349m3/s by January 2020 and recovering by the end of March (Idem). **Water storage levels were also extremely low** in both 2019 and 2020 across the basin, especially at the Kariba dam just downstream of Western Province in Zambia, which was strongly influenced by evaporation and slow recovery from the previous dry year (Hulsman et al., 2021).

The low levels in the Kariba dam also resulted in **power cuts and electricity shortages** across the country, as Zambia´s energy is 85% hydropower (FMECD, 2022). This generated electricity rationing (load shedding), which progressively worsened in 2019, greatly impacting those areas with irrigated agriculture (Kabisa et al., 2019a;KI05). By December 2019, **load shedding** occurred for a minimum of ten hours (N. Nkhuwa, 2020). This contributed locally to the shift to charcoal-production and selling in Western Province as described in section 4.1 (WWF, 2021b; KI09). A Ministerial Statement issued by the Minister of Energy in February 2020 stated that the Kariba Reservoir was 10% full compared to 43% the previous year (N. Nkhuwa, 2020). Electricity generation in the country remained a significant concern by February 2020, primarily attributed to the low rainfall in the 2018/19 season (N. Nkhuwa, 2020). In March 2020, the Guardian warned that Zambia continued to face **severe water and electricity shortages** as the rains were insufficient to refill reservoir levels after the prolonged dry spells (Gibbons, 2020).

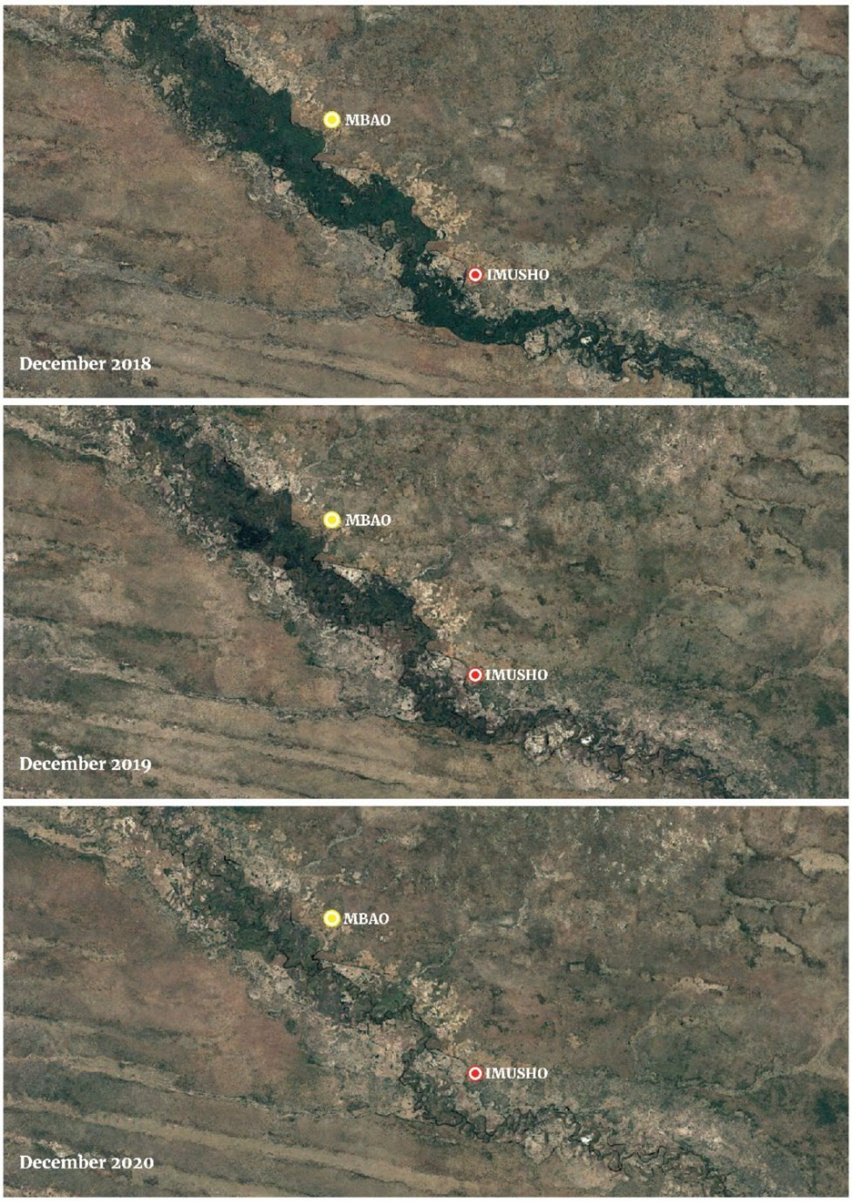


Figure 8. Satellite imagery of Imusho and Mbao. The comparison highlights the extent of the progressively dried-up areas around both communities between 2018 - 2020. Imagery Source: Google Earth Satellite Data.

In Zambia, around 829,000 people die from diarrhoea annually due to unsafe water (Chihango Kabanda & Mapanza Sikananu, 2021). The Western Province has one of the lowest rates for access to improved water supply in Zambia (49%) (African Development Bank Group, 2014), greatly affecting the vulnerability of these areas to dry spell events as more unreliable sources of water dry up.

The **reduced surface water availability** resulted in issues for humans and animals. During 2018-2020, humanitarian actors reported issues in drinking water access and increased use of poor-quality groundwater for drinking and domestic purposes (Green Climate Fund, 2018b; IFRC, 2021a; OCHA, 2019; ZVAC, 2019). Reports and interviews also mentioned an increase in **water-borne diarrheal diseases** (IFRC, 2020; KI3; KI4). Of the two villages covered with FGDs, only Imusho village experienced an increase in water-borne diseases, yet epidemiological data on this is missing[4]. All focus group discussions also highlight the **lack of clean drinking water**, increases in the time spent to fetch water, and safety issues due to wild animals close to water points (see for example the quote below).

[4] Similarly, one interviewee mentioned poor air quality due to dried soils and respiratory issues as a health impact. There were no reports to corroborate this finding.

Furthermore, **increased interactions of livestock and wild animals** due to sharing dwindling water resources and increased proximity of humans to wildlife while fetching water led to an increase in human-wildlife conflict and attacks close to water sources. This finding was mentioned repeatedly in all focus group discussions, as well as interviews in Western Province. This issue was particularly rife in areas where communities live close to or in national parks and where migration routes of elephants cross through. Attacks from crocodiles (KI07; KI09) and elephants (KI04; KI07; KI14) were mentioned as key issues.

> " *When the river water levels decrease, animals go to deeper waters, where people also fish, and reports of attacks by hippos, elephants, and crocodiles increase.*
>
> *KI07*

Limited surface water and loss of pasture also resulted in negative impacts on livestock health, due to dehydration, lower reproduction rates and increased exposure to diseases (KI08; KI09; Banda et al., 2021; Rosen et al., 2021; ZVAC, 2019; Ministry of Finance, 2019). The sharing of few available water sources between humans and livestock, as well as wildlife, contributed to an increase in **livestock disease outbreaks** (e.g. foot-and-mouth disease, anthrax) (KI11; OCHA, 2019). The onset of these diseases reduced the ability of affected households to sell their livestock to supplement their income (ZVAC, 2019). Focus group discussions also emphasised the variability of prices of livestock, with some households having to sell at very low prices, resulting in long-term impacts on their livelihoods.

Long-term shifts in livelihood strategies were also mentioned by those who would normally depend on fishing and reed-mat-making. As these livelihoods weren't viable anymore in 2018/2020 due to low water levels, many villages shifted to charcoal-based livelihoods in the province (KI09; KI10). As one interviewee put it: *"[…] people opted to sell charcoal in town so that they can return home with a bag of maize to feed their families. In the past, you would find coal in Senanga or Sesheke but today you find it everywhere across Western Province."* (KI09).

Positively, findings from the research indicate that conflicts over land and water resources were rare. Most interviewees mentioned that the traditional land governance system, and particularly the interference of local chiefs and traditional courts (described in Annex 1) supported dispute settlement and abated most tensions over land- and water resources (KI04; KI07; KI14). However, some interviews (KI08; KI05) mentioned rare instances where tensions over productive land and water resources between host communities and those moving to find alternative livelihood options emerged, and cases where people moved to areas where aid was distributed.

Load shedding due to nationwide energy shortages also contributed to increased charcoal demand and higher selling prices (Mpundu & Sichilima, 2020). This **shift to charcoal-based heating** and selling of charcoal locally influenced deforestation and fire occurrences (Mpundu & Sichilima, 2020). Analysis of fire occurrence shows pronounced increases in fire occurrences in 2019 compared to 2017 (Figure 9). Wood harvesting to make coal is a significant driver of deforestation in Western Province, usually done by starting a fire (Ngoma et al., 2023; WWF, 2021a). Besides timber harvesting for charcoal production and heating, deforestation and fire occurrence are also driven by field burning for agricultural expansion (Chomba et al., 2012; GRZ, 2023; Masikati et al., 2021). Although not mentioned in the interviews, an agriculture assessment of the Western Province (PIN, 2018a) also reflects that low expected yields due to uncertain seasons in the uplands of the Western Province tend to reduce farmers' invested labour time and increase **less suitable field management practices**, like burning fields during clearance and in between seasons. This further enhances the impacts of the dry spells by decreasing the capacity of fields to hold water and shortening their production period (Keddy, 2003)This also compounded impacts on dry spell exposure locally in the long term, as deforested areas typically see more soil moisture loss and higher temperatures. In Imusho and Mbao, deforestation and wildfires were considered significant drivers of the impacts experienced between 2018 and 2020.

Figure 9. Deforestation in Imusho is reflected by comparing satellite imagery from 2017 (above) and 2020 (below)

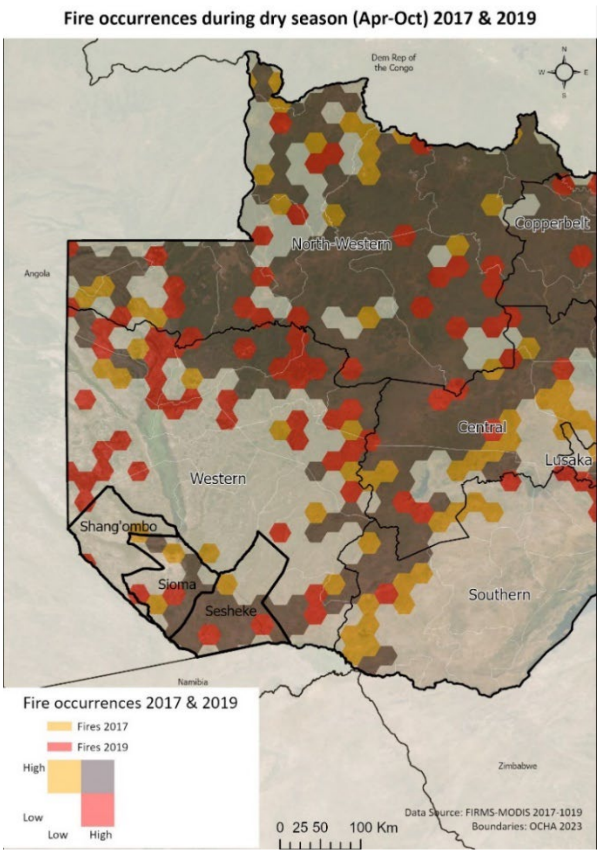


Figure 10. Fire Occurrences during dry seasons (Apr-Oct) 2017 & 2019. Red: low fire occurrences in 2017 and high occurrences in 2019. Orange: high fire occurrences in 2017 and low occurrences in 2019. Brown: high fire occurrences in 2017 and high occurrences in 2019. Brown: high fire occurrences in 2017 and high occurrences in 2019. Own diagram, data source: FIRMS-MODIS 2017-2019. Type: 0 = presumed vegetation fire; Confidence: >75%.

3.2 Drivers of Risk

This section further explores the different drivers of risk that contributed to the impacts described in section 4.1, based on the analysis of risk interactions from interviews, FGDs, literature and other secondary data. These drivers are categorized as **physical, biological, or socio-economic**. The cognitive maps below summarize the findings of the drivers of risk and specific factors determining exposure and vulnerability for 1) food insecurity impacts (Figure 10) and 2) water resource impacts (Figure 11). The full cognitive map is captured in Figure 21. Figure 12 shows the geospatial overlay of the various drivers identified.

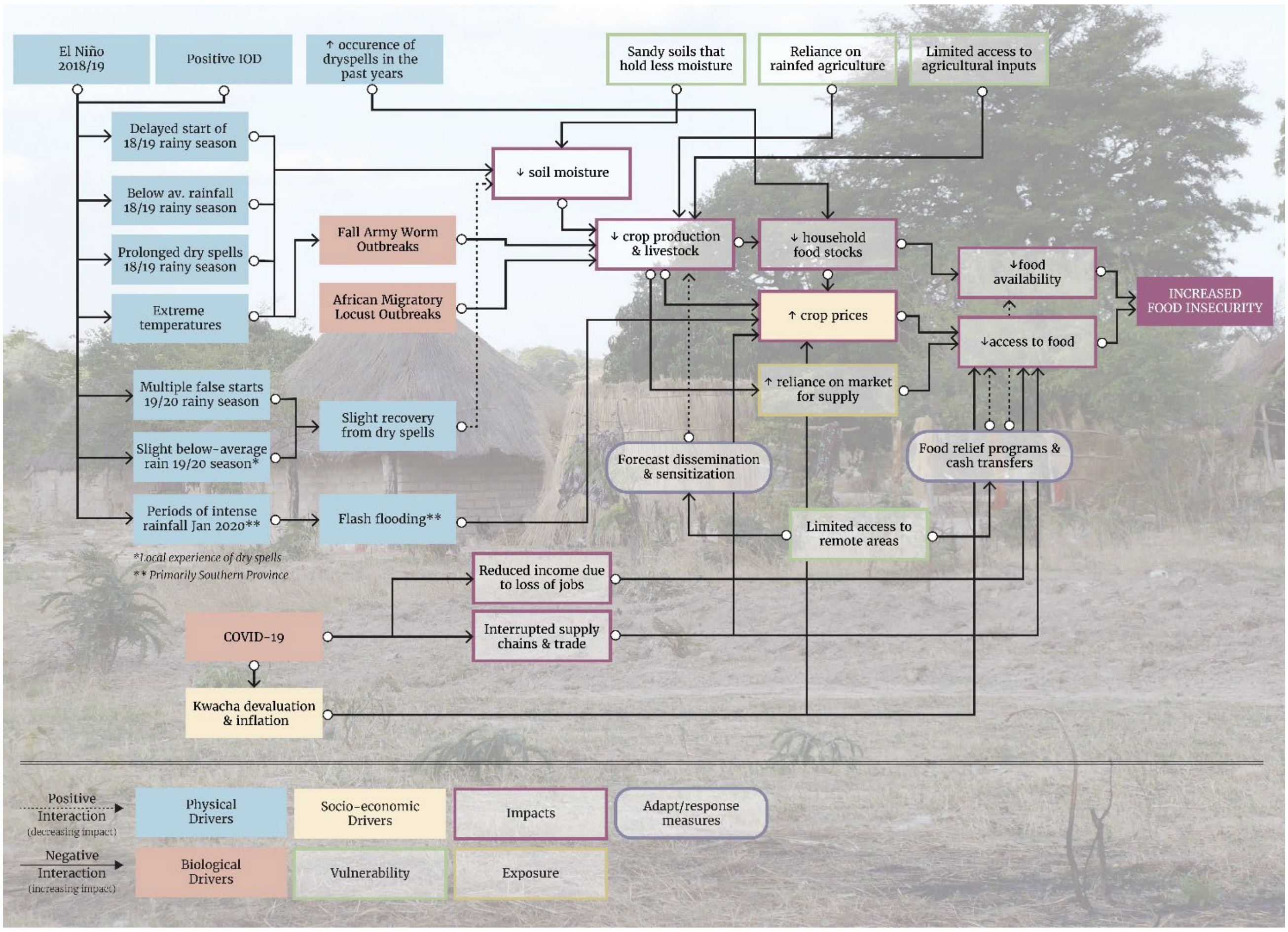


Figure 11. Reduced food security during 2018-2020 in Zambia, cognitive map in the Western Province. Background image credit (edited transparency): Florence Devouard, CC-BY-SA-4.0, Via Wikimedia Commons.

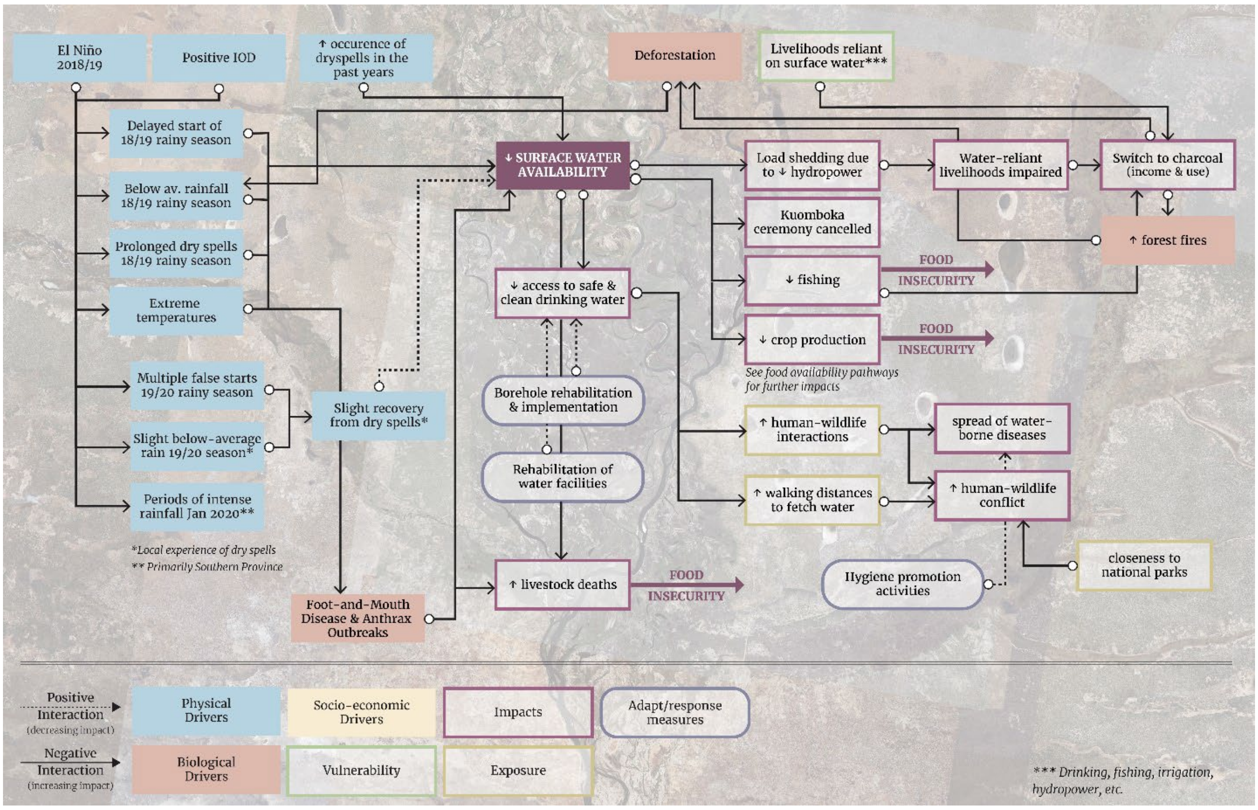


Figure 12. Reduced surface water availability cognitive map, summarizing the main drivers and impacts. Background image credit (edited transparency): Google Earth Satellite Imagery.

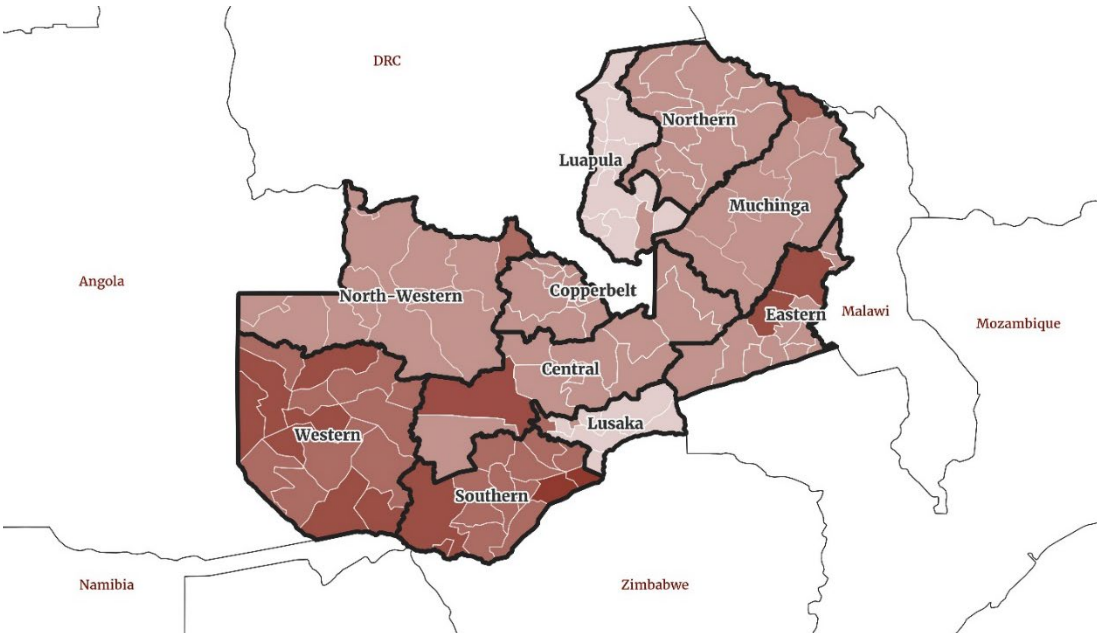


Figure 13. Geospatial overlay of the physical and biological drivers of risk, including the most affected areas for the following layers: 18/19 dry spells, 2019 floods, 2019 foot- and mouth disease outbreaks, January 2020 floods, COVID-19, 2020 African Migratory Locusts outbreaks. Areas with darker red colour indicate the highest number of events experienced. This figure shows geospatial co-occurrence, and some impacts are spatially disconnected, as explored in the section below. Annex 3 includes the individual maps of the identified drivers.

Physical risk drivers

Drought conditions 2018/2019 and 2019/2020

Interviews, situation reports, and focus group discussions directly link the food and water crisis of 2018 - 2020 to prolonged dry spells during the 2018-2019 and, in some cases, the 2019-2020 rainy seasons, along with non-physical drivers related to food prices and access. However, the definition of the dry conditions behind the 2018-2020 food insecurity crisis is not straightforward due to local differences in climatology and hydrology. Both rainy seasons (2018-2019 and 2019-2020) saw below-average total rainfall in the southern half of Western Province (Figure 13). The rainy season of 2018/2019 was characterized by prolonged dry spells, a late start, early cessation, and below-average total rainfall across the Western, Southern, Lusaka and Central provinces (Figure 13; Giriraj & Niranga, 2022). According to the Zambia Meteorological Department (ZMD), the 2018-2019 rainy season was one of the worst in the southern half of the country since 1981 (OCHA, 2019).

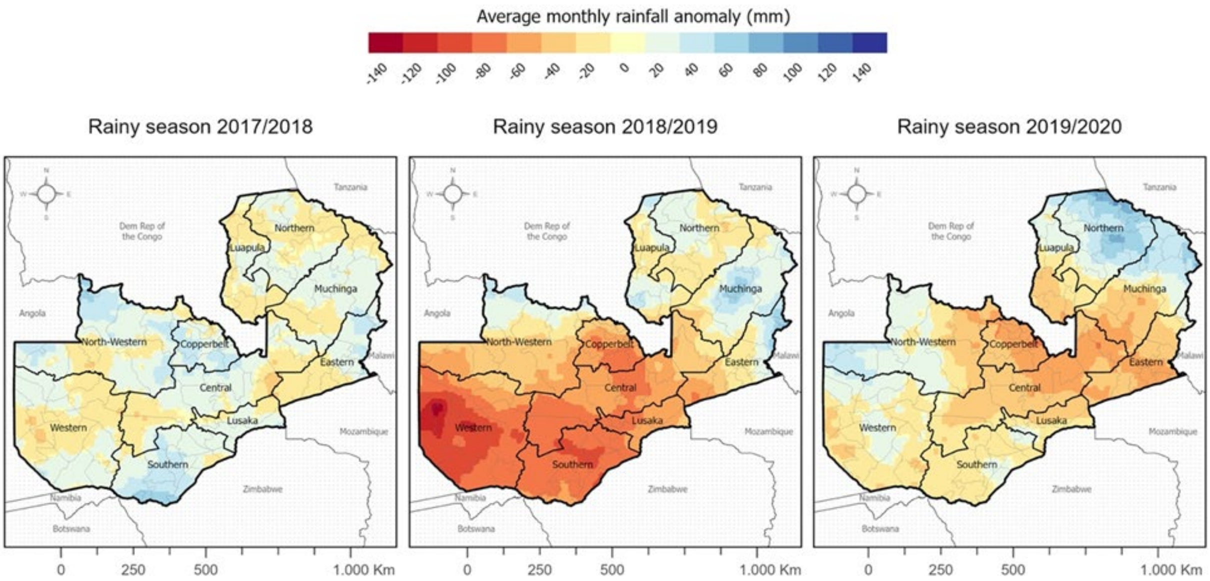


Figure 14. Annual precipitation anomalies for Jul. 2018-Jun 2019 (left) and Jul. 2019-Jun 2020 (right). Anomalies are computed in terms of percentage with respect to the 1991-2020 climatology as estimated by CHIRPS. Red colours depict below-average values. Data source: FEWS-NET

However, focus group discussions in the Sesheke district (Mbao and Imusho villages) highlighted the 2019/2020 season as having the most drought impact. This crisis experience deviates from the general crisis timeline based on interviews and situation reports (Figure 3). In 2019-2020, total rainfall was slightly better compared to the previous season across the province (Figure 13). However, rainfall data from Sesheke district shows that the 2019-2020 season was characterized by multiple false starts to the rainy season, prolonged periods of little to no rain (albeit fewer compared to 2018-2019) and short periods with very intense rainfall (Figure 14). Although total rainfall was higher in 2019/2020, the rainfall peak arrived considerably late, in Feb-March (Figure 14 and Figure 15). Due to the late start, with multiple "false starts" (December 2019) and relatively early cessation, farmers were unsure when to plant and harvest. However, both the vegetation health index and soil surface moisture index show 2018-2019 to be the driest season in Western Province, but in 2019-2020, there were still areas facing dry conditions (Figure 16 and Figure 17). Nonetheless, soil moisture and rainfall data do not fully explain the deviation in the experience of dry conditions and failed harvests in 2019-2020, compared to 2018-2020 locally in the focus group discussion locations.

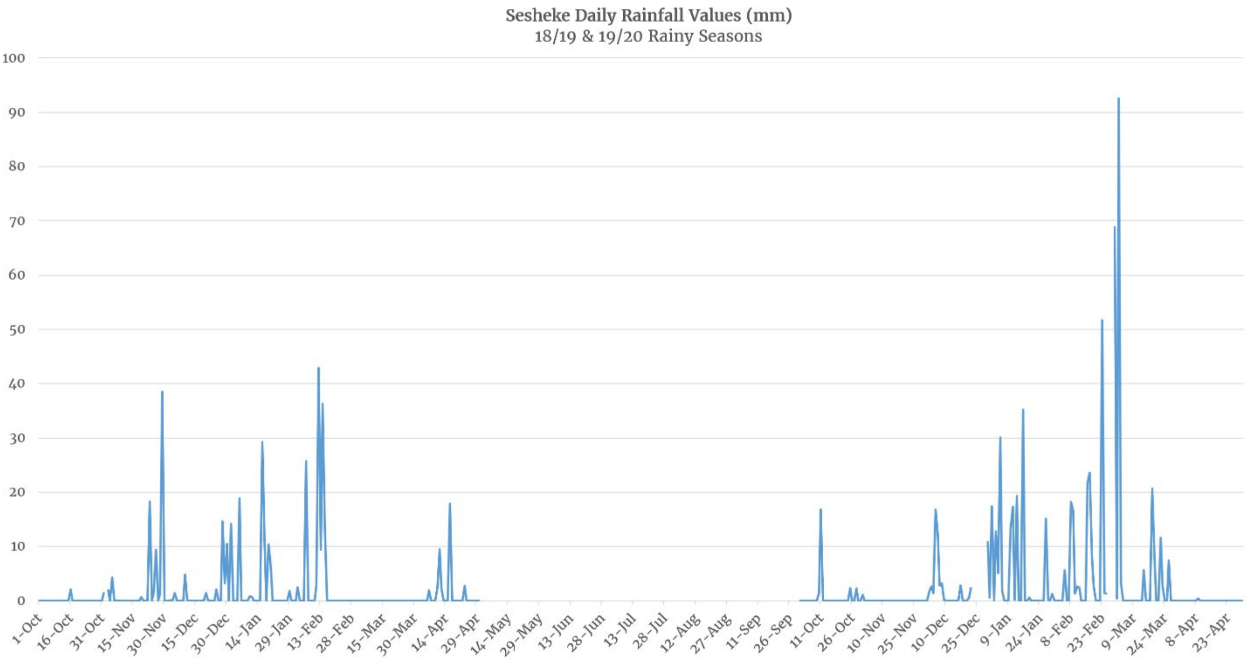


Figure 15. Satellite-observed rainfall totals timeseries (daily) for 2018/2019 and 2019/2020 rainy seasons in Sesheke, Zambia. Data source: ZMD.

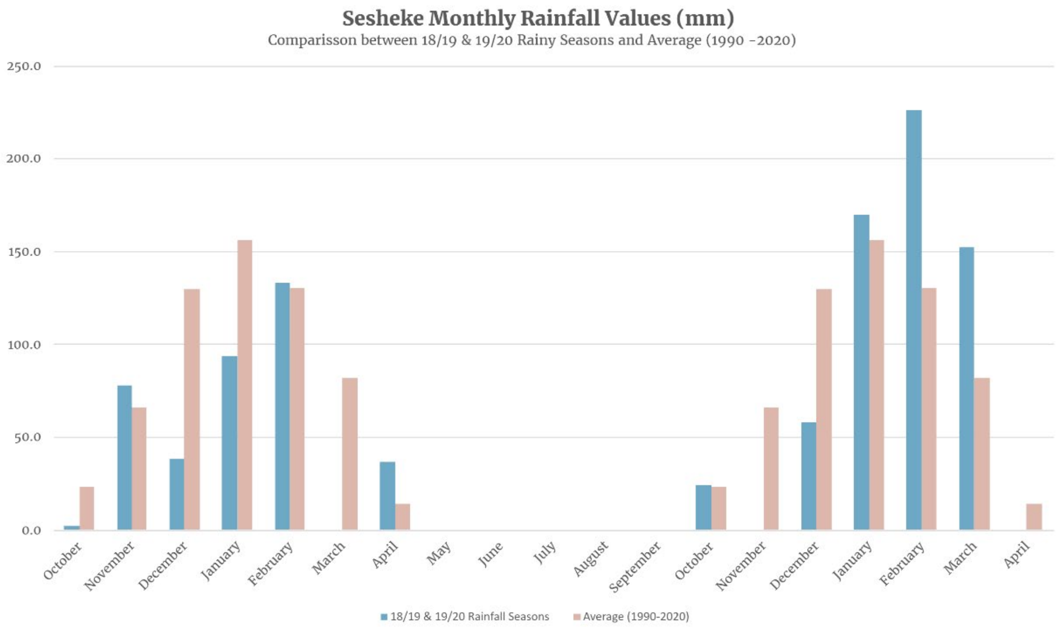


Figure 16. Satellite-observed rainfall monthly totals for 2018/2019 and 2019/2020 rainy seasons in Sesheke, Zambia. Data source: ZMD.

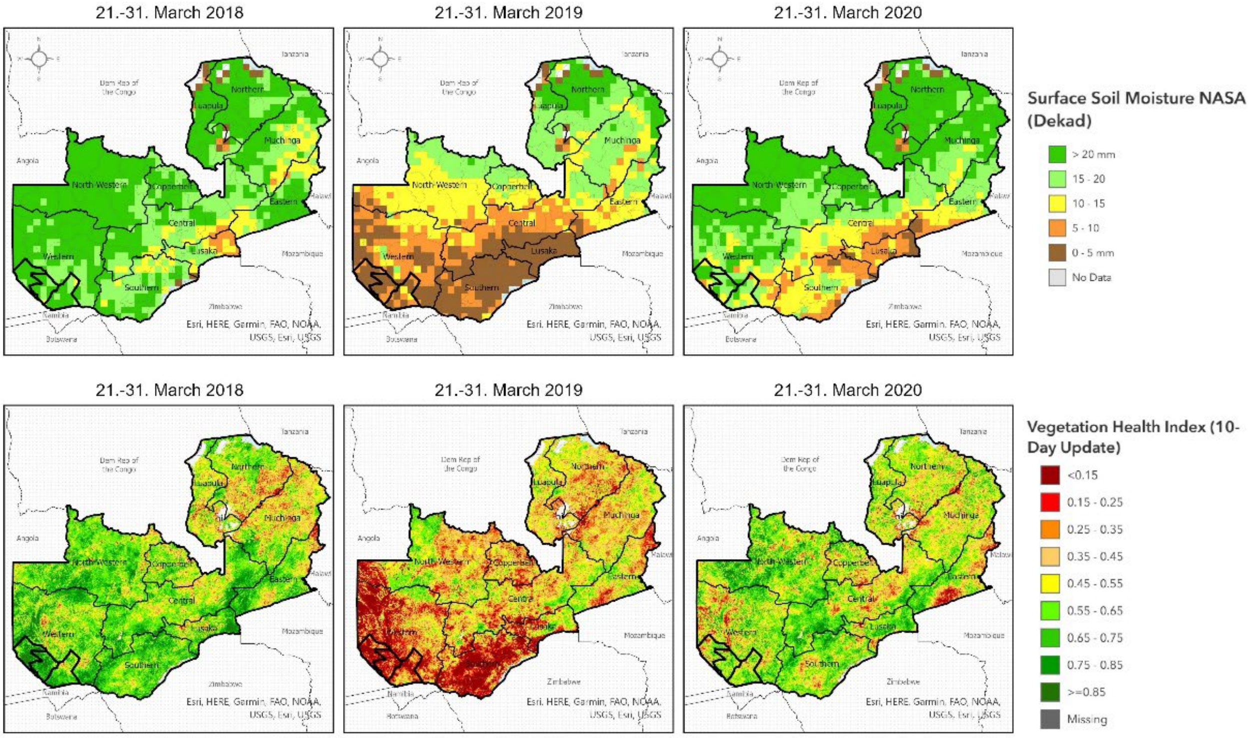


Figure 17. First row: Surface Soil Moisture (DEKAD) for 21-31 March 2018-2020 (Data source: NASA 2018-2020); Second row: Vegetation Health Index (DEKAD) for 21-31 March 2018-2020 (Data source: FAO 2018-2020).

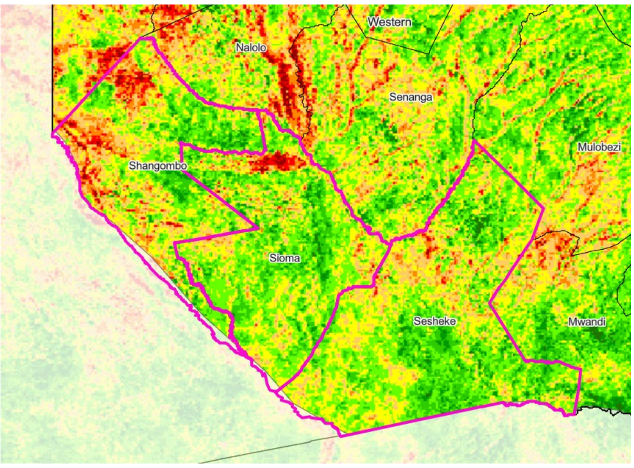


Figure 18. Zoomed in the March 2020 Vegetation Health Index (VHI) map for Sesheke, Sioma and Shangombo districts in Western Province, Zambia (pink lined). Red areas indicate diminished VHI. Data source: FAO, 2023.

Inter-annual variability: ENSO and IOD

On an inter-annual timescale, El Ninõ Southern Oscillation (ENSO) and the Indian Ocean Dipole (IOD) dynamics influence rainfall dynamics strongly across Zambia (Gachigonta & Reason, 2006; Palmer et al., 2023). In 2018-2019 and 2019-2020, rainfall dynamics correlated (negatively) with a positive ENSO phase (El Nino). Positive ENSO is typically linked to rainfall deficits across southern Africa and Zambia, although these episodes were relatively moderate compared with, for example, 2015. The 2018-2019 season was also marked by a neutral to a slightly negative IOD, which would either have a slightly negative or a neutral effect on precipitation. For more details, see Annex 3.

Changes in climatology

Changes in climatology can be considered a driver of risk, influencing the hazard occurrence and intensity over the past decades. While the dry spells of 2018-2020 fall within the boundaries of natural variability in Zambia, dry spell occurrences have increased in frequency over the past 60 years and mean annual rainfall has decreased by a rate of 1.9mm per month since

1960 (SADRI, 2021). Average temperatures have also been increasing, reflected in a 0.7 °C increase for the wet season and a 2.3 °C increase in the dry season between 1982 and 2015, influencing evapotranspiration (Mwongera et al., 2020). The mean annual temperature across Zambia is also expected to increase between 1.9 °C and 2.3 °C between 2050 – 2100 (Mwongera et al., 2020)[5].

Extreme heat

Beyond the dry spells in the rainy seasons of 2018/2019 and 2019/2020, other hydro-meteorological conditions (indirectly) contributed to the observed impacts in Western Province. Participants in focus group discussions and interviewees (KI01, KI02) mentioned that high temperatures towards the end of 2018 and at the start of 2019 contributed to the loss of soil moisture and evapotranspiration, affecting crops and water sources and influencing health outcomes for humans and livestock. One interviewee also mentioned observing issues such as heatstroke in community visits in Western Province, although no data confirmed this.

Floods in Northern, Central, Eastern and Southern Provinces

In 2019 and 2020, the northern, central, and eastern areas of Zambia were affected by floods and water logging. The floods damaged agricultural production, which was meant for domestic markets. This likely contributed to increased food prices across the country, as the south was simultaneously facing the second consecutive season with prolonged dry spells (European Commission, 2019; IPC, 2020).

Biological drivers of risk

COVID-19

The global onset of COVID-19 in February/March 2020 compounded the impacts of the prolonged dry spells in Zambia. As of December 2020, Zambia had seen 17,916 cases of COVID-19, with 364 registered deaths (OCHA, 2020). One interviewee mentioned that they lost many people active in agricultural support and dedicated farmers during the pandemic, which influenced the government's ability to support farmers during dry spells (KI14).

Furthermore, the measures initiated in response to the pandemic, strongly contributed to food insecurity due to limitations in market access, mobility, and the ability of households to earn income. During interviews and focus group discussions, it was mentioned that in the border districts of Western Province, where the economy is strongly dependent on trade and migration to Namibia and Angola, border closures had a significant impact on communities' livelihoods and ability to buy food (KI01; KI06; FGD2; FGD4). People could not go to markets across the border nor send back remittances (FGD2). Other measures included closing schools and airports, restricting travel to large gatherings, and closing recreational activities (bars, restaurants, etc.) (CERF, 2020). All four focus group discussions touched on the drastic price increase of staple foods in early 2020 due to the dry spells and the co-occurrence of COVID-19.

Not only did the COVID-19 crisis directly contribute to food insecurity, but the restrictions and budgetary consequences also negatively impacted the response to the food security crisis in 2020. It was repeatedly mentioned in interviews that school feeding programmes had to stop, and disaster response efforts were slowed down due to lockdown measures (KI07; KI04; KI06). In some cases, ongoing resilience-building activities for farmers were paused, and the COVID-19 response resulted in reduced budgets for NGOs and the government to respond to the impact of food insecurity (KI04; CERF, 2020). Furthermore, the health system was overrun in the first months of the pandemic. While agricultural production improved as rainfall and soil moisture recovered mainly to normal levels in 2020 across Western Province (with local differences), the increase in food prices and impacts of COVID-19 at the national, district and household levels prolonged the crisis and had lasting impacts on coping capacity of communities, extending the food security crisis further into 2020.

Fall armyworm

Fall armyworm (FAW) outbreaks contributed to crops' destruction across Zambia in the 2018/2019 season (KI01; MoA, 2019). The IPC 2020 report also mentions FAW as one of the causes of severe food insecurity this year (IPC, 2020). FAW posed a significant threat to farmers, particularly those who plant maize. The army worms usually attack maize crops at the tasselling stage,

[5] It should be noted that there is an ongoing debate about whether the observed increase in the occurrence of dry spells will persist under climate change (GRZ, 2020; RCCC, 2021a; Kimutai et al., 2023). Various assessments indicate that total rainfall over the Western Province may increase, although this varies strongly depending on the global emission scenarios, and model output variation is high (Idem). Research shows a stronger signal on more variable rainy season onset and cessation, with a higher likelihood of shorter periods with intense rainfall – like the 2019-2020 rainy season, which will have implications for growing seasons (Idem; Green Climate Fund, 2018).

when they produce cobs, massively affecting fields and leading to crop failure (KI01). These species thrive under warmer climates as temperatures increase their growth rate and shorten their development time (Yan et al., 2022).

Foot and mouth disease

Foot and mouth disease (FMD) greatly impacted livestock trade and products, leading to devastating socio-economic effects as infected animals experience decreased milk production, weight loss and poor growth (Mulenga, 2019). The Southern parts of the Western Province, including the district of Sioma, are a high-risk area for this disease, which recorded a rise in FMD reports from 2015 - 2020 (Banda et al., 2021), including outbreaks in 2019 and 2020.

FMD outbreaks threatened livestock significantly during this period. FMD is a highly contagious transboundary animal disease that can spread rapidly among domesticated livestock (Banda et al., 2021). The disease can also persist in certain wildlife species which do not exhibit signs of the disease but can further transmit the virus to livestock (Idem). In Zambia, wild herds of African buffalo carriers, among other host species, pose a significant threat to livestock (Banda et al., 2021). Since 2004, Southern Africa has been experiencing an unprecedented rise in FMD outbreaks in livestock (Banda et al., 2021). The disease, endemic in Zambia, has greatly affected the Southern, Western, Eastern, and Central Provinces of Zambia (Ibidem). Although the causes of recent outbreaks are unknown (Sinkala et al., 2014), the poor performance of vaccination programmes has been suggested as one of the main reasons (Banda et al., 2021).

Locusts

In the 2019/2020 agricultural season, an outbreak of locusts, one of the most destructive pests in the world, greatly affected areas along the Zambezi River, leading to a reduction in crop production (FAO, 2020b). Affected districts include both Sesheke and Sioma (Ibidem). The outbreaks, which started in February 2020, affected more than 450,000 hectares in Zambia (CERF, 2021). KIs mentioned that the locust outbreaks added another layer of complexity: "*In 2020, the community faced an invasion of red locusts, which devastated the crops that had been grown in the plains [red: of Western Province]. This further intensified the challenges already present*" (KI14). As described in Imusho village focus group discussions, crops dried up due to the dry spells and high temperatures, and locusts and wild animals ate the few that survived.

Socio-economic drivers of risk

Kwacha value reduction and inflation

At a government level, rapidly increasing inflation and Kwacha value reduction from 2019 onwards influenced budgetary spending and debt servicing costs, with implications for the DRM/response budget. Inflation and depreciation of the local currency, aggravated by the COVID-19 pandemic, also affected food (discussed in the next section) and a rise in commodity prices (WFP, 2020b). According to FAO, the currency depreciated by about 50% as of October 2020 every year (FAO, 2020a), greatly increasing food insecurity (OCHA, 2020).

For households, the economic shock of the cost-of-living crisis, related to the global economic recession due to COVID-19, significantly impacted spending and coping capacities. In a financial survey developed by the Bank of Zambia in the Western Province between September – October 2020, 56.6% of urban adults (aged 16 or older) struggled to keep up with regular expenses. This was the case for 51.1% of farmers in Western Province (Bank of Zambia, 2020). In the 12 months before the survey, 67.9% of rural adults (65.7% of farmers) in the province struggled to manage unexpected expenses. However, it was not clarified what these unexpected expenses were (Idem). Furthermore, 78.3% of rural adults reported that they experienced hardships due to climate change, including 56.7% who experienced rises in prices due to goods and services and 54.7% who experienced loss of crops, livestock, or their own businesses (Idem).

National and local food prices

Food prices were high across the country in 2019 and 2020. Locally, food prices were influenced by local production of staple crops such as maize, but also influenced by import costs and global drivers. Nationally, the average price of maize grain increased by almost 70% by August 2019 compared to the previous year (FAO, 2019). In March 2020, prices of maize grain hit a record high and then slowly began to recover by October 2020, although they remained higher than in 2018 (FAO, 2020a). This increase in prices was also mentioned in the focus group discussions, and while the exact prices differed, the participants emphasized that in 2019 and 2020 they were struggling with high maize prices. In Western Province specifically, prices for Maize meal, for example, increased by approximately 35.1% by the end of 2019 in comparison to 2018 (FAOSTAT, 2021; Figure 18), with the highest price recorded between August and December 2019. This phenomenon can also be seen when analysing prices in Shang'ombo and Sesheke (Figure 19), where food prices increased by 21.8% and 32.5% respectively, from 2018 to 2019 and remained high in 2020.

The cognitive map below (Figure 21) depicts the intersections and cascading and compounding impacts of these various drivers of risk, bringing together the impact-specific cognitive maps in Figure 5, Figure 10 and Figure 11 previously described.

Figure 19. Average prices for different varieties of Maize in the Western Province across seasons (2018-2021). Zambia has three seasons namely cool dry (May to July), hot dry (August to October) and wet rainy (November to April). Districts analysed include: Kaoma, Mongu, Nalolo, Kalabo, Lukulu, Sesheke, and Shang'ombo. (FAOSTAT, 2024).

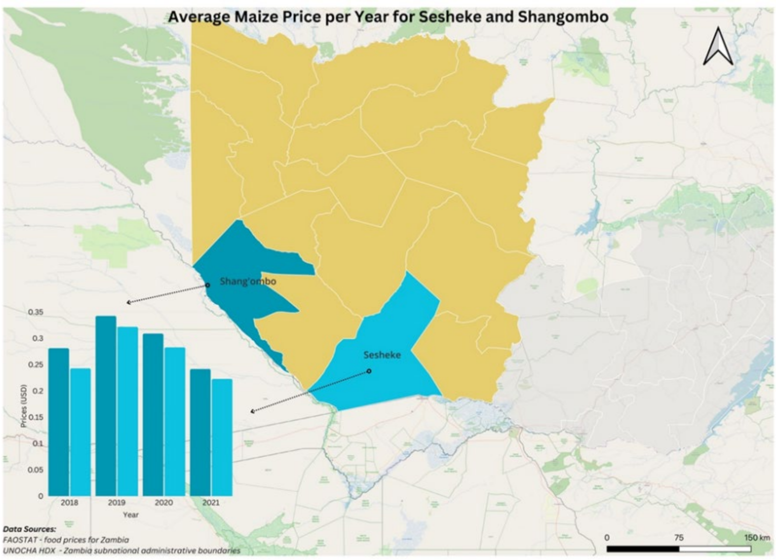


Figure 20. Average prices for different varieties of Maize in the Western Province in Shang'ombo and Sesheke (2018-2021) (FAOSTAT, 2024).

3.3 Root causes

The following chapter outlines the main root causes identified based on the primary data and literature review for the food and water-related impacts on communities during the 2018-2020 crisis, summarized in Figure 20.

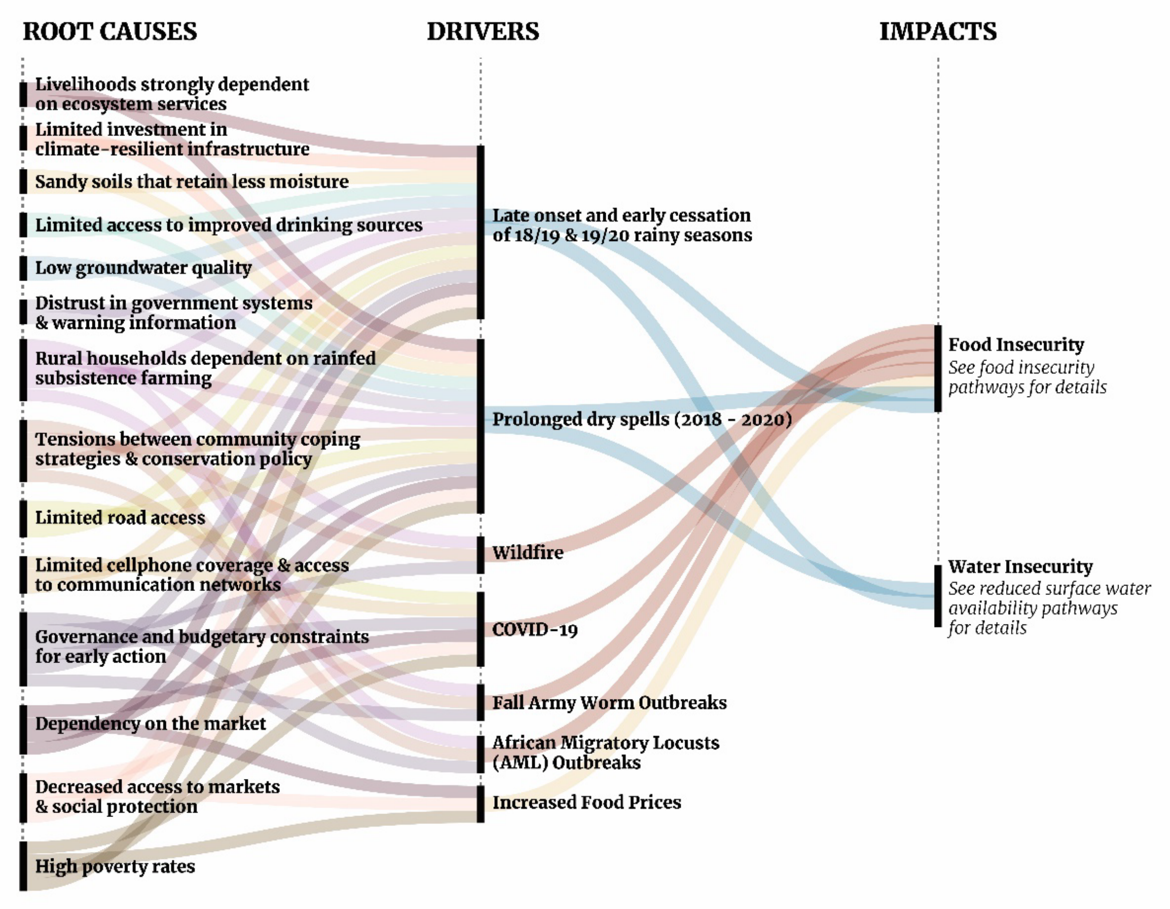


Figure 21. Summary of root causes of vulnerability in the Western Province (WIP).

Root causes of food security risks

Following interviews, FGDs and situation reports (e.g. IFRC, 2020), the food security impacts were severe in the Western Province due to the widespread dependence on small-scale rainfed maize subsistence farming. Lack of effective irrigation infrastructure was mentioned as a major root cause of this reliance on rain-fed agriculture, based on interviews. Western Province has very little mechanized irrigated agriculture, and investment in more drought-proof infrastructure and practices is limited (Mwongera et al., 2020). Traditional irrigation methods such as bucket irrigation and shallow well digging are more common yet face efficiency and scale challenges. Imusho village has a small-scale mechanical irrigation scheme, but participation is limited by land ownership and governance challenges to 15 households. Other farmers practice bucket irrigation, but this is not efficient. In Mbao village, communities could not afford an irrigation scheme. As such, if rains do not arrive at the expected time during the season or are of the right duration, this can generate major impacts on crop growth and harvesting. Wider consultation with interviewees during validation suggested that the low access to irrigation in the study region is due to a combination of limited institutional support (no dedicated agency) and policies, low private industry investment in the region due to land tenure challenges and high investment costs for farmers. The traditional schemes and water user associations are hampered by ageing infrastructure and technological limitations, including the shortage of equipment.

The province also has limited access to other agricultural inputs, such as quality seeds, fertilizers, equipment and facilities for storage and processing, which are key to accessing markets and improving the profitability of crops (Green Climate Fund, 2018b). Officials and farmers expressed challenges around seed availability, where agro-dealers do not have an adequate supply of suitable seed options during predicted dry periods, stating that: *"farmers buy seeds that are available, but not right for the weather. When the rain stopped, crops tassled and failed"*. An underlying issue is the lack of guidance and regulation from the government for agro-dealers, and limited awareness among farmers of best practices, determined often by education, gender and remoteness. Fertilizer use in the Western Province is the lowest in Zambia (Mulenga et al., 2020) and especially the costs and availability of such inputs are considered a barrier based on FGDs.

Maize production, the main staple crop, is also characterized by structurally low efficiency in Western Province (Central Statistics Office Zambia, 2020). While there is increasing recognition of the need to diversify crops and investment in water retention infrastructure, the high poverty rates and limited private investment in the region limit options (PIN, 2018b). Furthermore, recurrent seasons with prolonged dry spells at key moments in the (maize) crop cycles are considered a relatively recent phenomenon, requiring changes in traditional practices (KI8). However, one of the major gaps, is the lack of know-how, finances and organisational capacity to mitigate investment risks within communities (PIN, 2018b).

It should be noted that gender is an important factor determining vulnerability, influencing access to productive assets, access to education and jobs, traditional household roles, and access to information and agricultural inputs (Green Climate Fund, 2018b, 2018a). For example, this study finds that access to ploughing power, especially oxes, is a major determinant of coping capacity. However, in Zambia, 23% of female headed-households' own cattle, compared to 33% of male-headed households (Lubungu & Birner, 2021). Western Province has the highest rate of female-headed households (30%) across Zambia (Mpundu & Sichilima, 2020). Women have a greater dependency on natural resources for their livelihoods and represent a high percentage of the poor in communities, particularly in rural areas (Green Climate Fund, 2018a). Furthermore, although they are key to climate adaptation and resilience, women are underrepresented in decision-making and environmental management and, therefore, less able to confront vulnerabilities (Green Climate Fund, 2018a).

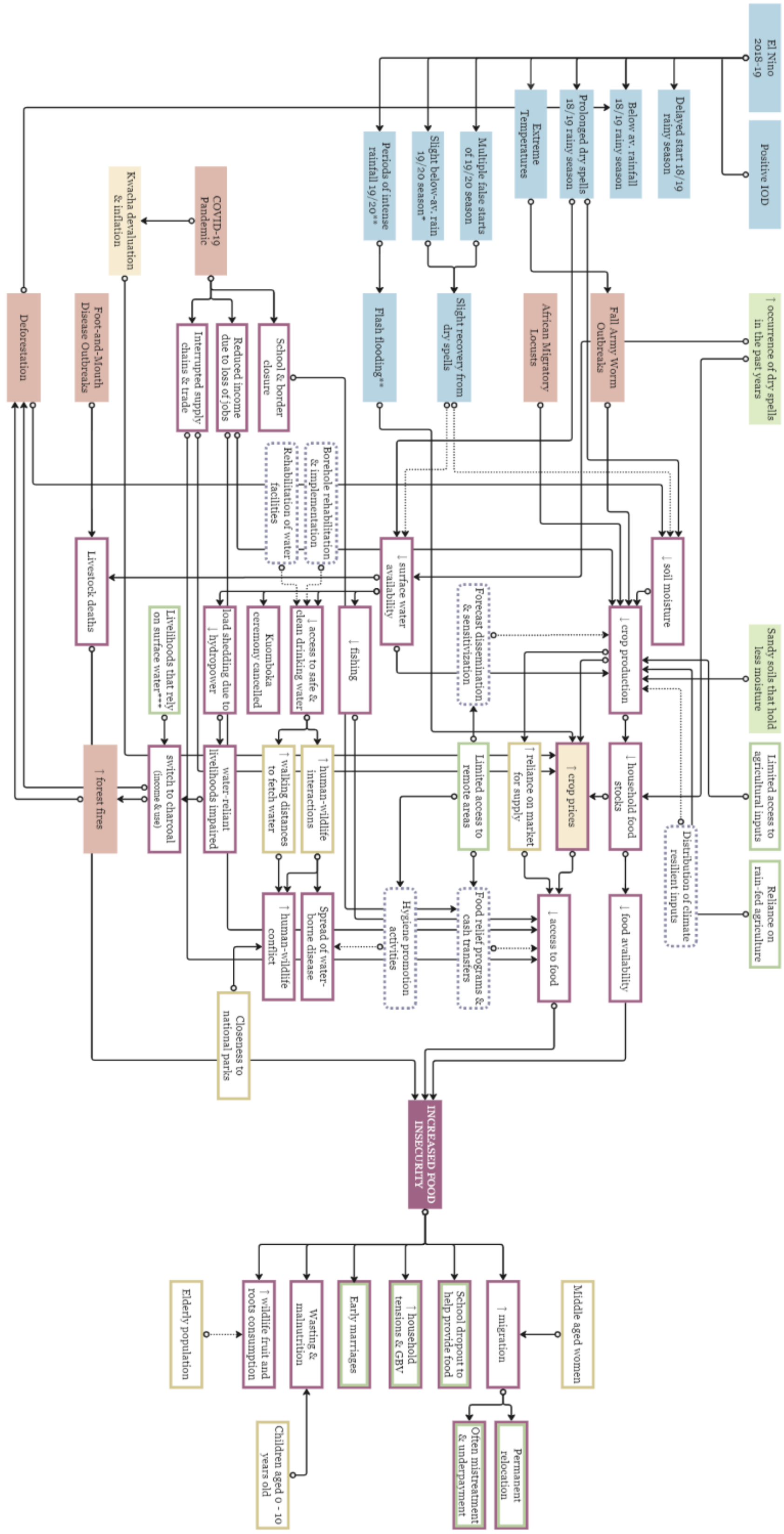
For areas such as the villages of Imusho and Mbao, access to markets was a major barrier and there was limited access to social protection such as the Food Reserve Agency. For example, the nearest Food Reserve Agency and market location 5 hours away from Imusho village, makes communities highly reliant on their own production. Mechanisms that help farmers refinance activities after losses, such as crop/livestock insurance cover and social protection schemes such as the Farmer Input Support Programme (FISP) in Zambia, also have limited coverage in the study area. Farmers cited limited availability and negative perceptions of reliability, remuneration and affordability.

Finally, local differences were observed in the data regarding the onset and severity of food insecurity and failed harvests. This has implications for EWEA and response, as it influences effective windows of opportunity for early action. The sandy soils in the border districts of Shang'ombo, Sioma and Sesheke are a structural driver of exposure to drought conditions, as the soil retains little moisture (KI02). However, based on consultations with local meteorological experts, there are also strong micro-climate influences on rainfall and evaporation in Western Province. While this knowledge is available at the provincial level, little has been published on the influence of these microclimates on agriculture and how this is addressed in early warning systems. Other gaps in the available literature that might shed light on local variability of impacts, include information on groundwater dynamics and river flows. Such research is not available for the region under study.

Root causes of water access risk

While the water-related impacts were mainly driven by the basin-wide rainfall deficits, various preconditions increased the vulnerability of communities. Firstly, communities in Western Province have the lowest access to improved drinking water sources across Zambia and remain highly reliant on surface water and shallow boreholes (ZSA, 2018). There is no in-depth research exploring water access challenges, and more research is needed to understand the root causes of local access to WASH services. Across rural Zambia, research indicates that rural water governance, limited investment and maintenance challenges are key issues to water access (Chihango Kabanda et al. 2021; Scanlon et al. 2016). Furthermore, aquifer characteristics in Western Province often make groundwater not potable, with high salt content. Installing and operating deeper boreholes to access better quality water is costly, according to key informants. Focus group discussions highlighted that during the 2018-2020 period, the deeper boreholes remained operational for longer compared to the shallow boreholes, but they faced issues in deteriorating water quality.

Figure 22. Full cognitive map, combining figure 10, 11 For a fully interactive version, see: https://storymaps.arcgis.com/stories/68abb7c623f7492784ac67d747958502



Chapter 4: Early Warning Early Action during 2018-2020

The following chapter outlines the findings relating to the functioning of the early warning and early action system at the national and local levels during Zambia's 2018-2020 food and water crisis. It differentiates between the main components of the EWEA system: understanding risk, forecast availability and monitoring, warning dissemination and communication, early action planning and implementation, and financing.

During the 2018-2020 food and water crisis, while there were mechanisms for early warning of hydro-meteorological conditions, no formal system existed at the national or local level to trigger early action and release funds ahead of forecasted extreme events. ZMD was sharing early warnings for hydro-meteorological conditions, and DMMU was mandated through the 2010 Disaster Management, 2010 (Act No. 13 of 2010) to monitor and coordinate disaster situations in the country (GRZ, 2010). DMMU uses Standard Operating Procedures to guide response to natural hazard-related disasters (Silengo, 2022). For more details on the policy landscape in Zambia, please refer to Annex 1. Since 2020, DMMU has chaired the national technical working group on Forecast-based Financing (FbF), the main coordination platform for developing EWEA/anticipatory action approaches for the country. At the time of writing this report, , the Technical Working group was exploring national trigger mechanisms for drought early action. The sections below explore what elements of the EWEA chain were functioning during the event, with the aim to identify opportunities for further strengthening of EWEA and long-term DRM interventions.

4.1 Understanding risk

Ahead of the dry spell and food insecurity period starting in 2018, there was awareness among government and humanitarian actors of exposure, vulnerability and potential impacts, drawing on experiences from past events – captured in various policy frameworks. The Zambia National Drought Plan, as well as the National Climate Change Response Strategy, underline drought and dry spell risks (MTENR, 2010; Mwitwa, 2018). Past events have provided insights into dry spell and drought dynamics and, to a lesser extent, impacts on food and water security (Alfani et al., 2021; Libanda et al., 2019; Rosen et al., 2021). Furthermore, FEWS NET operated in Zambia until 2017, providing regular updates on food security dynamics at national and district levels. Beyond FEWS NET, chronic food security and risk factors for malnutrition have been researched in the past (Masiye et al., 2010; Mzumara et al., 2018; USAID, 2021). While general information is available on historical rainfall and drought conditions, gaps remain in the transparent analysis of vulnerability, understanding impacts, and risk interactions. The available assessments and strategies did not address potential hazard inter-relationships, such as co-occurring droughts and pandemics.

As will be further explored in Sections 5.3-5.5, limited early action was implemented before the crisis. Key informants identified limitations, including a lack of impact-based information, which depends on granular and up-to-date risk information and disaster loss data from past events. Past assessments have found that data on losses from disasters in Zambia is limited (UNDRR, 2023). While a flood-specific impact-based forecasting model was under development at the time, this focussed on different hazards and impacts (Houston, 2021). The main source of information for government and humanitarian actors during the crisis was the Zambia Vulnerability Assessment Committee (ZVAC), yet this information only became available after the 2018/2019 rainy season. In July 2019, DMMU conducted a comprehensive Vulnerability and Needs Assessment in 86 districts affected by food insecurity. Following the ZVAC assessment, DMMU organized consultation meetings with Government ministries, UN agencies and civil society organizations to formulate a response. The assessment findings were used to develop sector-specific response strategies to finalize the Zambia Drought Action Plan (2019/2020) and the UN Humanitarian Response Plan (2019/2020), and implementation started towards the end of 2019/start of 2020. The response was built on annual contingency planning processes coordinated by DMMU in collaboration with other stakeholders and line ministries to establish disaster preparedness measures for times of disasters (Hon. Mwansa, MP, 2020). Contingency plans reference the seasonal forecasts produced by ZMD and develop a risk analysis to determine the sectors and main areas affected to prepare for the eventualities that are likely to occur under different analyzed scenarios, at the time separated by hazard (e.g. floods) (DMMU, 2009). These address activities to be carried out in critical sectors, including agriculture, health, education, water and sanitation, infrastructure, human settlement, and shelter (Silengo, 2022)[6].

[6] Since the event, the Zambia Red Cross Society (ZRCS) also developed a multi-hazard contingency plan that tackles compound risks associated to floods, cholera, COVID-19, droughts, crop diseases and election related violence (RCCC, 2021d).

4.2 Forecast availability and monitoring

In 2018 and 2019, various national formal early warning signals (forecasts) were available for the below-average rainfall conditions and food insecurity. However, no early warnings were produced for the other drivers identified in Chapter 4, such as low river levels, crop and livestock diseases, socio-economic conditions and related impacts. For the low river levels, the Water Resources Management Agency (WARMA) is responsible for hydrological monitoring and forecasting. However, before 2020, the capacity for forecasting was very limited, and the emphasis of capacity development has been on flood forecasting (KI05). Since 2023, there has been more attention to hydrological drought monitoring and forecasting (KI05). The seasonal weather outlooks and sub-seasonal monitoring of weather conditions, crop yield forecasts, and food security outlooks are relevant to the crisis under study and are further described below. There is no monitoring system available in Zambia currently for malnutrition, water access and other impacts, nor was there an impact-based forecasting model available at the time. Important to note are the early warning signals communities relied on, based on local knowledge, which were described in the focus group discussions.

Weather forecasting

2018-2019 Rainy Season

The dry conditions in the 2018-2019 season were anticipated in advance, with the first signals emerging in June based on global forecasting products, and more high-confidence downscaled outlooks available in November. In 2018, the first signs of a potential abnormally dry rainy season emerged with the ENSO forecast, Enso3, which predicted a positive ENSO for the end of 2018-start of 2019 (NOAA, 2018). Positive ENSO (referred to as "El Nino") events are typically associated with below-average rainfall across the southern half of Zambia (Hachigonta & Reason, 2006). A mildly positive ENSO event materialized in line with the forecast. For a detailed overview of the climatology and evaluation of available early warnings, please refer to Annex 3.

However, in August, the SADC SARCOF outlook for 2018-2019 assigned a low probability to the below-average conditions in the Western Province conditions observed for the months of January, February and March (SARCOF, 2018). Like every year, the Southern African countries came together in August to develop the regional, seasonal outlook at the Southern Africa Development Community Southern Africa Regional Climate Outlook Forum (SADC SARCOF).

The ZMD rainy season outlook, on the other hand, published in September 2018, warned of normal to below-normal conditions in Western Province, with dry spell risk across Zambia, early start (extreme western and southern parts) and early cessation (southern half specifically) of the rainy season (ZMD, 2018). This largely corresponded to the events observed in the rainy season. ZMD downscales the SADC SARCOF seasonal forecast for October-March for Zambia based explicitly on a triangulation with available sources. Beyond the SARC SARCOF, ZMD relies on IRI, UKMO, ECWMF and other international forecasting agencies as sources. The global ECWMF SEAS5 seasonal outlook indicated in November a 40-50% chance of below-average rainfall in JFM, FMA over Zambia – missing the above-average rains in the North but correctly capturing the dynamics in Western Province (SEAS5 COPERNICUS, 2019).

2019-2020 Rainy Season

For the 2019-2020 season, the early warning signals were less clear. Observations for Sesheke district in Western Province (Figure 14) show that the season had multiple false starts in November, and the rainy season onset materialized only towards the start of January. In January, February and especially March, several days occurred with relatively high precipitation and multiple consecutive dry day periods.

The ENSO forecast published in June suggested a very mild positive phase (nino3~0.5) for the end of 2019 and early 2020, pointing to less predictability for the coming seasons (fall and winter) (NOAA, 2018; see Annex 3). In August, the SADC SARCOF regional outlook was forecasting a normal to above-normal first half of the rainy season (October, November, December) (SARCOF, 2018). In SADC verification documentation, this forecast was classified as a miss for Western Province in October, November, and December 2019, and partly a miss in January, February, and March 2020 (SARCOF, 2019).

By September 2019, the ZMD rainy season outlook predicted normal to above normal rainfall across Zambia for October-February; onset of rains in November; likelihood of normal to below normal rainfall in January-March; reduced rainfall and dry spells around February (ZMD, 2019). Although ZMD forecasted the seasonal precipitation amount for the second half of the season from January to March (normal to below normal) relatively well, other elements, such as the rainy season onset and the precipitation amount for the 2019 fall season and the variations in rainfall locally in Western Province, were missed in the national seasonal outlooks. Focus group discussion participants indicated that these uncertainties complicated farmers' decisions on when to plant and when to harvest.

Food security

Food production: Crop forecasts survey

Each year in May, the Ministry of Agriculture of Zambia publishes a crop forecast survey – comparing expected production with the previous season, which provides an indication of the availability of staple crops such as maize compared to the national demand. In May 2019, the Ministry of Agriculture communicated an overall expectation of reduced production compared to the 2017/2018 season of key staple and cash crops, specifically: season rice (-31%); sorghum (-49%); millet (-23%); maize (-16%)

(MoA, 2019). While this reduction was a warning signal for potential impacts on food security, the ministerial statement did share the expectation that national maize requirements would be met through the Food Reserve Agency (FRA) stock management. The FRA was established to manage the National Strategic Food Reserve to ensure national food security and provide access to markets for rural smallholder farmers (Chapoto et al., 2016). The 2019/2020 season National Food Balance Sheet reported a deficit of 354,930 megatons of maize for human and industrial consumption, mainly due to the decrease in crop production of the 2018/2019 season, according to the Ministry of Finance (2019). Nationally, the improved rainfall conditions in 2019/2020 were reflected in the improvements in production for key staple crops such as maize (+69%), sorghum (+200%), rice (+17%) and millet (+81%) (MoA, 2020). However, the Crop Forecast Survey only serves as an indicator of production. Focus group discussions emphasized the importance of the rise in food prices and COVID-19 in 2020 for their food security, underlining the importance of looking at multiple indicators for food security.

IPC/ZVAC food security classifications

Signs of deteriorating food insecurity characterized the 2018-2020 humanitarian crisis, with the first signal available in May 2018 based on combined reporting from the ZVAC and IPC. The IPC published their data on food security in Zambia on 1 May 2018, followed by yearly updates, including outlooks for the season ahead (IPC, 2018). The May 2018 report provided an indication of the rapid worsening of food insecurity, and this trend was confirmed in August 2019 (IPC, 2018, 2019, 2020). The August 2019 report built on the in-depth ZVAC research carried out over the dry season in 2019, which provided a strong warning signal of worsening food security across various provinces in Zambia – with Southern and Western provinces most severely affected (ZVAC, 2019). Up to 60% of the population in Sioma and Shang'ombo were projected to be in IPC +3 during the 2019-2020 rainy season, for example, compared to 18 and 19%, respectively in the previous rainy season (IPC, 2019). In November 2020, the IPC outlook indicated continued high food insecurity in the country despite increased agricultural production. Recovery was expected for 2020/2021 based on IPC outlooks, but COVID-19 hampered recovery (IPC, 2020).

It should be noted that validation and skill assessments for the IPC data on current and projected food insecurity are missing. FEWS NET stopped its activities in Zambia in 2017, and since then, the IPC has been the major source of information used for disaster preparedness. Since there are no alternative data sources to compare statistics, little is known about the skill of the IPC assessment approach in Zambia. While no verification is available, high levels of food insecurity were observed to align with the information from key informant interviews and focus group discussions to the extent that those can be generalized.

Local knowledge

One finding from the focus group discussions was the strong reliance of communities on traditional local knowledge for early signals of rainy season onset, potential dry spells, and drought conditions. Communities saw early signs of prolonged dry spells in 2018/2019, which included weather conditions such as high temperatures and strong winds and ecological indicators such as massive locust invasion in the fields (red locusts) and changes in vegetation dynamics (Table 1). Based on these signals, communities decided on planting time and harvesting, for example, although options for action were limited (see Early Action section).

Warning Signal	Interpretation
High temperatures and strong winds just before the rainy season	Likely below-average rainy season
Locust invasion (red locusts) and mopane worms	Less rainfall than normal during the rainy season
Vegetation dynamics: Abundance of mango fruits, *echika,* and *mukononga*. The lack of flowering of the rose wood tree (local name: *muzahuli*), African custard apple (local name: *malolo*), Dialium Angolese (local name: *muhamani*).	Likely less rainfall than normal during the rainy season. This belief is rooted in the idea that nature provides plentiful resources before periods of scarcity
Altered migration patterns of certain bird species and butterflies	Less rainfall than normal during the rainy season
Decrease in fish populations in local water bodies	Likely drought conditions and low river levels in the next year
Altered patterns of wildlife movement, especially elephants	Changes in environmental conditions, especially vegetation health

Source: Focus group discussions and interviewsTable 1. Overview of traditional signals that signalled oncoming drought to communities in Western Province, Zambia.

Integration of local knowledge in early warning systems is recognized as an opportunity to improve the relevance of forecasting mechanisms and to increase the sustainability of interventions (Hermans et al., 2022). At the time, communities relied heavily on these local traditional early warning signs for dry spells because formal information from ZMD and other sources did not reach them or did not trust this information (see Section 5.3). However, there is no integration of this information in ZMD seasonal outlooks or agricultural advisories, nor is there information on the various signals and their specific meaning, accuracy, and occurrence. As mentioned by one of the key informants, the integration of traditional knowledge into national forecasts was a challenge and something they wished to improve on to enhance the uptake and integration of information in local practices (KI02), after which they indicated: *"But now we are trying to embrace it. We are trying to understand how to embrace it unlike in those 18-19-20 seasons." (KI02).*

Trigger information for future early warning early action for drought/dry spells

To contextualize the available early warning signals in the EWEA system for drought that is under development in Zambia, we compare the conditions in 2018-2020 with the recently developed national drought EWEA trigger. The trigger for anticipatory action for drought from the FbF Technical Working Group (TWG), articulated in Zambia Red Cross's drought EAP (forthcoming), includes a multi-trigger approach determined by key stakeholders of the TWG in 2023 based on evaluations of historical performance and accessibility. The pre-trigger is the EWMWF Enso3 index; the first trigger is the ECWMF SEAS5 seasonal forecast, and the second trigger is the Crop Survey Forecast by the Ministry of Agriculture. In 2018, the trigger for ENSO would have been reached in August, and the first trigger for below-average rainfall in November. For the final trigger, the decision on whether the trigger would have been reached would be made in the TWG meeting based on the crop forecast survey. Given the significant projected reductions reported in May 2019, a trigger decision would be likely. In 2019, only the pre-trigger for ENSO would have been reached, and as a result, the other triggers would not have been reached. Findings from Chapter 3 emphasize local differences in the rainfall observed and harvests. Rising food prices and COVID-19 also strongly influenced food security during this period. As a system to manage residual risk, which means it should trigger in extreme situations, this demonstrates that on the national or provincial scale, the conditions of 2018/2019, in hindsight, should have triggered widespread early action. However, the system would not have triggered for the more localized impacts observed for seasons such as 2019/2020, where the hydro-meteorological drivers of impacts were compounded by socio-economic conditions and local variations in weather conditions resulting in large variations in harvests and water availability (Chapter 3).

4.3 Warning dissemination and communication

For the 2018/2019 rainy season and the high food insecurity in 2018-2020, government and non-governmental actors extensively communicated risks and advised preparedness and response measures to the public. However, both localized findings from focus group discussions and the key informant interviews brought up challenges in connectivity, clarity, and trust that hampered warning dissemination and uptake.

Communication Channels

Various actors regularly engage in community outreach to disseminate climate information to different user groups. The rainy season outlook is shared in Parliament and subsequently disseminated to the public (Lusaka Times, 2018; Mushimba, 2018a, 2018b; RCV, 2018). Once early warnings are validated through parliament for the rainy season and the crop forecast, the information is broadcast to the public via local television, radio, email, Facebook, and WhatsApp groups. According to interviews, one of the main challenges of the communication channels is the difficulty of reaching all farmers at the appropriate time, particularly for more extreme scenarios like the 18/19 dry season (KI11; KI14; KI09). In many remote areas, the lack of access to technology, limited network signal, and few TVs generate difficulties in accessing the broadcasted information (KI14; FGD2; FGD4). Radio coverage in the border areas is also minimal, with communities mainly accessing Angolese or Namibian radio stations (KI13; KI14).

In response to these challenges, the Ministry of Agriculture sends information to agricultural camp extension officers on the ground, who are then responsible for disseminating it to communities in meetings (KI14). Humanitarian actors such as ZRCS and UCZ also went door-to-door in specific at-risk communities to raise awareness (KI01; KI08; KI13). Both camp extension officers and the radio were recognized as the main source of information in the focus group discussions. Still, the mobility of the camp extension officers was limited, and as a result, there were differences between the villages regarding access to information. Interviews mentioned that resource constraints and the difficulty of accessing remote areas due to inadequate transport infrastructure pose great challenges to the former communication channel (KI11; KI14). The camp extension officers also reported issues with mobility at the time, as there was no funding for fuel to travel to more remote villages (KI10).

Warning Messages

DMMU typically liaises with relevant ministries to create advisories and to communicate warning messages to relevant target groups. In the case of the rainy season 2018/2019, the Ministry of Agriculture developed advisories for farmers based on the ZMD forecast, which was then communicated through the extension officers (KI11; KI12; KI14). Advisories include information on what types of seeds to plant and on timings of planting and harvesting, all to minimize risk and avoid losses (KI14).

When discussing the effectiveness of early warning messages in focus group discussions, there was a clear difference between answers from the women and men, where the men said they did receive information during camp extension meetings. In contrast, women in both Imusho and Mbao state they did not receive any information. It was said that the major determinant of access to warning messages was attendance of the camp extension meetings in both communities by both men and women. Women faced issues in attending the meetings due to the many competing tasks and responsibilities and the timing of the meetings. For those who did not attend these meetings, accessing information through other channels was hard due to the previously explained reasons. Furthermore, sharing among the community was limited, as mentioned in most of the FGDs, for example, by the FGD4: *"Climate and weather information is very difficult to share with neighbours because of suspicion, attitude, and behaviour of people in the community and lack of trust of each other and the dissemination channels."*

Understanding and actionability of warnings

This distrust of the warning information and of community members among each other was also brought up as a challenge in interviews. There was a perception among key informants that limited accuracy of the outlooks resulted in diminished trust among communities, while also noting that this has improved strongly in recent years (KI05; KI02; KI12; KI14). To address scepticism among communities of outlooks and advisory information, ZMD and the MoA, for example, engage lead farmers, who have more openness towards information, and women explicitly in their dissemination networks (KI02; KI14). However, findings show the clear difference in access to information for women in the FGDs and overall distrust among community members may limit the effectiveness of such approaches.

Another theme from the interviews was the understanding and actionability of forecast information and actions advised in agricultural advisories, specifically the rainy season outlooks, for end users such as farmers (KI05; KI02; KI12; KI10; KI14). The advisories for farmers are provided in English and translated into local languages by extension officers. The overall reliance on extension officers limits the access to advisory information. The content of the advisories was also considered a challenge. Issues highlighted by local officials include: complex language, lack of actionable information, and limited integration of traditional beliefs and practices. One KI mentioned that the probabilistic expression of risk confuses people, which also increases mistrust. For farmers specifically, it was recognized that information was not easily understood, as they may not know how to interpret typical statements in seasonal outlooks such as "normal to below-normal rainfall" (KI10). At the same time, there was also limited attention to communicating potential impacts and risk reduction strategies in the outlooks and advisories, which ZMD together with partners such as the Ministry of Agriculture is currently trying to improve through impact-based forecasting and more actionable content in advisories (KI02; KI05). Even so, interviews brought up that having access to information is not enough to translate into effective planning. Even if farmers receive and understand the information, lack of resources and essential farming tools greatly constrain the capacity to respond (KI07).

4.4 Early action planning and implementation

The following section explores to what extent early actions were planned and implemented for the dry spells in the window of opportunity for EWEA, focusing on reduced crop yields as the main direct impact. Early actions build on existing policy frameworks, contingency plans and funding streams to help the population at risk reduce the negative impacts of an extreme event based on a warning signal (IFRC et al., 2024). Early action can be implemented from the household to the government level, supported by various actors or implemented independently by households/communities without external support. For drought or dry conditions, early actions can address a wide spectrum of impacts, ranging from water access and services improvement and epidemic control to crop production support (Heinrich & Bailey, 2020). As discussed in section 5.3, the first warning signals for a potential drought/dry spell event became available in June 2018 based on global ENSO indices, with higher confidence in this signal from November 2018 based on the downscaled ZMD seasonal outlook. During the rainy season 2018-2019, field observations signalled poor crop yields, later confirmed by the crop forecast survey (May 2019). By July 2019, there was also a clear formal warning signal of rapidly deteriorating food security in Zambia (ZVAC, 2019). The window between the pre-trigger based on ENSO forecasts (June 2018), the first trigger in November 2018 (onset first below-average rainy season and publication of ZMD seasonal outlook) and the subsequent lean season (starting November 2019) can be considered the window of opportunity for early action specifically, after which the crisis response would start[7].

While no formal EWEA frameworks or funding streams existed in Zambia at the government, humanitarian or community level, some planning occurred from August 2019 onwards, building on DRM protocols and contingency planning routinely carried out by DMMU. DMMU leads an annual contingency planning process in collaboration with other stakeholders and line ministries to establish disaster preparedness measures for times of disaster and have Standard Operating Procedures in place (OVP, 2020). Contingency plans reference the seasonal forecasts produced by ZMD and develop a risk analysis to determine the sectors and main areas affected to prepare for the eventualities likely to occur under different analysed scenarios (DMMU, 2009). These address activities to be carried out in critical sectors, including agriculture, health, education, water and sanitation, infrastructure, human settlement, and shelter (Silengo, 2022). Implementation of actions by the government and partners for the 2018-2020 food and water crisis started after the release of the ZVAC assessment (July 2019), when DMMU organized consultation meetings with Government ministries, UN agencies and civil society organizations to devise a response (CERF, 2020). The ZVAC assessment was used to develop sector-specific response strategies to finalize the Zambia Drought Action Plan (2019/2020) and the UN Humanitarian Response Plan (2019/2020). While many actions described in the response plans align with typical early actions, the timing of implementation starting November 2019 (one year after the onset of the first below-average rainy season) meant impacts had already become widespread, and these should be classified as response rather than early action.

> “ *By 25th August [red: 2018], we knew that we were having about 65-75% chance of El Nino. And by the time we had our national downscaled forecast, it was very clear which districts will be affected, and what will be the impact. It was very clear, but still, noone was moving.*
>
> *KI04*

Various key informants and focus group discussions underlined that there was no early action implemented to reduce food and water insecurity peaks based on these signals in the period between November 2018- November 2019, beyond the regular awareness-raising described in the previous section and some support through insurance (KI01; KI04; KI11). This is likely partly because in the period of 2018-2020, the concept of early action (or forecast-based financing/action) was just gaining traction in Zambia, with a focus on floods (KI01; see Chapter 2). The Technical Working Group for Forecast-Based Financing, chaired by DMMU, was also established during this period. Nonetheless, no funding was available yet at government, humanitarian, or community levels, nor was any research conducted on appropriate early action triggers and interventions. The available contingency plans and protocols were not based on evidence-based triggers for hydro-meteorological and other drivers of impacts, and the coordination protocols were reactive rather than proactive. Informants reported bureaucratic challenges and barriers to quick implementation, for example, in the absence of a declaration of an emergency by the President in 2019 despite the assessments conducted by DMMU. It should be noted that in 2018/2019, insurance pay-outs were provided to 7,821 farmers (48% women), which were majorly used for the acquisition of fertilizers, livestock feed, and seeds (Machado & Goode, 2022). Section 5.5 below explores funding in more depth.

Government and humanitarian actions

> “ *The warning came in time, but it is ‘what we do with the information’ that matters the most. As alluded to earlier, from government/humanitarian perspective, we are reactive instead of being proactive*.

[7] It should be noted that for slow-onset hazards such as dry spells and drought, it is often difficult to distinguish between response and early action, as these develop slowly with often lagged (indirect) impacts, often mediated by other drivers (Jokinen, 2019). Given the compounding dynamics between the two below average and erratic rainy seasons, COVID-19, general food price dynamics and other drivers of risk (Chapter 4), response actions for the dry spells of 2018-2019 were also contributing to reduction of risk for the subsequent shocks.

KI08

In the absence of early action, response efforts led by the government started towards the end of 2019 and start of 2020, when communities were already one year into the food and water crisis. Between the end of 2019 and 2021, various actors such as DMMU, Ministry of Agriculture, Ministry of Social Welfare, Ministry of Health, Zambia Red Cross, World Food Programme, amongst others, provided support to communities. Government and WFP support focused on food security, through distributions of maize meals and pulses (WFP, 2019b) and through the Food Reserve Agency. The MoA supported farmers through sensitization of drought-resistant practices and ZRCS distributed unconditional cash grants and borehole rehabilitation (KI1; KI14). WFP also supported MoA along with other partners to strengthen the resilience of smallholder farmers through promoting crop diversification and training in climate-resilient practices (WFP, 2019b). Several other efforts were made in the sectors of nutrition (i.e. screening, admitting, and treating malnourished children), education (i.e. school feeding programmes), protection (i.e. awareness raising and referral systems to respond to GBV), and health (i.e. electronic surveillance systems) (CERF, 2020; WFP, 2019b) in most affected districts.

However, when response operations started by early 2020, humanitarian needs far exceeded the capacity of actors to respond. As described by one key informant: *"I wouldn't say it was done 100% because most of the areas were still lacking. And this is because of our lack of funds from financial aspects to meet all of the needs of the entire country. So, I would say some selected areas were resolved, but still really having more to do."* (KI03). Although extensive efforts were made, results from interviews, FGDs and humanitarian reports highlight some key challenges in response capacity. Focus group discussions also highlight local differences in access to government and humanitarian crisis support, as the specific villages engaged did not receive any support. In the face of budget restrictions, interviews also highlighted transparency-related challenges in beneficiary selection and prioritization (KI04). Only 25 out of the 58 most-affected districts described in the ZVAC assessment were prioritized in 2019 due to funding constraints (WFP, 2019b). Although the DRM structure and policies in Zambia are in place to carry out this prioritization transparently, the functioning of community-based committees was reported to be limited at the time. In the FGD locations, for example, the local DRM committee, normally in charge of beneficiary selection, was not functional. However, this has been reported as having improved since then.

Furthermore, for the border districts of Western Province specifically, the distance from larger towns and settlements and the poor road conditions were a major barrier to (early) response and also limited the coping capacities of the community. While settlements in Zambia are relatively well connected across the country, the border districts of Western Province are an exception. Poor road conditions have been a challenge in Western Province and a political topic of debate (RTSA, 2020). As a key informant described for Western Province: *"One notable challenge was the difficulty in transportation, primarily stemming from the poor condition of the roads. Despite the support from partners who provided food parcels and other essentials, the inadequate road infrastructure made it challenging to transport these provisions to the villages, where they were needed the most. The absence of suitable transport compounded this issue."* (KI09)

Lastly, in Zambia's food security policy, the Food Reserve Agency (FRA) has a key role in managing food prices and maize stocks and prices. The Food Reserve Agency has already been mentioned as a program to provide access to markets for rural smallholder farmers. During periods of food insecurity or any disaster that can create volatility in prices, the FRA purchases, stores and releases stocks in the market for its´ stabilization (CUTS, 2018). However, in 2019, the FRA planned to buy 300,000 megatons (mt) but by September, had only managed to buy 90,000 mt, limiting the potential for market stabilization (Sakala, 2019b). Although its main aim is to ensure security and stability, the FRA has faced several challenges, including inadequate funding and mismanagement (Lusaka Times, 2023). The FRA is also criticized for failing to alleviate rural inequality and having very little impact on the income of the poorest households, in addition to the fiscal burden that the agency places on the GoZ (Chapoto et al., 2016; CUTS, 2018). Strategies of buying maize at higher than market prices in producing areas fail to benefit most of the poorest rural households who do not produce surplus and/or are net buyers of maize (Chapoto et al., 2016; Mason & Myers, 2011). As such, the FRA rarely buys produce from most smallholder rural farmers and their surplus from larger suppliers or a small percentage of smallholder farmers (Ibid). Furthermore, strategies to stabilize market prices by selling surplus maize to the market at a discounted rate also negatively impact farmers who produce early maize, grain traders, and millers without access to the reduced price (Chapoto et al., 2016). Recently, the various FRA challenges have begun to be addressed, as the MoA announced in 2017 that it will be reviewing the FRA Act to improve the agencies´ operations (CUTS, 2018).

Box 1: The role of community-based early action

The focus group discussions highlighted how people cope in Imusho and Mbao villages without external support and shows the need for long-term investment in development and disaster risk reduction to enable more effective early action at the community-level. Community-based early action to address the risk of crop losses for subsistence farmers was hindered due to limited access to warnings from government sources (described in the previous section) and a lack of resources to make changes to practices based on traditional knowledge. Implementing routine activities such as awareness raising was highly limited by a lack of personnel at the district and community level, with a great demand for more ZMD and DMMU staff, for example. This has since improved with more decentralization of services (KI14).

FGD3: Q: Did you take any early action against the drought? If so, what did you do? If not, why not?

A: No because we did not know a drought was coming. By the time we realized that we were not going to have food it was too late for any action.

The response strategies in the villages differed before and during the COVID-19 pandemic. Before COVID-19, villagers pooled resources together to buy food in the nearest town, and people migrated to Namibia for piecemeal work. After COVID-19 started, borders closed, and transport was challenging. People resorted to gathering fruits and roots. Both communities mentioned they did not receive any government or humanitarian support, and during COVID-19, they could not access the Food Reserve Agency or markets in Namibia.

Additionally, people simply could not act if they had information. As the Chief of Imusho village explained, *"Having weather information does not always translate into effective planning due to resource constraints. Even if people understand the information and know what to do, t the implementation is often hindered by a lack of essential farming tools"*. For example, advisories suggested planting more drought-resistant crops and early maturing varieties. However, focus group participants emphasized that lack of access to ploughing power (often oxes), fertilizer and access to different seeds and complementary inputs greatly limited their ability to change crops planted, and planting and harvesting times. Furthermore, those that did plant drought-resistant crops (e.g. sorghum and millet) (mentioned in Imusho only) saw their crops still fail or eaten by wildlife and locusts. One woman from Imusho village explained: *"I had a good field of sorghum that year because I planted early but elephants came and ate all of it, I tried to chase them away, but they became aggressive. In the end I ended up being hungry like everyone else"*. There was also no crop or livestock insurance coverage in the villages, and the losses of the 2018/2019 season greatly impacted the ability to plant and keep livestock in 2019/2020. This highlights how EWEA systems need to focus on the last mile to result in meaningful early action and impact reduction in communities, which requires addressing the structural barriers to resources, knowledge and power.

4.5 Financing

Limited capacity to mobilize sufficient resources in time for early action and (early) response for government, non-governmental and community-level actors in Zambia was one of the main barriers. While Zambia has robust DRR legal frameworks to guide quick response to disaster situations, DMMU effectively coordinated the assessments and response (see Annex 1). Barriers existed at the different levels of financing, relating to bureaucracy and dependency on international funding.

Government financing

Firstly, releasing government emergency funds and foreign support to respond depends on the formal declaration of a state of disaster, which can only be done by the president. The declaration typically only occurs when crisis impacts are evident and is a political process by the President and Parliament – informed by the assessments and advice of DMMU. No provisions existed (and still do not exist) for releasing funds ahead of crisis impacts based on established triggers. Once a disaster is officially declared, additional resources and coordination efforts are deployed to address the emergency effectively. This current budgeting and funding process for response, according to interviews, is very time-consuming and often delays action, making it difficult to implement actions when needed (KI08; KI14). As one KI described: *"So, the timing really was late. And unjustifiably late, because if we actually believed in our early warning systems or if we respected our early warning systems we would have been acting much earlier. By the time we started moving countrywide, people were already affected, so the timing was not really good. It was not evidence based. It was more reactive when people started crying out there in the communities. And then we have a situation where we have a huge time lag and a backlog of people to reach out to."* (KI4)

> “ *...we rely on government through DMMU. They would first have to declare state of disaster before we can intervene. What we have seen as a challenge is that, by the time government declares, communities have already been affected by the disaster. We intervene when communities are already feeling the impacts.*

KI08

No disaster was formally declared in the 2018-2020 period, despite the assessments of DMMU, calls from the opposition and some humanitarian agencies (Lusaka Times, 2019a; Sakala, 2019a), the government considered the food security situation was not severe enough, as the north of the country did experience a good rainfall season believed to be enough to feed the rest of the country (Mbewe, 2019). As a result, there was no full-scale disbursement of funds accessible through such a declaration from the international community and insurance.

Since 2020/2021, the government of Zambia has increased access to pre-agreed financing, a crucial step towards improved EWEA. However, although Zambia now has pre-arranged financing options available to help cover costs associated with the immediate response and recovery to droughts and floods, there are no financing mechanisms in place to cover up to 82% of the annual average losses (Kaimuri-Kyalo et al., 2023). The main pre-agreed financing mechanism is the Sovereign crop drought risk product for Maize production by the Africa Risk Capacity programme (ARC), which Zambia has taken out since 2020/21 (Kaimuri-Kyalo et al., 2023). The ARC programme contributes towards strengthening national systems for disaster preparedness through support to drought insurance premiums and capacity building. This disaster risk financing program is in its infancy and Zambia’s classification as a middle-income country has somewhat hindered its access to some funding sources. This mechanism provides payouts to the Zambia government to support the response costs that it incurs when drought leads to low levels of maize production. Since 2021, Zambia has also established the National Disaster Relief Trust Fund (NDRT). This fund is provided under Part V of The Disaster Management Act, 2010 in part is to be used for the provision of essential commodities and other relief to victims of any disaster, hazard, or emergency and other matter relating to the preparedness, prevention, mitigation of, and recovery from disasters. The account for this fund was established in 2021, but no other information exists on whether this fund has been accessed to date.

At the household scale, social protection schemes focusing on insurance of crop losses have been a major focus of government policy and partner support (Machado & Goode, 2022). Zambia has the largest insurance program in sub–Saharan Africa and is ranked first in the world for the number of people covered by microinsurance schemes, which total 1 million farmers (idem). This was partly due to the 2017/2018 scheme in which Zambia bundled agriculture insurance with the Government’s Farmer Input Subsidy Program (FISP). This saw an increase in the number of farmers with access to agriculture insurance from 20,000 to over 900,000 within one year. However, in the case study area, FGDs and interviewees mentioned that insurance payouts were very late and limited and that the Farmer Input Subsidy Program (FISP) was only available for registered farmers and strongly delayed in providing support. Small-scale farmers in Western Province do not commonly have access to insurance mechanisms and FISP. According to interviewees, this is due to various factors: limited availability/offer, education and remoteness are limiting factors to uptake, and the current insurance mechanisms are seen as slow, with low payouts, expensive premiums and not affordable.

Humanitarian Financing

As mentioned, humanitarian frameworks for early warning early action/anticipatory action were not established at the time. Instead, funding focused on responding to the impacts once these materialized. However, a humanitarian appeal was developed in partnership between the government and humanitarian organizations based on the DMMU ZVAC assessment in August 2019. The government-led UN humanitarian appeal for food security response was only funded at 36% by December 2019. COVID-19 further compounded this situation, as it prompted the reprogramming of some funding to increase assistance to areas most impacted by the pandemic (CERF, 2020). The late arrival of contributions (received in November and December 2019) and prolonged times between the acquisition and delivery of pulses further challenged food relief measures (WFP, 2019a, 2020a). By March 2020, GRZ had made the decision to halve the pre-agreed maize meal ration and provide blanket feeding, which caused additional delays in the distribution (WFP, 2020b, 2020a). The IFRC and Zambia Red Cross published an information bulletin on the food security crisis in September 2019 (IFRC, 2019a) and launched their emergency appeal also in October 2019 (IFRC, 2019b). ZRCS had to reduce the scope of their response to fewer districts due to funding constraints. The travel restrictions and delay in planning and implementation of capacity building due to COVID-19 also led to a low coverage of community outreach services and affected the capacity to reach beneficiary targets (Ibid). During 2020, the Kwacha faced a 50% depreciation against the United States Dollar (see Section 4.2). The weakened currency constituted a key driver behind the concurrent food price increase (Whitehouse, 2021). It was also a major challenge that impacted the potential for government co-financing (Green Climate Fund, 2020).

❝ *I recall it being a substantial challenge for us in terms of resource allocation, finding the right resources to reach everyone, despite being aware of the urgent need. The failure to reach everyone had inevitable negative consequences. Farmers who had planted crops had complete crop loss, and at the community level, the impact translated into heightened levels of hunger.*

KI14

Chapter 5: Conclusion and Recommendations

To encapsulate the comprehensive insights gained from this study, the following section will summarize the key findings, laying the groundwork for the subsequent recommendations and concluding reflections.

5.1 Summary

Between 2018 and 2020, this research identified various risk drivers that contributed to the high food insecurity and water access challenges affecting Western Province in particular. Prolonged dry spells, late-onset and early cessation of the rainy season of 2018-2019, and 2019-2020 across the southern half of Zambia were the main physical drivers affecting **harvests and availability and food access** at the household level. Crop pests such as fall armyworms and locusts and damage from wildlife were also compounding challenges. Food prices for maize, the main staple crop, were high due to limited production and the consequences of COVID-19 economic measures. COVID-19 also elongated the food crisis. Elderly women living alone and young children were most severely affected by malnutrition. Structural issues include the reliance on rain-fed agriculture and lack of irrigation infrastructure because of limited investment and complex land ownership structures.

The second main impact during the 2018-2020 period was the **reduced availability of water**, which resulted in limited access to drinking water, loss of livelihood opportunities/income and increased exposure to wildlife attacks and zoonotic diseases. Across the Zambezi and Cuando Basins, the main rivers in Western Province in 2019 and the first half of 2020 were extremely low flows due to basin-wide below-average rainfall. As wildlife watering holes and communities' drinking water sources dried up, people were forced to fetch water further away, in locations often shared with various types of wildlife and livestock. To our knowledge, the experience of attacks from wildlife and losses of crops due to wildlife searching for food and water are major findings that have not been presented in literature/reports on the crisis. Furthermore, tension between community coping strategies and conservation policy was mentioned as a root cause of issues. Due to the combined impacts on basic needs and livelihoods, a large portion of the adult population in the villages researched migrated to Namibia and Angola to find alternative income, which was later hindered due to COVID-19-related border closures.

The in-depth exploration of impacts, drivers of risk, and root causes helped inform the retrospective assessment of **early warning and early action** functioning during the crisis and identified areas for future investment. The early warning system at the time was functional at the national level. Still, it lacked sufficient granularity, and clear triggers for early action and did not reach the last mile to the extent needed to reduce impacts. Early warning information was limited due to a lack of impact-based forecasting information and mainly focussed on hydro-meteorological conditions. For the 2018/2019 rainy season, there was a clear early warning for a below-average rainy season in Western Province. However, in 2019/2020 the impacts were driven more by a combination of local below-average conditions, lingering impacts from the previous season, and the socio-economic implications of COVID-19 and local influences on food prices. These impacts in the Western Province were underestimated.

The lack of capacity at the community level to access, disseminate and act on warning information was a major barrier. Dissemination of warnings in both seasons in the case study area hinged upon attendance at camp extension officer meetings, with limited trust in warning information from government sources. Poor road conditions and connectivity, including limited cell phone networks, Zambian radio/TV coverage and limited access to information in the case study area. However, traditional local knowledge also foreboded dry conditions. For those who did consider themselves warned, early action capacity was limited by structural issues. In the time between the first warnings (August-December 2018), the limited access to alternative drought-resistant seed varieties, fertilizer, irrigation, insurance and compounding damage from wildlife limited the implementation of household-level early action.

DMMU was key in coordinating all government ministries, departments, humanitarian organisations, development organisations, and donor organisations. However, the main constraint during the food and water crisis in 2018-2020 was the lengthy bureaucratic process for budget approvals and coordination, which requires a disaster declaration. Government and humanitarian support only started towards the start of 2020, a year into the crisis. Government and humanitarian actors could not access financial resources before the crisis's impact materialized, resulting in a larger population dependent on food support later in the crisis. In 2020 and 2021, COVID-19 measures and pressure on the response budget also limited the response's scope, scale and flexibility. They could, therefore, not respond to the worsening food and water security in the case study area in 2019/2020.

5.2 Recommendations

A robust Disaster Risk Management (DRM) framework is necessary for averting crises and effectively handling residual risks by proactively anticipating and responding to emergencies, especially when long-term investments in resilience are constrained. The event studied in this retrospective study is an example of other socioeconomic and biological crises compounding food and water-related impacts triggered by dry spells. Encouragingly, the government has recently demonstrated progress through initiatives such as multi-hazard contingency planning, fortification of local DRM committees, and bolstering response structures. Additionally, the Technical Working Group on Forecast-based Financing, under the leadership of DMMU, has been instrumental in advancing early warning early action strategies for droughts in Zambia following the studied event.

Recommendations for improvement of DRM in Zambia to enable effective EWEA:

However, to strengthen preparedness for future crises, heightened focus on several fronts is recommended for action by government, donors and humanitarian and development actors across the DRM continuum:

Improve national-level analysis of local food insecurity and water access risks through enhanced monitoring and evaluation before, during and after crises. Understanding the complexity of risks is crucial for effective long-term strategies in DRM. This study highlights the locally diverse interplay between vulnerability and multiple hazards and gaps in granular impact data and data services at the national level. This emphasizes the need for comprehensive risk assessments and monitoring, building on the ZVAC assessments. No published data exists to validate the ZVAC outlooks, and there is limited post-disaster assessment. The study underscores the importance of considering factors beyond hydro-meteorological hazards, such as micro-climatic conditions, food prices, exposure to wildlife, access to agricultural inputs, and mobility, as major determinants of food insecurity. Strengthening impact reporting and monitoring by multidisciplinary actors can facilitate a better understanding of risks by bringing together various ministries and organizations across agriculture, water resources management, health, education, protection, migration and transport. In Western Province, early action and response support should be further tailored to the different livelihood strategies, going beyond the predominant focus on subsistence agriculture. Building on the findings of this report, a broader perspective on food and water security is warranted, encompassing various socio-economic drivers of risk.

Measures to mitigate the impacts of future events and sustained efforts to reduce risks in the long term can be combined to address root causes of vulnerability. DRM and Climate Change Adaptation (CCA) initiatives must address underlying vulnerabilities linked to poverty, education, livelihoods, and accessibility. Communities face challenges in accessing essential resources and information to implement early actions based on warnings, such as agricultural tools and knowledge on drought-tolerant crops like sorghum and cassava. Limited telecom and media coverage restrict access to information, while poor road conditions impede access to essential services and markets. Dependence on rain-fed agriculture and inadequate water and sanitation facilities exacerbate vulnerabilities. Addressing these root causes is essential for effective DRR/CCA implementation and fostering development co-benefits. Donors should prioritize efforts to mitigate structural barriers identified in this report to enhance food and water security initiatives.

> " *Our upbringing is deeply rooted in cultural practices inherited from our forefathers, and changing this mindset is a gradual process. Change does not happen overnight or in a short period. People who embrace change often encounter losses compared to their traditional methods. The shifts in climate, alterations in rainfall patterns, and the necessity to adapt force individuals to adopt new approaches. While it may seem like people are resistant to change, they are, in their own way, adjusting to the evolving circumstances. This adaptation, although expensive and challenging, becomes a necessity with limited alternatives.*
>
> *KI07*

Recommendations for Early Warning and Early Action (EWEA) implementation:

Expand communication channels for early warnings: Ensure forecasts and warnings reach beyond community meetings to enhance coverage and trust in information. While TV and radio channels are widely used, vulnerable communities with limited access to these resources rely on community-based meetings. Diversifying communication methods such as Namibian/Angolan radio channels, free SMS messages, or the local chief system would be beneficial, especially in remote areas like Mbao and Imusho.

Enhance actionability of warning information: Improve the usefulness of information by adopting a cross-sectoral approach. Regularly check if people understand the information provided and whether it meets their needs. For example, the main source of information on actions in Western Province is the agricultural advisories prepared by the Ministry of Agriculture. However, these do not cover health issues and appropriate public health practices, while this information could help reduce impacts. Impact-based forecasting and communication can help improve the actionability of early warnings by communicating the anticipated impact of forecasted weather extremes and recommending early actions to reduce risks (RCCC et al., 2020). For future dry spell events, focusing on impacts on food security, water access, and health, as well as other drivers of these risks, is recommended. For example, communication about the 2019/2020 season focused on the forecasted rainy season but missed the opportunity to integrate socio-economic dynamics, e.g. food prices and the influence of COVID-19 on the markets once this information became available. Furthermore, the agriculture-specific content of advisories is not always considered actionable by farmers because it is either not specific enough or not suitable to the local conditions. This should be improved in dialogue with at-risk communities, identifying viable alternative varieties to plant, strategies to protect from wildlife damage, and recommendations for timing of activities – connected to trusted traditional early warning signals.

Promote Early Action: Emphasize and support early action. Simply sharing warning information does not always guarantee action, especially when pre-existing barriers are not addressed. Despite the strong warnings through the seasonal outlooks of ZMD (2018; 2019), the ZVAC report and IPC projections (published in 2019), the study found there was little evidence of early action by government or humanitarian actors, and the action taken was limited to sharing information among community members. While this is a valuable step, proactive action rather than a reactive response could have reduced suffering (albeit not prevent all impacts, given the scale of the event). Early action by the government and humanitarian/development partners could have made a difference for communities in the window between the first warnings and the start of the response through livelihood support, rehabilitation of water services, sensitization to potential health risks and active monitoring of vulnerable groups for health issues (between August-December 2019), and this should be strengthened in future crises (for suggested early actions, see Figure 22). It is crucial to unpack further trade-offs, risk perception, and flexibility to reduce risk locally, emphasising understanding vulnerabilities. To enable early action at scale, this will need to be embedded in the standard operating procedures of DMMU and other DRM actors, ideally with a common national-level trigger for early action responsive to different types of drivers of food and water-related impacts.

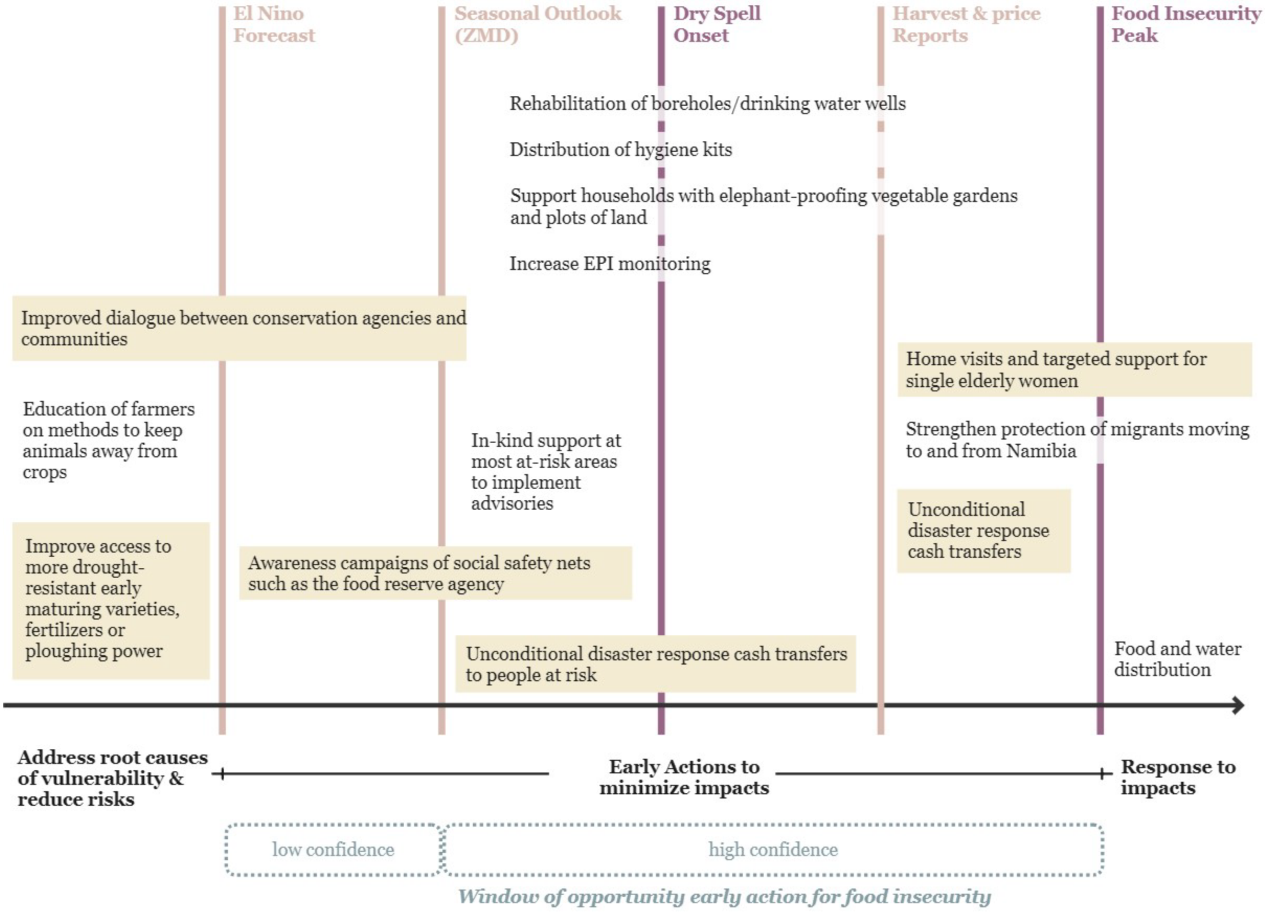


Figure 23. Overview of potential windows of opportunity for early action in the case of similar dry spell events in the future. For more details, see Annex 4.

Strengthen Mechanisms for Pre-Crisis Funding Access: Enhance efforts to access funds before major crisis impacts occur. While many actors advocated for rapid action, such as DMMU in the 2019 ZVAC report and various humanitarian actors in the ensuing funding appeals, the current funding structure in Zambia is still heavily focused on response rather than early action. The emergency budgets and crisis funding sources can only be accessed through a declaration of an emergency and communities can only access insurance funds after impacts have been established. Expanding access to pre-agreed financing, coordinated through DMMU with support from the broader government, can support more pre-active early action in the window between forecasts and peak impacts. Dedicating part of the annual budget for crisis situations, to be released ahead of major impacts, could enable early action at scale in Zambia. Furthermore, the extensive social protection system in Zambia has the potential to offer support to farmers ahead of harvest failure, as some pilots are already underway, which could be further scaled up. The key is accessibility and affordability, which are identified as major barriers in Western Province.

Recommendations for further research

It is recommended to delve deeper into the identified gaps in information concerning vulnerability related to displacement, mental health impacts of dry spells, and the effects on non-farming livelihoods.

1. A comprehensive understanding of the lived experiences of individuals with the lowest socio-economic backgrounds and highest poverty levels regarding food security issues is needed. While much of the literature and interviews assume that food security challenges are primarily linked with subsistence farming, individuals working for daily wages in agriculture without land tenure may be more vulnerable. Yet, these groups are missing in the literature, warranting further investigation into these nuances.
2. Addressing the connection between microclimates and food insecurity outcomes in the Western Province is crucial for enabling effective impact-based forecasting and early action.
3. Traditional local knowledge and early warning systems for dry spells and drought, mapping various traditional early warning signs and tracking their occurrence and reliability would facilitate the integration of traditional knowledge systems into government forecasting efforts.
4. Expand ongoing research into drought and dry spell-related innovative agricultural practices and water storage in Western Province, especially in low-resource contexts. This includes developing better management approaches for human-wildlife interactions.

In conclusion, tackling the diverse challenges of food insecurity and water access in Zambia's Western Province requires across timescales with involvement of local communities. Recognizing the interconnected nature of risks is key to effective disaster risk management. The 2018-2020 food insecurity crisis in Zambia demonstrates how early warning systems can be designed to be more impactful, how community participation can be made effective, and how multi-risk strategies should be implemented. Strengthening capacity, ensuring that funding reaches local communities, and addressing the underlying causes of vulnerability are crucial for building resilience and preventing future crises. Cooperation among government entities, humanitarian organizations, research institutions, and donors is crucial to executing these recommendations and securing food and water resources in Zambia's Western Province.

Annexes:

Annex 1. Context profile: Physical and socio-economic and governance context of Western Province, Zambia

1.1 National Context

Zambia is a landlocked country in central Southern Africa bordered by eight countries: Tanzania to the north-west, Malawi to the east, Zimbabwe and Mozambique to the south-east, Botswana and Namibia to the south, Angola to the west, and the Democratic Republic of Congo to the north. The country is composed of 10 provinces, all of which are sub-divided into several districts: Central, Copperbelt, Eastern, Luapula, Lusaka, North-Western, Northern, Southern, Muchinga and Western Provinces (Figure 23).

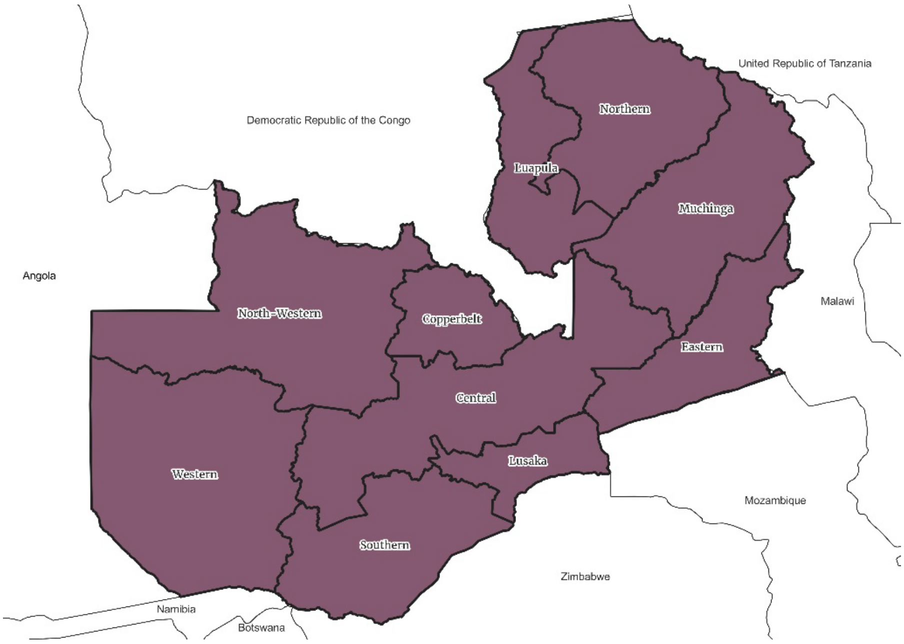


Figure 24. Zambia Provinces.

Zambia has a total population of 19.6 million people, of which 11.8 million (60%) live in rural areas (ZSA, 2022c). The country´s rural economy is primarily based on agriculture, and most livelihoods depend on rain-fed staple crops like cassava and maize, whose harvests are reliant on a timely rainy season and stable temperatures (SADRI, 2021). With around 60% of the countries´ households dependent on predominantly rainfed agriculture as a main source of livelihood (Mwongera et al., 2020), the country is highly vulnerable to precipitation variability. These rural populations in Zambia are more vulnerable to dry spells due to their limited short-term coping capacity. This is particularly true for those more remote areas that lack infrastructure and therefore are more difficult to reach by external relief resources when a hazard occurs (UNDRR, 2019).

Water is vital to Zambia's economic development as it is used for agriculture, fishing, livestock watering, home consumption, and energy production in both rural and urban regions (GRZ, 2020). The country is regarded as one of the most water secure countries in Sub-Saharan Africa as it is situated within two large river basins, the Zambezi River basin, and the Congo River basin (USAID, 2016). Even so, there is still an uneven distribution of surface water resources across the country, with local water shortages in the south during summer droughts and contaminated water and the spread of waterborne diseases in the north during floods (USAID, 2016).

Zambia has a long history of dry spells, exceptionally high temperatures, and seasonal and flash floods, all of which have gotten worse and happened more frequently recently (UNDRR, 2019). According to a Zambia Water Resource Report by Nkhuwa et al., 2013, climatic variability (resulting in frequent floods and droughts) and periodic water supply shortages, along with increasing water demand from key sectors of the economy, and insufficient water infrastructure, put a substantial limitation on the country's medium and long-term growth prospects (Nkhuwa et al., 2013). This occurs as these hazards adversely impact food and water security, water quality, energy, and people´s livelihoods, especially in rural communities (SADRI, 2021).

1.2 Disaster Risk Management (DRM) and EWEA in Zambia

In Zambia, the Disaster Management (DM) 2010 (Act No. 13 of 2010) is the main disaster law established to provide legal frameworks to manage disaster situations in the country (GRZ, 2010). The act provides detailed provisions related to Disaster Prevention and Mitigation with reference to existing risk assessments, prevention and mitigation measures, community-based disaster risk reduction, and the linkages between different ministries and departments in charge of these actions (IFRC, 2021b). It also establishes detailed provisions for Early Warning Systems (EWS), Disaster Preparedness (i.e. contingency plans, funding for activities, training, etc.), Disaster Response (i.e. declaration of disaster, use of emergency power, etc.), and Disaster Recovery (IFRC, 2021b). In addition to this Act, the Government of the Republic of Zambia (GRZ) has also implemented other regulations and policies related to DRM, including the National Disaster Management Policy (2015) and the National Disaster Management Operations Manual (2015), both of which operationalize the provisions of the DM 2010 Act (Silengo, 2022).

The DM 2010 Act outlines the roles and responsibilities of the diverse range of institutions involved in disaster management in Zambia. These include the establishment of the three main organizations that lead the disaster management system in Zambia:

1. The *National Disaster Management and Mitigation Unit (DMMU)*, a department in the Office of the Vice-President responsible for the implementation of the provisions of the act as well as all disaster management programmes and activities. The DMMU coordinates and monitors the institutions for prevention, mitigation, preparedness, response and post disaster recovery for all potential disaster risks (DM 2010 Act, Part II, Sections 4 - 7) (GRZ, 2010).
2. The *National Disaster Management Council (NDMC)* in charge of (i) formulating and updating national disaster policy, (ii) direct lining ministries to assume their responsibilities, (iii) mobilizing the resources for disaster management, approve national disaster management plants and guidelines, and (iv) recommending the declaration of national disasters to the president (DM 2010 Act, Part II, Sections 8 - 9) (GRZ, 2010).
3. The *National Disaster Management Technical Committee (NDMTC)* is responsible for (i) recommending policy and program directions to the NDMC, (ii) coordinating the implementation of NDMC decisions, (iii) supervising disaster management activities, (iv) supervising DMMY in monitoring and reviewing disaster management plants, and (v) controlling disbursements of the Trust Fund (DM 2010 Act, Part II, Sections 10 - 12) (GRZ, 2010).

In addition to these three organizations, the DM 2010 Act also establishes *Provincial Disaster Management Committees* in each of Zambia's provinces to oversee all disaster prevention, preparedness, and mitigation programmes in each province, providing links between national level resources and the districts (DM 2010 Act, Part III) (GRZ, 2010). Furthermore, there are also other governmental and non-governmental organizations in Zambia that are key stakeholders responsible for disaster risk management and reduction through several activities. These include:

1. *Community-Based Organizations* (CBOs) which work closely with local communities to raise awareness and conduct risk assessments to implement community-level interventions.
2. *Humanitarian Organizations* (i.e. Zambia Red Cross Society, CARE International, World Vision, UNICEF, WHO, FAO and WFP) which provide support in capacity building, community engagement, early warning systems, disaster response, and recovery efforts. NGOs tend to work closely with government agencies and communities to implement their projects.
3. *Academic and Research Institutions* (i.e. University of Zambia) which conduct research and provide training and education programs related to disaster risk reduction, as well as contribute to policy development.
4. *Development Partners* (i.e. International Organizations, bilateral agencies) which collaborate with government agencies to provide support, funding, and technical assistance to increase disaster risk reduction capacity.

Early warning systems are a key aspect of DRM. In Zambia, various institutions engage in EWEA. The Zambia Meteorological Department (ZMD) oversees the monitoring, prediction and analysis of weather and climate change-related data and information (UNDRR, 2020). ZMD produces the yearly seasonal forecasts and disseminates early warning information to communities through volunteers and other channels (Silengo, 2022). Since 2023, there is also a dedicated Drought Management System that includes short-term forecasting (Ministry of Agriculture, 2023). The Water Resources Management Authority (WARMA) carries out studies and GIS mapping of river catchments and collects data from 65 stations for hydrological forecasting and planning (Silengo, 2022). One of the key challenges, however, is the low coverage of automatic stations, although there are initiatives in place to expand these (UNDRR, 2020). Zambia also issues early warnings on food security through the annual Zambia Vulnerability Assessments Committee (ZVAC) by DMMU, which informs the IPC Acute Food Insecurity Situation Reports. Based on hydro-meteorological conditions and supported by DMMU, the Ministry of Agriculture develops advisories for farmers with early warning information and agriculture advice. Response to potential climate extremes is covered through the annual contingency planning process of DMMU and is supported further through various humanitarian actors.

DMMU spearheads innovation related to early action trigger development based on forecasts under the National Technical Working Group for Forecast-based Financing (TWG), which includes national agencies involved in early warning such as ZMD and WARMA, as well as stakeholders in early action such as the ministries of agriculture, health, social protection and various humanitarian and development actors. So far, formal systems for early action that include pre-agreed financing and early actions have focussed on floods in Zambia, developed between humanitarian actors and DMMU. Similar approaches for drought are currently under development by WFP, and ZRCS. Zambia is among the first countries in the world to establish anticipatory action frameworks for humanitarian actors, building on previous experience with EWS. In 2016, the Start Network funded Catholic Relief Services, Concern Worldwide, Oxfam, Save the Children and World Vision to address worsening food insecurity, which was anticipated based on late rains in Western Province and Southern Province (Anticipation Hub, n.d.-a). In 2017, the Zambia Red Cross Society (ZRCS) began undertaking Forecast-based Financing (FbF) along with several partners and local actors to enable humanitarian action after a forecast was produced yet before the hazard onset (RCCC, 2021c). In 2020, an Early Action Protocol (EAP) for flooding was approved in the country, implemented by the ZRCS in coordination with DMMU, WARMA, and ZMD (IFRC, 2020b). This protocol was first activated in 2023. Furthermore, at the time of writing, the drought early action protocol of ZRCS is undergoing validation by the IFRC (to approve humanitarian pre-agreed financing). WFP is also currently exploring drought anticipatory action in Zambia.

1.3 Case study context

The Western Province of Zambia is the largest administrative jurisdiction in Zambia, with a total area of approximately 126,386 square kilometers (WPA, 2022). The Western Province is in the Upper Zambezi River Basin. This area contains the Barotse plains, one of Africa's greatest wetlands, which supports various livelihoods in the province. While the region is home to several ethnic groups, the Western Province predominantly serves as the homeland of the Lozi people (or Barotse), who reside in and live from the Barotse floodplains (Milupi et al., 2019). The area is also referred to as "Barotseland", which indicates the area in Zambia between Angola (to the west) and Namibia (to the south). Western Province borders the Zambian Central and Southern provinces (to the east) and the North-Western Province (to the north).

In the Western Province, governance of natural resources (i.e. access to land) is influenced by two parallel institution systems: the Barotse Royal Establishment (BRE), or traditional authority of the area based on the norms and values of the Lozi people, and the formal government system headed by the Provincial Minister and Permanent Secretary (Madzudzo et al., 2013). The BRE is a traditional institution led by the Litunga, or King, who owns the land and is assisted by other members, such as the Indunas (Milupi et al., 2019). The organizational structure of both systems is seen in Figure 24.

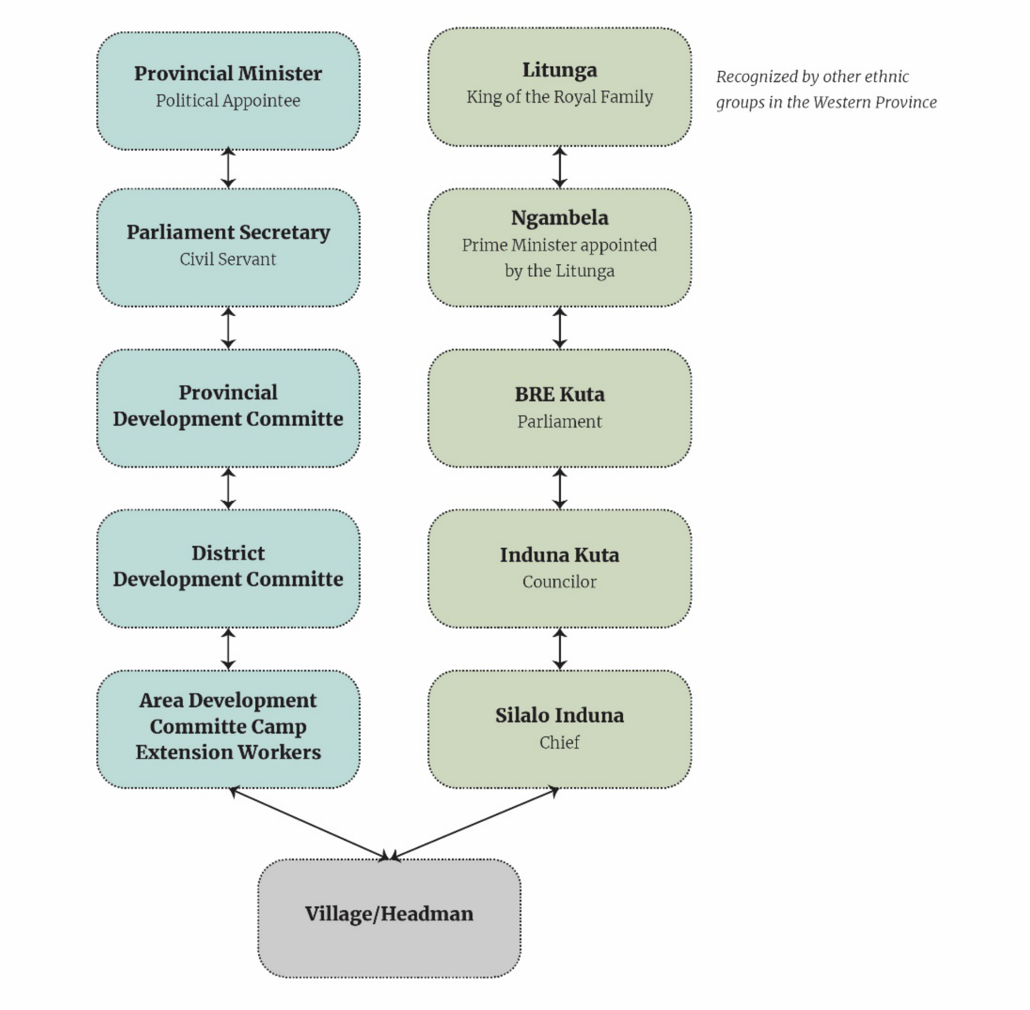


Figure 25. Leadership structure in the Barotse Floodplains.

Sources: Madzudzo et al., 2013; Barotse Broadcasting Network, 2018

Western Province is mostly situated in Zambia´s Agro-Ecological Regions I and II, which on average receive the lowest rainfall amount of Zambia (less than 700mm and 800 – 1000mm total rainfall per year, respectively) (Arslan et al., 2014). Despite the relatively low total rainfall, Western Province has access to water and fertile land. The Zambezi and Cuando river and their tributaries pass through the area, and the province is geographically divided into floodplains and more arid uplands. Communities move between these areas, spending the rainy season between October-March in the uplands and the dry season between April-October near the floodplains (KI04).

The rainy season in Zambia occurs from November to April/May, with the wettest period being December and January. In April, rainfall rapidly declines and leads to the dry seasons, that range from May to mid-October (IFRC, 2021c). The Western Province forms part of Zambia´s Agro-Ecological Regions I and II, which are the regions in the country most prone to dry spells due to the reduced total rainfall that they receive yearly (less than 700mm and 800 – 1000mm yearly respectively) (Arslan et al., 2014). Apart from being one of the driest regions in the country, one of the biggest challenges in the Western Province is the unreliability of seasons and variability of rainfall in the changing climate (Green Climate Fund, 2018b; PIN, 2018b). The region is highly vulnerable to increasingly altering patterns and unpredictability of rainfall, both due to its' increased poverty rates and because of the main sources of livelihood.

Between September and October 2020, the Bank of Zambia developed the FinScope 2020 Survey in the Western Province for adults aged 16 years and older in 1,170 households to assess the financial landscape of the region (Bank of Zambia, 2020). They found that in the Western Province, 87.6% of the adult population (aged 16 or older) resides in rural areas, with the main source of income being farming activities (Bank of Zambia, 2020). The local economy of several communities in the region is anchored on ecosystem services, with agrarian, pastoralist, and fishing livelihoods that are greatly dependent on rainfall patterns. Rain-fed agriculture is predominant in the Western Province, which is the main producer of rice and millet of the country in addition to concentrating large sums of maize production (ZSA, 2020).

The communities of the Western Province migrate between two main environments: the floodplains, which survives mainly on aquatic ecosystems and rely on the Zambezi River flooding for crops, and the drier uplands. When the floods come, communities relocate upland, and when the water recedes, they return to the plains. This form of livelihood further increases vulnerability to any fluctuations, particularly with respect to extreme events where communities are exposed to regular dry spells and flooding (KI04).

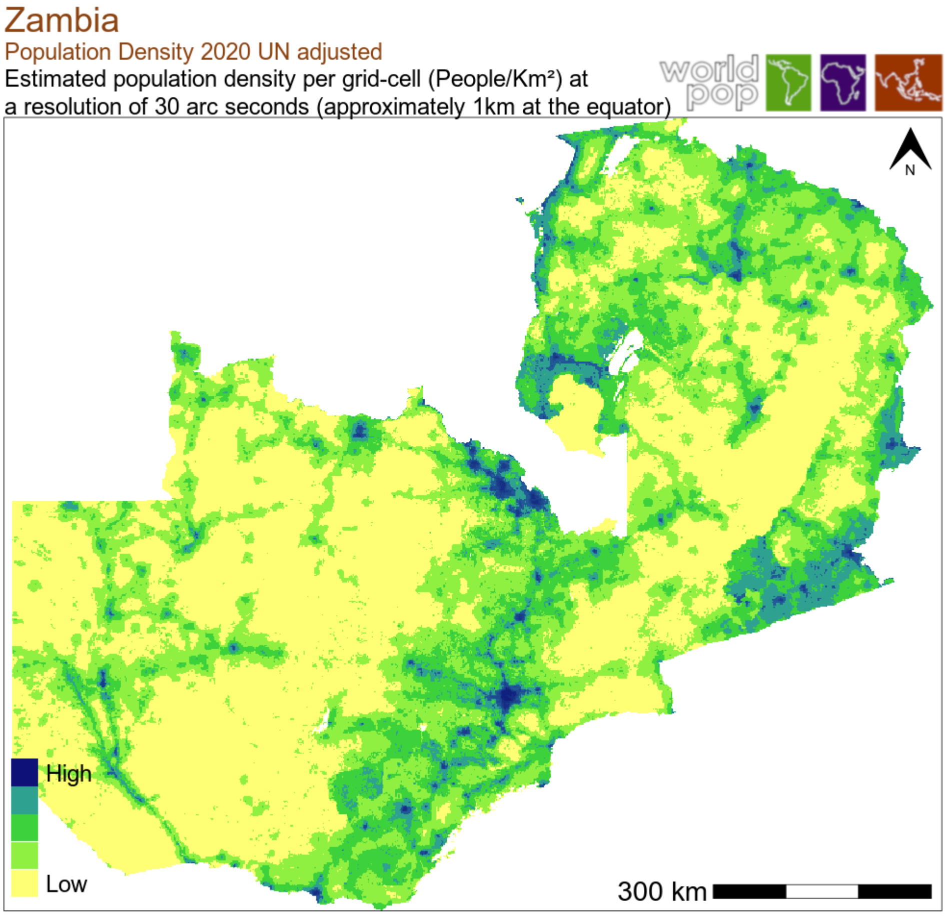
This sector is highly vulnerable to unreliable seasons and changing rainfall patterns. Most farmers in the Western Province (59.2%) receive their income seasonally (Bank of Zambia, 2020). If rain does not arrive at the expected time during the season or does not last long enough, this can generate major impacts on crop growth and harvesting (Green Climate Fund, 2018). Another major challenge in the region is the sandy soil that characterizes the Western Province, which has low moisture retention capacity. This type of soil generates major challenges due to its' lower quality and decreased capacity to hold soil moisture, affecting further crop growth. (PIN, 2018b, KI02)

This form of livelihood is reflected in all three of the focus districts. In Sioma, the main sources of livelihoods for most of the population are small-scale agriculture and small-scale fishing (Sioma Town Council, 2022). In Shang'ombo, the main economic activities include subsistence level farming, fishing, trading and tourism (Commonwealth Network, 2020). Similarly, in Sesheke, apart from crop production, fishing, and mats production, livestock rearing and timber industries are also important sources of income (ZVAC, 2004) Acting Chief Imusho).

According to the Zambia Statistics Agency, in 2021 the Western Province only accounted for 3% of the National GDP, only succeeded by Muchinga Province with 2% (ZSA, 2022a). In 2022 (ZSA, 2022b), the province was also second in incidence of poverty by province, with 78.6% of the population considered poor[8], again only succeeded by Muchinga Province with 82.6%. When assessing the distribution of adults by progress out of poverty index (PPI)[9], the FinScope 2020 found that most adults in the Western Province (74.7%) were in the lowest income percentile (PPI1) (Bank of Zambia, 2020). 83.5% of farmers lie within this lowest income category (Ibidem). This has major impacts on the coping capacity of the populations to climate changes in addition to limited investment capacity to support climate-resilient infrastructure, such as irrigation systems.

[8] In the assessments carried out by ZSA, "the food poverty line, equivalent to the cost of the food basket, relates to the Extreme Poverty Line, while the basic needs basket, which corresponds to the overall poverty line, represents the Moderate Poverty Line. Based on these poverty lines, individuals are then classified as extremely, moderately or non-poor" (ZSA, 2022)

[9] According to the survey, the Progress out of Poverty Index (PPI) "is used to estimate household poverty levels in this report. It is a quantitative tool based on a set of ten questions standardised and consistent with the circumstances of a country. The PPI scores were segmented into five (5) intervals (quintiles)", with PPI1 being the lowest and PPI 5 being the highest incomes (Bank of Zambia, 2020).



WorldPop (www.worldpop.org School of Geography and Environmental Science, University of Southampton; Department of Geography and Geosciences, University of Louisville; Departement de Geographie, Universite de Namur) and Center for International Earth Science Information Network (CIESIN), Columbia University (2018). Global High Resolution Population Denominators Project ... Funded by the Bill and Melinda Gates Foundation (OPP1134076). https://dx.doi.org/10.5258/SOTON/WP00675

Figure 26. Zambia Population Density.

Annex 2: Terminology

Table 2. Overview of terminology used in this report

Nomenclature	Definition
Events	A happening, occurrence or episode at a specific time and place.
Weather and climate extreme events	Weather or climate events characterized by variables above (or below) a threshold value (IPCC, 2012).
Socio-economic events	Events developed by social processes or economic activities or by their interplay.
Drivers	These include climate, weather (physical drivers) and socio-economic (societal drivers) processes, variables and phenomena that directly influence the level of disaster risk (through the components of hazards, exposure, capacity and vulnerability). Primary drivers: primary triggers of an event; Secondary drivers: impacts that could trigger a secondary event.
Impacts	Effects of an event on natural and human systems. In this report, the term 'impacts' is used to refer to the effects on natural and human systems of physical and socio-economic drivers.
Disaster Risk	The potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability and capacity (UNDRR, 2020). Here, we use the term disaster risk to refer to environmental and societal impacts from weather and/or climate and/or socio-economic events.
Exposure	The situation of people, infrastructure, housing, production capacities and other tangible human assets located in hazard-prone areas (UNDRR, 2020)
Vulnerability	The conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards (UNDRR, 2020)
Capacity	The combination of all the strengths, attributes and resources available within an organization, community or society to manage and reduce disaster risks and strengthen resilience (UNDRR, 2020)
Hazard	A process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation. Hazards may be natural, anthropogenic or socio-natural in origin (UNDRR, 2020)
Response actions	Actions taken directly before, during or immediately after a disaster in order to save lives, reduce health impacts, ensure public safety and meet the basic subsistence needs of the people affected. Disaster response is predominantly focused on immediate and short-term needs (UNDRR, 2020)
Anticipatory action / Early Warning Early Action	Acting ahead of predicted hazardous events to prevent or reduce acute humanitarian impacts before they fully unfold (UNDRR, 2023; Anticipation Hub, n.d.)

Preparedness	The knowledge and capacities developed by governments, response and recovery organizations, communities and individuals to effectively anticipate, respond to and recover from the impacts of likely, imminent or current disasters (UNDRR, 2020)
Compounding risk interaction	Events that either occur simultaneously or successively combining into severe impacts; extreme(s) combined with systemic conditions that amplify impact; or extremes that result from combinations of 'average' events (Pescaroli & Alexander, 2016; UNDRR, 2022)
Consecutive disasters	Two or more disasters that occur in succession, and whose direct impacts overlap spatially before recovery from a previous event is considered to be completed (de Ruiter et al., 2020)
Cascading risk interaction	Causal chain of dependent phenomena due to an originating event (triggering event) that connect hazards and/or risks and/or accumulated vulnerabilities across multiple scales (Pescaroli and Alexander, 2016)
Root causes of vulnerability	The root causes of vulnerability involve social and economic structures, such as the characteristics of power, wealth and resource distribution, as well as ideologies and historical heritage. Such root causes may change, albeit slowly (Marchezini & Wisner, 2017)

Annex 3: Overview of climatology and forecast analysis

Zambia is a Southern African country with a humid and dry subtropical climate, marked by two distinct seasons: i) the dry season from April to October, and ii) the rainy season from November to March. Although the country is relatively well watered during this rainy season to support the various livelihoods, some regions are occasionally subject to hydrometeorological hazards, notably drought in the southern and south-western regions of Zambia (Gannon et al. 2016).

On an inter-annual scale (from one year to the next), two main elements (or mechanisms) drive the distribution of rainfall in Zambia: ENSO and IOD (Gannon et al. 2016). This means that, depending on the configuration of these elements, rainy seasons can be deficit, surplus or normal. The first of these is ENSO (El Ninõ Southern Oscillation), a planet-wide phenomenon initiated over the Pacific with impacts visible over the rest of the globe from a few months to a few years. For example, positive ENSO - El ninõ phases (positive sea surface temperature anomalies over the eastern Pacific) result in rainfall deficits in southern Africa and Zambia in particular. Conversely, during a negative ENSO - la Ninã episode (negative sea surface temperature anomalies over the Eastern Pacific) excessive rainfall can be expected. Figure 26 reflects this reality by showing negative correlations between the Ninõ3 index and annual rainfall over the last 30 years.

Secondly, the IOD (Indian Ocean Dipole), often referred to as the Indian Ocean ENSO, can modulate precipitation in Southern Africa (Palmer et al. 2023). Thus, a positive IOD event (positive sea surface temperature anomalies over the eastern Indian Ocean) would tend to reinforce atmospheric convection in this part and consequently over southern Africa. For example, there has been an increase in cyclonic activity.

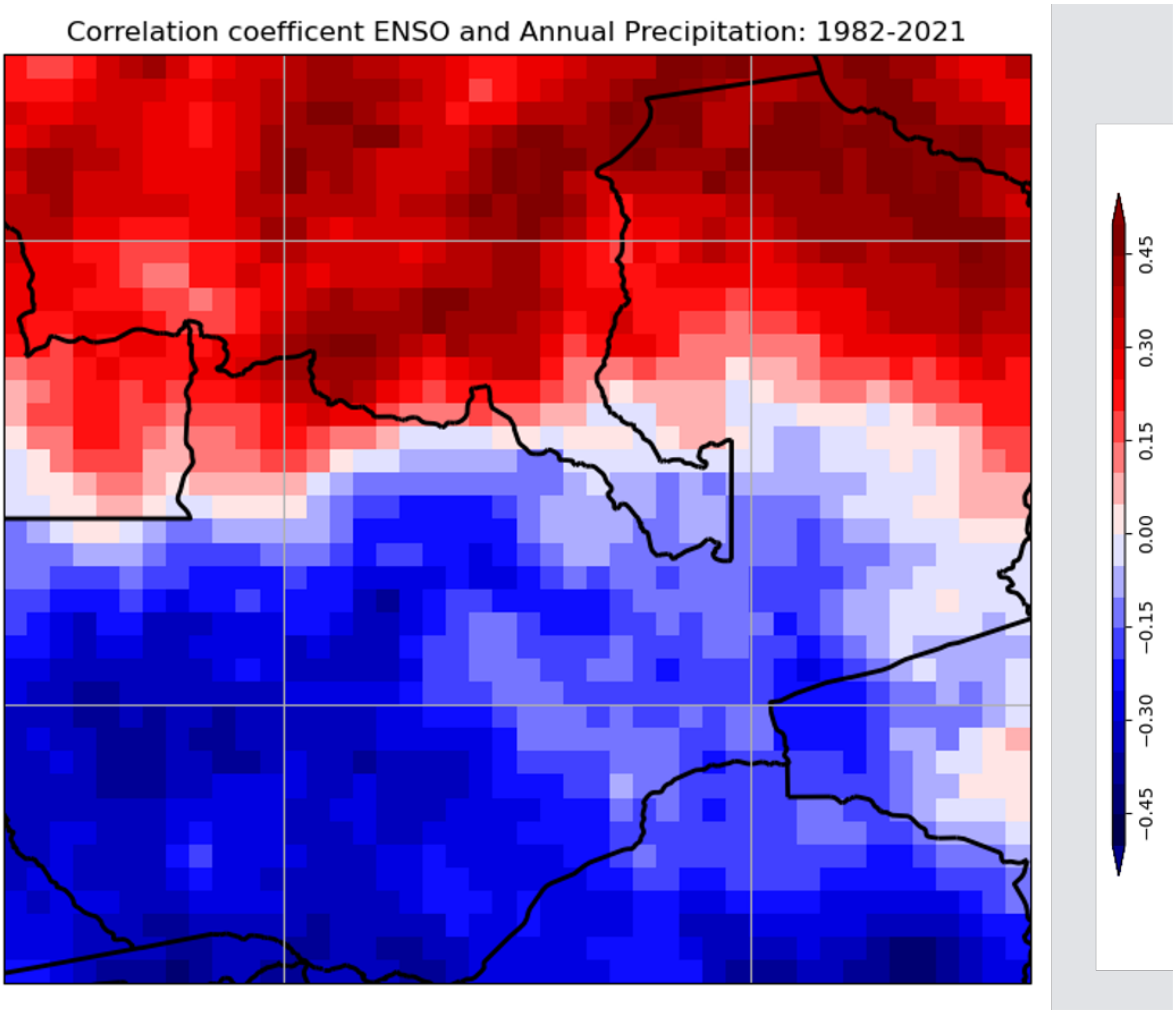


Figure 27. Spatial correlations between CHIRPS precipitation and NDJFM ENSO multivariate index, based on 1991-2020 climatology.

Between 2018 and 2020, Zambia experienced two rainfall-deficit seasons with disastrous consequences for food security (see other sections of this report). Figure 27 illustrates these two deficit years (2018-2019/ 2019-2020) with below-normal rainfall. This situation is well correlated (negatively) with ENSO, since both years presented a positive ENSO phase, although these episodes were relatively moderate compared with, for example, 2015. Figure 28 shows that the season 2018-2019 was marked by a neutral to a slightly negative IOD which would either have a slightly negative or a neutral effect on precipitation. On the other hand, 2019-2020 IOD state was positive and, in this case, the impact on precipitation would be expected to be positive. To summarize, while in 2018-2019 both ENSO and IOD were favourable to a dryer season, in 2019-2020, the two indices were competing. Spatially (Figure 29), we can see that the precipitation deficits that caused these droughts were clearly visible in the western regions of the country but could also extend into the southern and central parts of Zambia.

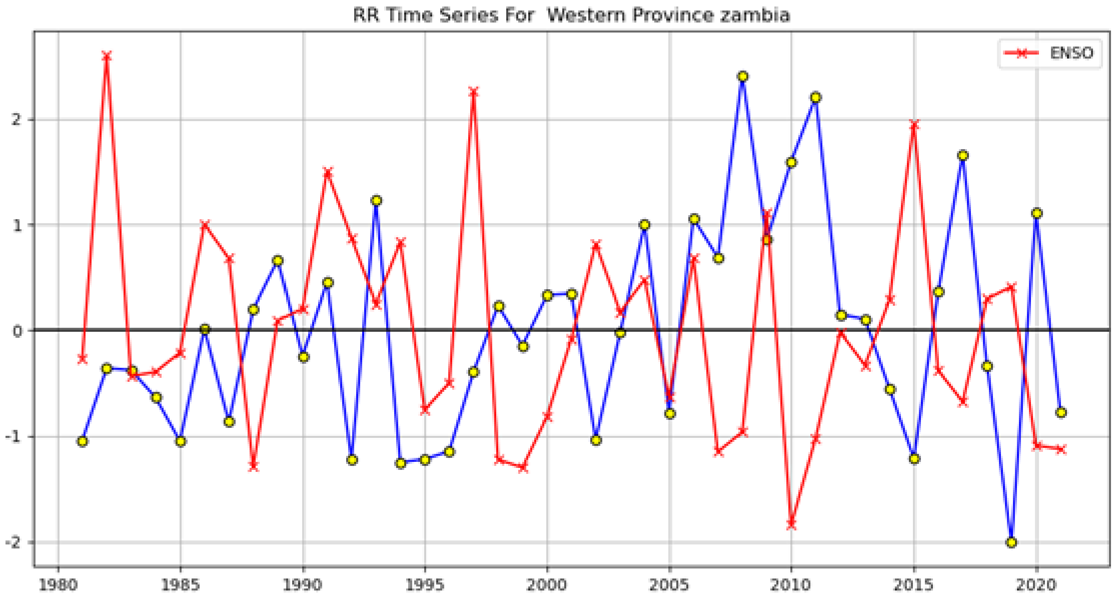


Figure 28. ENSO index (blue) and standardized precipitation anomalies over western Zambia. Source: CHIRPS and NOAA

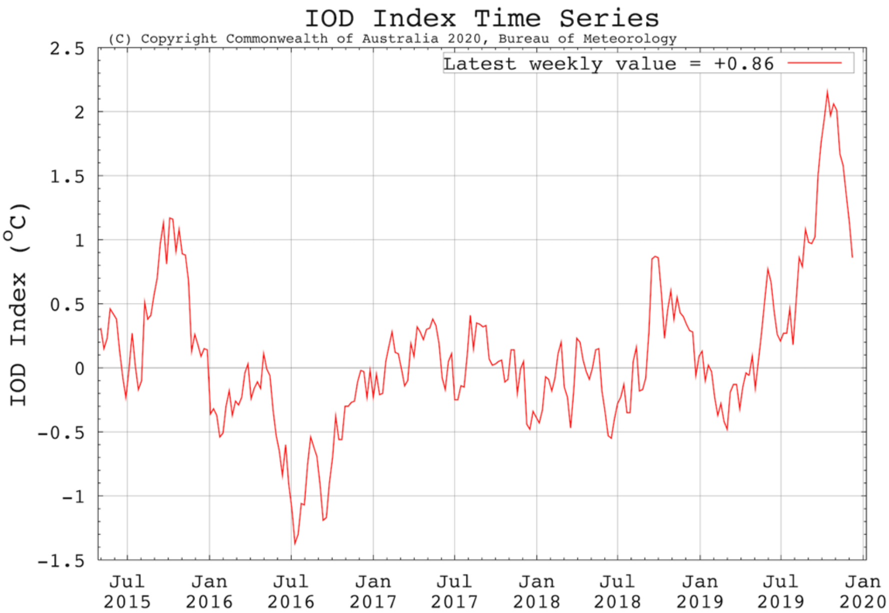


Figure 29. IOD time series from 2015 to 2020. Source: Bureau of Meteorology Australia, 2020

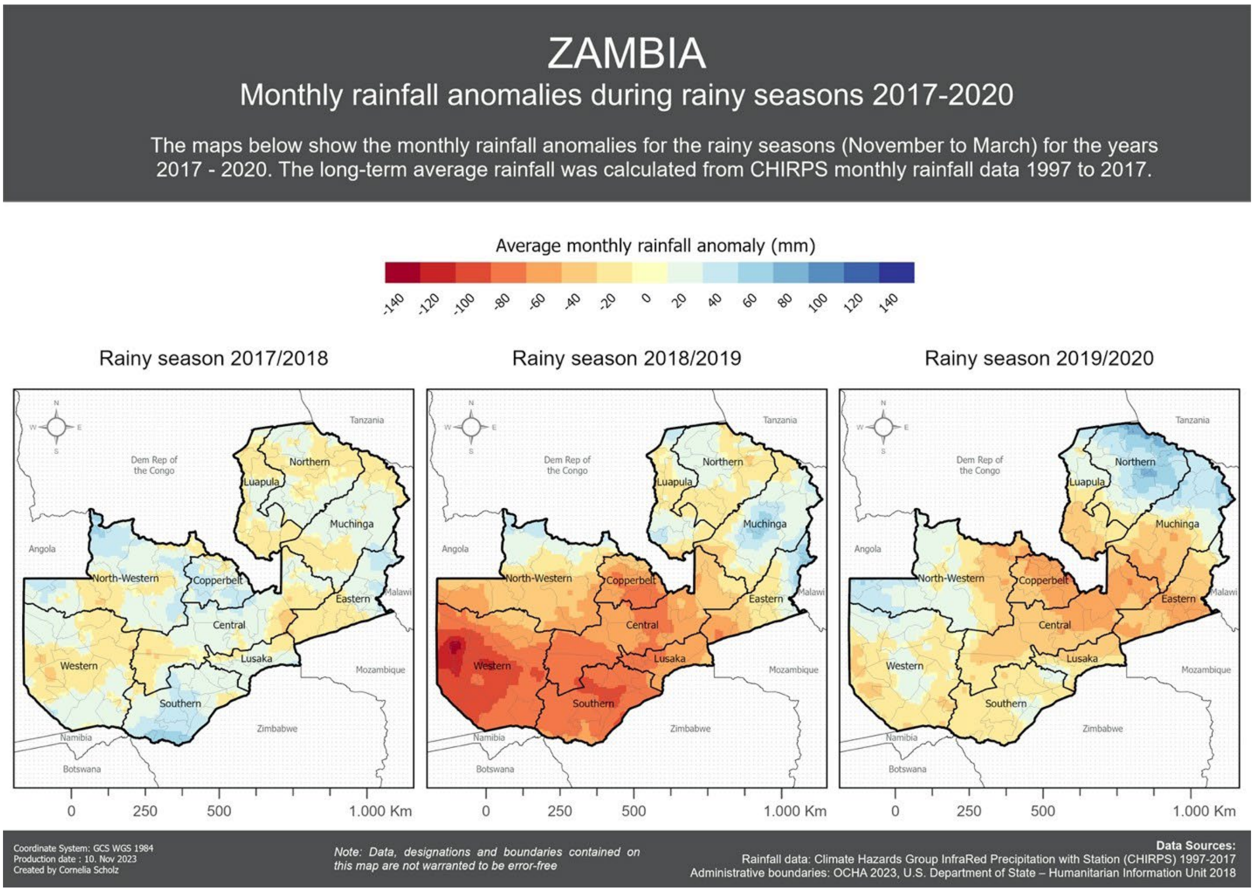


Figure 30. Monthly precipitation anomalies for the rainy seasons Nov. 2017 - March 2020 (left to right). Anomalies are shown in mm rainfall difference from the long-term mean. The long-term average rainfall was calculated from CHIRPS monthly rainfall data 1997 to 2017. Red colors are depicting below average values, blue above average. Source: own diagram, Data source: CHIRPS.

The table below (Table 3) shows an overview of available forecasting information and a summary of the evaluation of forecast accuracy.

Table 3. Overview of available early warning information and abbreviated verification information for Zambia. OND = October, November, December; JFM = January, February, March, DJF = December, January, February etc.

Date published	**Forecast**	**Did this happen?**
June 2018	**NINO3.4 index:** Positive ENSO for end 2018-start 2019 predicted globally (NOAA, 2018)	This corresponds to observations.
August 2018	**SADC SARCOF** meeting: for OND, normal to below normal season. However, for the rest of the season (JFM) over the western province, it is a normal to above-normal season (SARCOF, 2018)	OND corresponds to observations, the JFM outlook did not correspond (missed the observed below-average rainfall conditions).
September 2018	**Rainy season forecast 2018/2019 ZMD:** Normal to below-normal conditions forecasted in Western province, with dry spell risk across Zambia, early start (extreme western and southern parts) and early cessation (southern half specifically) of the rainy season (ZMD, 2018)	This largely corresponds to the observations, although DJF was also below-normal and this was missed.
November 2018	**ECMWF SEA5**: 40-50% chance of below average rainfall in JFM, FMA over Zambia (Copernicus models, nd)	Corresponded for Western and Southern, did not capture the above average rainfall in Northern Zambia.

November 2018	**IRI seasonal outlook** for DJF, JFM, FMA indicate normal to below-normal precipitation. Signal not particularly strong (IRI, 2018)	Although the overall estimation of below-normal precipitation corresponded to observations, the forecasts underestimated the conditions.
August 2019	**SADC SARCOF:** for OND season, SARCOF was forecasting a normal to above normal year (SARCOF, 2019).	In SADC verification documentation this forecast was classified as a miss for Western province in OND 2019 season, and partly a miss in JFM 2020.
September 2019	**Rainy season forecast 2018/2019 ZMD:** Across Zambia normal to above normal rainfall for OND, NDJ and DJF. In JFM likelihood of normal to below normal, reduced rainfall and dry spells around February. Onset of rains in November (ZMD, 2019).	Captured the variation in the season, e.g. south western area of Zambia fluctuating between above normal and below normal in one rainy season.

Annex 4: Overview of relevant early actions

Table 4. Overview of identified potential early actions to address observed impacts on food and water security in Western Province, Zambia.

Impact observed	Early action	Level (household, community, institutional)	Most vulnerable	Timeframe for action
Maize harvest failure	Improving access to more drought-resistant, early maturing varieties, fertilizers or ploughing power, or flexible cash grants; awareness campaigns of social safety nets such as the food reserve agency, in-kind support to most at-risk areas to implement advisories	Institutional	Subsistence rainfed farmers, especially women-headed households with school-going children	Before and during the rainy season, typically between August and March
Limited food purchasing power due to high prices	In-kind or flexible cash support; home visits and targeted support for single elderly women	Institutional	Elderly living alone; women-headed households with school-going children	During periods with high prices, typically the lean season after a season with limited harvests
Damage to crops from wildlife	Education of farmers on methods to deter animals and improved dialogue between conservation agencies and communities. Early actions may include supporting households	Community; institutional	Subsistence rainfed farmers, especially women-headed households with school-going children	In the latter half of the rainy season and in the hot and cool dry seasons, with local variations in wildlife and

	with elephant-proofing vegetable gardens and plots of land ahead of predicted dry periods			planting dynamics
Reliance on poor-quality drinking water; increase in water-borne diseases; Injuries from wildlife attacks while fetching water	Rehabilitation of drinking water wells; hygiene kit distribution; awareness raising; dialogue among conservation agencies and communities	Community-level; institutional	Women and girls responsible for fetching water	In the hot and cool dry seasons after a below-average rainy season, with rehabilitation actions possible earlier
Unsafe conditions for people migrating to Namibia/Angola for piecework	Strengthened protection of migrants moving to and from Namibia/Angola	Community-level; institutional	Women and men of working age	During periods with high food insecurity

Annex 5: Geospatial analysis and supporting materials

Open-source geospatial datasets were used to create maps to show which areas were impacted the most by the different events identified in the literature review. If no geospatial data was available, the areas affected as described in the literature were converted into a geospatial layer. Layers were downloaded through online scoping reviews of open-source data portals. The maps were created using ArcMap Desktop. The downloaded geospatial data was processed and cleaned to extract the relevant information and export visualizations using the ArcGIS layout function. The following process was followed for the layers:

- **Rainfall Data** (Source: CHIRPS Data Nov 1997 – March 2020). The rainfall dataset was processed to calculate: (i) MEAN monthly rainfall during the rainy season (Nov-March) across 1997-2017 (baseline) and for the 2017/18, 2018/19, 2019/20 seasons, (ii) rainfall anomalies were calculated by subtracting the seasonal baseline from the 3 rainy seasons, and (iii) accumulated rainfall by calculating the mean accumulated rainfall for the rainy seasons (Nov-March) for the baseline and for the 2017/18, 2018/19, 2019/20 seasons, and (iv) maximum and minimum value of monthly rainfall for the baseline and for the 2017/18, 2018/19, 2019/20 seasons using cell statistics.
- **Wildfires** (Source: FIRMS-MODIS). The presumed vegetation fires (Type 0) with a confidence of >75% were filtered for the dry seasons (April – October) in 2017, 2018, 2019 & 2020 to explore both the joint fire locations for this period and the spatial-temporal changes between the different seasons.
- **Soil moisture** (Source: NASA Soil Moisture 10 days). Dataset was filtered for 21/03/2017, 21/03/2018, 21/03/2019, and 21/03/2020.
- **Vegetation Health Index** (Source: FAO Vegetation Health Index 10 days). Dataset was filtered for 09/2017, 09/2018, 09/2019, and 09/2020.
- For the identified events, literature reviews were carried out to identify where these took place. Once identified, these locations were mapped at the district level as different layers using QGis.

Supporting maps

Minimum monthly total rainfall (mm) during rainy season 2018-2019: The map below shows the minimum total rainfall (mm) per grid cell during the rainy season November 2018 to March 2019. The minimum recorded rainfall was 2,4mm in March 2019. A comparison with historic monthly rainfall data (1997-2017) showed that the lowest recorded monthly rainfall during the rainy season was 4,3mm. The lowest recorded monthly rainfall in the months March 1997 to 2017 was 7,6mm. The areas marked in purple in the map below indicate areas with record low rain fall (< 4,2mm) in March 2018.

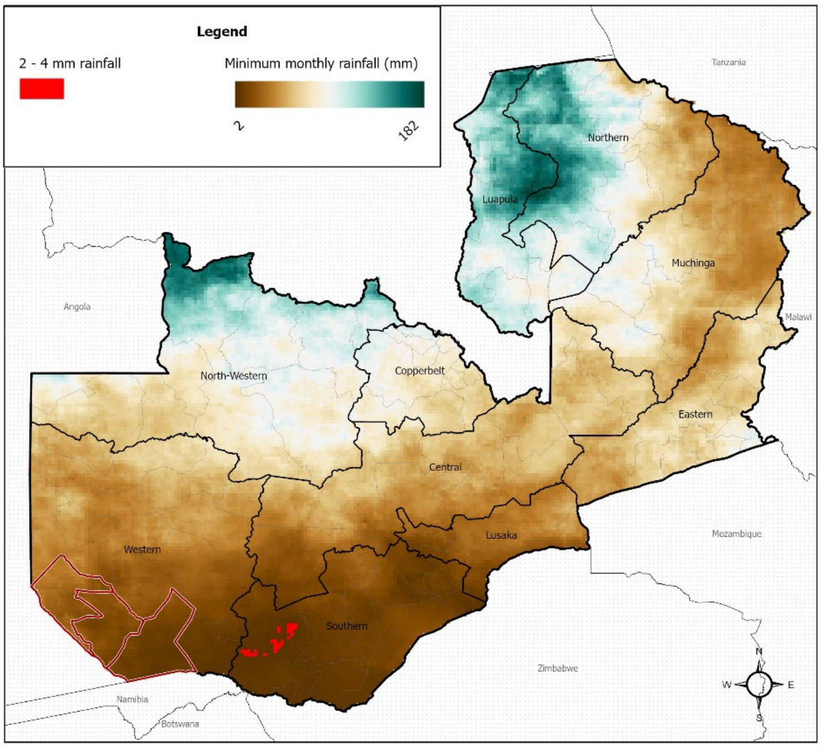


Figure 31. Minimum monthly total rainfall (mm) during rainy season 2018-2019. Source: own diagram, Data source: CHIRPS 2018-2019.

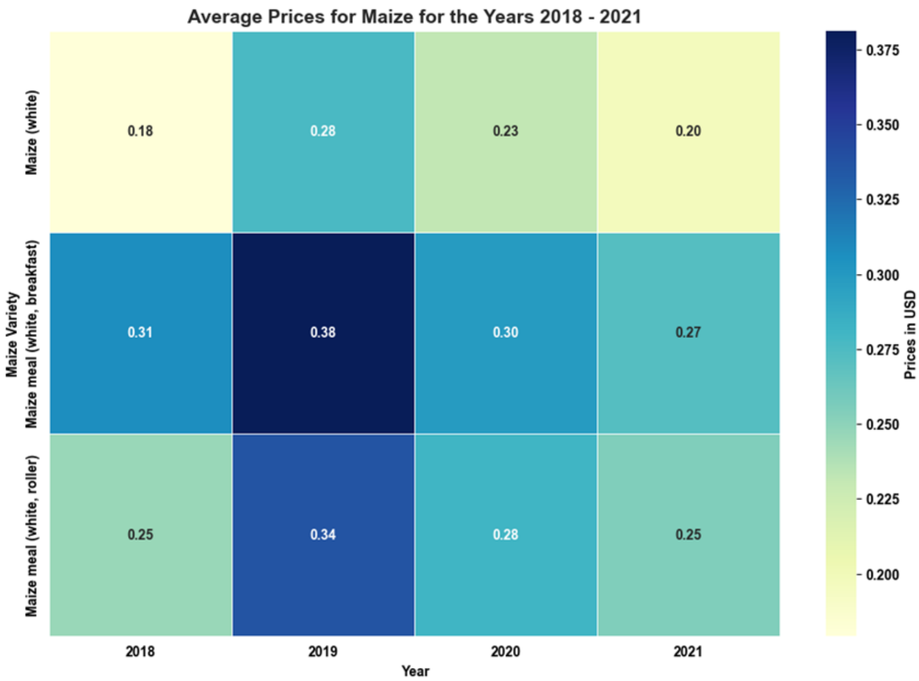


Figure 32. Average prices for different varieties of Maize in the Western Province (2018-2021). Districts analyzed include: Kaoma, Mongu, Nalolo, Kalabo, Lukulu, Sesheke, and Shangombo. Source: FAOSTAT, 2024.

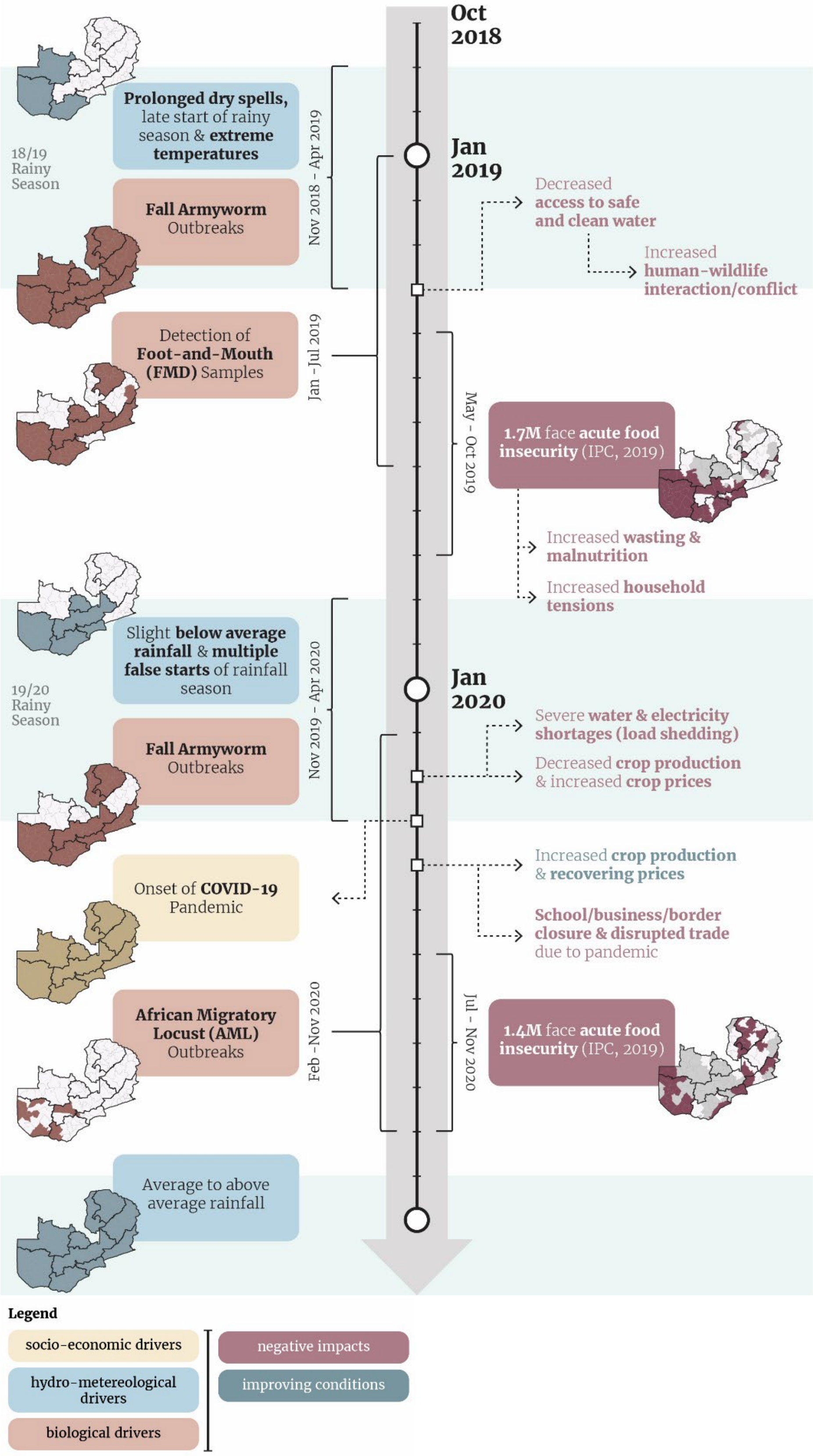


Figure 33. Drivers and impacts timeline.

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