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Working Paper

UNDERSTANDING COMPOUND EVENTS IN FRAGILE CONTEXTS

Insights from Ethiopia & Kenya

((GCRP)) Global Crisis Risk Platform

WORLD BANK GROUP Fragility, Conflict & Violence

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Executive Summary

Interactions between natural, socioeconomic and political threats can lead to compound crises where the cumulative impacts are far larger than the sum of individual threats. The implications of compound crises can severely undermine development gains by hindering progress towards poverty reduction shared prosperity. These impacts are particularly pronounced in contexts affected by Fragility, Conflict and Violence (FCV), which serves to limit coping capacities of affected communities and amplify vulnerabilities to future compound threats. In turn, impacts and responses to given disasters can exacerbate underlying conditions related to FCV, further increasing long-term exposure to compound risk.

The Horn of Africa is especially prone to compound crises. Many parts of the region are characterized by high levels of institutional fragility, socio-economic vulnerability and food insecurity amongst other drivers of risk. Limited national and regional capacity to support cross-sectoral risk management means that many countries are highly exposed to successive threats with spill-overs that spread across multiple sectors. In addition, the impacts of climate change are likely to hit the Horn of Africa especially hard through increased climate variability and rising temperatures, with knock-on implications for wider political, social, economic and demographic challenges.

Many governments across the Horn of Africa, and elsewhere, struggle to address the drivers of compound risk. Risk management activities are heavily focused on monitoring and addressing singular threats, with little attention paid to supporting cross-sectoral coordination and response. Limited national resources and technical capacity needed to support holistic risk management, making the task of managing compound risk especially challenging. Understanding root causes of compound crises is an important first step in supporting governments' ability to promote risk reduction across the Horn of Africa. Despite this need, little is known about how different types of risk interact and what windows of opportunity exist in preventing compound crises from materializing, particularly in FCV contexts.

To address key knowledge gaps related to compound risk, this report documents findings from a retrospective analysis of two compound crises in the Horn of Africa. The linked crises occurred in Kenya and Ethiopia between the end of 2016 and the beginning of 2018, when a severe drought was immediately followed by extensive flooding during the long rainy season (see Figures ES1 and ES2). The situation was further compounded by spillovers and interactions with wider dynamics including ethnic conflict, political disruption, displacement and crop pest infestation, with severe implications for livelihoods and wellbeing.

FIGURE ES1: Disaster events timeline in Ethiopia from January 2017 to July 2018

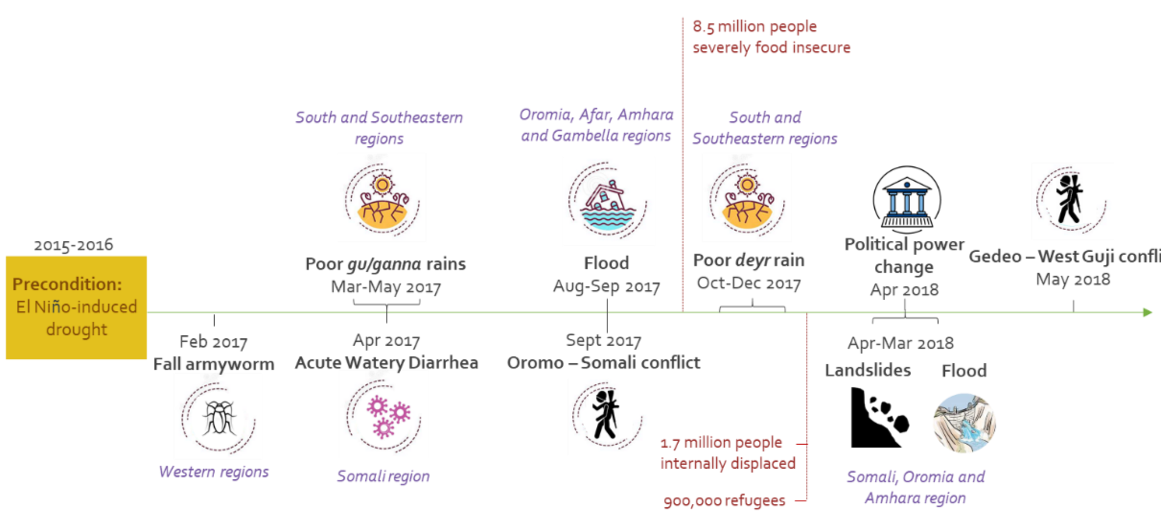
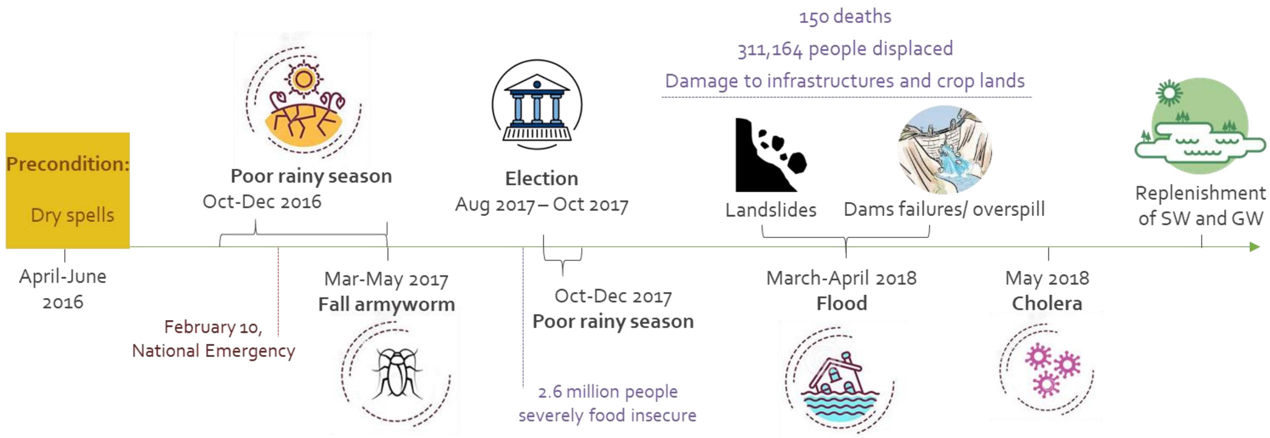


FIGURE ES2. Disaster events timeline in Kenya from April 2016 to July 2018.



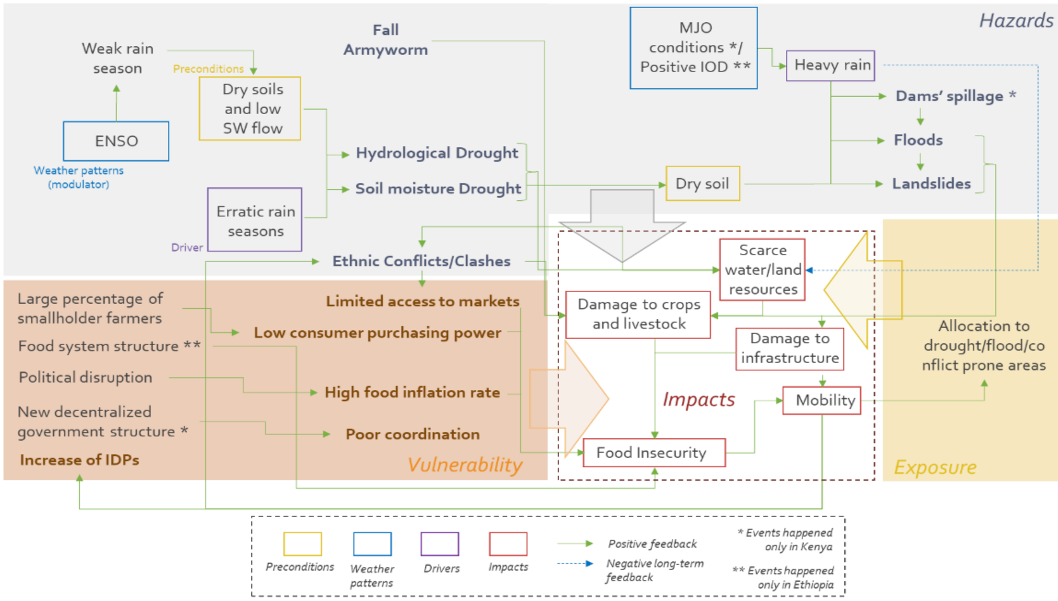
A series of qualitative and quantitative methods are used to explore the interaction of various threats and outcomes from the two crises. More specifically, the work seeks to understand the drivers of compound risk and how they materialize over time, as well as identifying relevance windows of opportunity that can support early action based on the two case studies.

Key Findings

A summary of key findings from the retrospective case study are presented below.

- **The 2017-2018 compound crises in Ethiopia and Kenya resulted from interactions between successive multi-sectoral threats, exacerbated by conditions related to FCV**. These had considerable knock-on implications for wider drivers of risk and outcomes that included displacement, increased food insecurity, inter-ethnic tension, and health-related concerns in both countries. A strong contributing factor to the crises was past exposure to slow-onset regional climate extremes coupled with high levels of socio-economic vulnerability that materialized in the years prior. Political disruptions, institutional fragility and conflict in both Kenya and Ethiopia further escalated exposure to compound risk, laying the groundwork for the crises that ensued shortly after.
- **Communities affected by different types of threats were hardest hit.** For example, those that experienced the highest levels of food insecurity weren't necessarily those exposed to the highest levels of rainfall. Instead, communities simultaneously affected by conflict and other wider threats were consistently revealed to have the worst food-related outcomes. This occurred due to the interaction of consecutive weak rainy seasons with structural poverty, political marginalization, and conflict severely limited coping strategies adopted by affected communities. In other cases, quick succession between hazards had severe consequences. In Ethiopia, rather than offering reprieve from a long drought, the arrival of rains shortly after the drought increased the risks of flash flooding and landslides in the immediate-term due to the dry and compacted nature of the soil. However, rains did lead to replenishment of water sources and amelioration of food security conditions in the longer-term.
- **Compound crises have many direct and indirect causes and feedback loops.** A glimpse of the complexity of the case studies examined as part of this research can be seen in Figure ES3. The Figure presents an analytical risk framework summarizing the primary hazards, exposure, vulnerabilities and impacts related to the compound events that took place in Ethiopia and Kenya.

FIGURE ES3. Summary of key drivers and impacts of compound events studied in Ethiopia and Kenya[1]



- **Findings also reveal the non-linear nature of responses and causality between compounding threats.** The diversity of interactions associated with compound risk mean that the impacts of a given sectoral shock can result in deteriorating conditions in another sector, which can in-turn feed-back and cause worsening conditions across both sectors. For example, the report documents numerous cases where food security threats (driven by natural hazards) served to undermine FCV conditions, which in turn heightened communities' sensitivity to future food insecurity – either as a result of climate extremes or worsening conditions related to conflict and fragility. Impacts are also spatially and temporally heterogenous making it difficult to identify singular policy response. Caution should be taken in efforts to prescribe simple policy responses that fail to disentangle the complexity of causal loops in the context of compound crises.

- **Coping mechanisms for one hazard can inadvertently increase vulnerability and exposure to others, particularly in FCV contexts.** Several strategies adopted by studied communities in Kenya and Ethiopia served to increase exposure to wider compounding threats. For example, disaster-induced migration was one of the primary coping mechanisms adopted by affected communities, particularly in the Ethiopia case. While this provided temporary reprieve, migration served to further exacerbated existing tensions between pastoralists and sedentary groups, aggravating resource-based conflict and inter-communal competition over land as well as increasing exposure to other subsequent threats. These conditions had knock-on implications for policy responses too, as rising insecurity in the aftermath of the crisis resulted in restricted access of humanitarian aid in both countries, further exacerbating the impacts of ongoing drought.

- **Policy responses to individual sectoral threats both reduced and heightened exposure to future compound risk**. In both cases, response measures that addressed individual hazards often heightened risk to other subsequent shocks. For example, redirection of government resources to address one

[1] The framework was developed by combining the risk framework proposed by GAR21 - (Reisinger *et al.* 2020) and by (United Nations Climate Change, 2020)

threat often meant that core delivery of core services in another sector was threatened. In other areas, targeted interventions to respond to a given hazard (e.g. swift application of pesticides to combat threat of locusts) had detrimental outcomes on livelihoods (e.g. ill-considered choice of pesticide harmed livestock) with knock-on implications for people's capacity to cope with subsequent sectoral threats.

- **Compound risks are likely to increase in coming years and decades, exacerbated by heightened vulnerability to climate change across the Horn of Africa.** In particular, gaps between successive flood and drought events have shortened dramatically. Communities affected by drought are now more likely to experience subsequent extremes (including flooding) before they have time to fully recover. This has major impacts on smallholder farmers and pastoralists whose coping strategies are severely weakened by consecutive or compounding shocks. Vulnerability to climate-related impacts will be especially pronounced in areas affected by FCV.

Implications for policy

Findings from the study have several implications for stakeholders seeking to reduce exposure to compound risk, in Kenya and Ethiopia as well as elsewhere.

- **Responding early is key to limiting future impacts related to compound crises.** The impacts of a compound crisis often cascade and increase exponentially after initial triggers. Acting early to address emerging threats and reducing underlying levels of vulnerability can play a significant role in lowering the risk of future compound crises. In the cases of both Ethiopia and Kenya, early windows of opportunity were evident though uptake was slow and remained limited within single sectors. For example, while seasonal and weather forecasts were issued well in advance of the initial triggers (drought events linked to El Nino), response activities were ill-coordinated and remained solely focused on the agricultural sector.
- **Cross-sectoral coordination is needed in reducing the impacts of compound crises.** Compound events do not hit all sectors in the same way and at the same time. Cross-sectoral coordination is needed in helping to communicate the emergence of initial threats and reduce the likelihood of impacts from one sectoral hazard spilling over across other related sectors. This includes coordination across spatial scales (e.g. between national and local government), across sectors (e.g. between relevant ministries and agencies), and across relevant stakeholders (e.g. between government, multi-lateral agencies, NGOs etc.).
- **Strengthen the capacity to respond to compound risk at local, national and regional scales.** Findings from the research demonstrate how considerable spatial diversity of economic, social and environmental traits in Ethiopia and Kenya results in differing levels of vulnerability across scales. Given that the focus of risk management activities is heavily oriented towards national-level coordination, greater attention is needed in tailoring and supporting local-level responses. In particular, while nationally mandated bodies are allocated dedicated (though meagre) financial and technical resources to coordinate national risk preparedness and response, the capacity of sub-national government is especially lacking. Considerable attention is needed in supporting sub-national governments in developing and implementing local prevention, preparedness and response plans as well as increasing their capacity to monitor localised risks. Plans should be tailored to recognise the diversity of socio-economic conditions and climate-related vulnerabilities in different regions of the country. In addition, the case studies demonstrate how compound threats can spill-over across national borders. This includes risks related to cross-border migration, macro-economic dynamics and

disease outbreaks amongst others. Such properties underline the importance of regional planning and coordination of risk management between countries across the Horn of Africa, including strengthening of dedicated regional bodies such as the Intergovernmental Authority on Development (IGAD) and regional risk management commitments like IGAD's Drought Disaster Resilience and Sustainability Initiative (IDDRSI).

- **Ensuring risk management strategies are conflict sensitive.** Numerous examples of how coping and response strategies exacerbated conditions related to FCV are provided throughout the report. In particular, disaster-induced migration was used as an immediate means of coping with both natural hazards and conflict in Ethiopia led to increases in ethnic tension that in-turn heightened levels of displacement and provided barriers to humanitarian access. Plans and policies aimed at reducing compound risk must factor in medium- and long-term implications on underlying drivers of FCV. With that in mind, strategies aimed at responding to compound crises should be conflict-sensitive and ensure that careful consideration is given to potential knock-on impacts on social cohesion, violence and discrimination of marginalised groups. This includes options to develop dedicated plans to manage and coordinate climate- and disaster-induced displacement.
- **Investing in holistic early warning systems can support early action and reduce the risk of compound threats from materialising.** Risk monitoring of ongoing or future crises is not sufficient on its own in reducing exposure to compound risk. Doing so necessitates that monitoring systems are effectively linked to outreach and communication activities as well as decision-making processes as part of effective early warning systems. These are crucial in providing timely windows of opportunity to support preparedness and response activities. Experiences from this case study also showcase the importance of promoting cross-sectoral early warning systems – ones that incorporate forward-looking information across a range of sectoral threats to allow for potential spillovers to be accounted for in decision making activities.
- **Compound crises have multiple windows of opportunity to support effective response.** As shown by the findings from this analysis, compound events are convoluted with multiple drivers, spillovers and impacts. While designing dedicated response activities is a challenge, it is possible to identify three main windows of opportunity that can guide effective risk management activities.

i. Prior to the onset of a compound crisis:

This time window provides opportunities to address structural issues and implement long-term risk reduction measures. Such activities relate to efforts to reduce future vulnerability and exposure of key hazards. This includes measures to tackle underlying causes of vulnerability such as poverty reduction strategies, social protection systems of resilience-building activities. The window is also a valuable opportunity to promote crisis preparedness measures at national and local levels. Supporting such measures can not only reduce the risk of a given hazard resulting in a disaster event, doing so also significantly reduces compound risk as a result of knock-impacts that can ensure from the initial trigger event.

ii. Immediately after a hazard is forecasted:

- Forecasts and real-time early warning systems provide valuable windows to support preparedness and response activities. The ability to provide accurate forecasts (and the length of advertised warnings) will differ depending on the type of hazard. In the case of climate variability, seasonal forecasts can provide meaningful warnings regarding conditions of above or below average rainfall to national and local decision makers up to 3-month in advance. Weather forecasts can also provide information about the likelihood of extreme weather events, with actionable accuracy up to 10 days and beyond. While these timeframes do not typically allow risk prevention, they can support decision makers in promoting preparedness and response activities days and months in advance of trigger events.

iii. **Shortly after the start of one or more trigger events:**

- Under this window, options are severely limited as the initial trigger event(s) has already started. However, responding immediately after an early hazard (one that has the potential to develop into a compounding event) can help to significantly reduce the risk of spill overs cascading across sectors – factors that often lead to complex crises given the exponential nature of their development.

- **Prioritising livelihood diversification, particularly in FCV contexts.** One of the main reasons for adopting adverse coping strategies like disaster-induced migration as part of the study was a lack of alternative sources of livelihood. In particular, strong dependence on rainfed agro-pastoral activities meant that many people were left with little alternative but to migrate – further exacerbated ethnic tensions and increasing vulnerability to future threats in the longer-term. Targeted support toward livelihood diversification and reducing people's dependence on single communities or resources can play an important role in promoting risk reduction in the face of compound crises. This should be a focus of interventions from government and development stakeholders, including integration with national and local disaster risk reduction strategies.

- **Enhancing crisis preparedness is key.** One of the most important measures for reducing compound risk is active support for crisis preparedness. This includes ex-ante interventions to: strengthen legal and institutional foundations for preparedness; monitor past, ongoing and future risks put in place adequate risk financing mechanisms; support primary response measures, including critical infrastructure and public health services; and strengthening food and livelihood support systems. Preparedness measures that support greater cross-sectoral coordination are especially key in preventing threats from materialising into compound crises.

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Introduction

1.1 Background

The World Bank is reviewing its crisis-related funding mechanisms and instruments to enhance the Global Crisis Risk Platform (GCRP). The platform was established in 2018 as an institutional mechanism and aims to build capacity to anticipate and track compound crises by supporting multi-dimensional risk analysis. The platform has two core objectives: (1) promote risk-informed investments to support crisis prevention and preparedness; and (2) strengthen institutional capacity for early response, especially where a combination of shocks amplifies impacts or spills across borders. To achieve the above objectives, GCRP is running three main activities: (1) the development of a suite of multi-dimensional crisis risk analytics tools; (2) the launch of a regular multi-dimensional crisis risk horizon scan exercise; and (3) the analysis of a series of retrospective country case-studies (which will feed into the risk analytics and horizon scanning initiatives). This report is framed within the third GCRP activity, investigating the interconnected hazards and the dynamic exposure and vulnerability that marked the humanitarian crisis in the Horn of Africa in 2017-2018. In that period, multiple compounding events substantially set back progress on economic development and poverty alleviation in Horn of Africa, leading around 18 million people under food insecurity.

Based on the literature on compound events (Leonard *et al.*, 2014 and Zscheischler *et al.*, 2018), consecutive or sequential disasters (de Ruiter et al., 2020), and the complexities of systemic risk (United Nations Office for Disaster Risk Reduction, 2019), we define ‘compound events’ as follows: events that result from physical and/or socio-economic processes of multiple hazards that occur successively or simultaneously, or extremes that occur in combination with background conditions. These events generate mechanisms that can amplify or reduce the overall impact. The nomenclature used in this report is clarified in Table 1.

TABLE 1. Definition used in this study

Nomenclature	Definition
Events	Happening, occurrence or episode.
Weather and climate events	Events at spatial and temporal scales varying from local weather to large-scale climate (IPCC, 2012).
Weather and climate extreme events	The occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variable (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. We refer to the term drivers throughout as direct causes of hazards, exposure and vulnerability. Primary drivers: primary triggers of an impact; Secondary drivers: impacts that could trigger a secondary impact.
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.
Risk	Risk is 'the potential for adverse consequences' (Zscheischler et al., 2018) Risks arise from the interaction between hazard, vulnerability and exposure and can be described by their products. Here, we use the term risk to refer to environmental and societal impacts from weather and/or climate and/or socio-economic events.
Exposure	The presence of people; livelihoods; environmental services and resources; infrastructure; or economic, social, or cultural assets in places that could be adversely affected (Zscheischler et al., 2018).
Vulnerability	The propensity or predisposition of the social and natural system to be adversely affected (IPCC, 2012).
Hazard	The (potential) occurrence of a natural or human-induced event that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, and environmental resources (IPCC, 2012).
Compound events	Events that result from physical and/or socio-economic processes of multiple hazards that occur successively or simultaneously, or extremes that occur in combination with background conditions. These events generate mechanisms that can amplify or reduce the overall impact.
Compound mechanisms	Types of interactions that develop between multiple drivers and/or impacts and that contribute to societal or environmental risk.
Compound risks	Risk of compound events.

1.2 Scope & Objectives

By using a mix of qualitative and quantitative methods, this study aims to disentangle the complex spatio-temporal interactions between physical forces (e.g., drought, floods) and societal factors (e.g., demographic changes, violence and conflicts) to understand how risks compound in socially vulnerable contexts, and which early-warning signs could enhance proactive interventions.

In particular, the analysis focuses on three research questions:

i. How did risks compound over time (including the interaction of natural, socio-economic and fragility factors)?
ii. What early-warning signs may have been apparent ahead of the compound crisis?
iii. What could have been the relevant windows of opportunity for early actions?

The research questions under analysis are addressed through a retrospective study of the humanitarian crises that occurred in Kenya and Ethiopia in 2017-2018, when a severe drought that occurred over the span of 18-24 months, was followed by an extensive flooding during the 2018 March-May rainy season. The events compounded with ethnic conflicts, political disruption and crop pest infestation, resulting in an increase in people under food insecurity both in Kenya and in Ethiopia.

1.3 Report structure

The report is structured as follows. Chapter 2 describes the methodology used. Chapter 3 provides the analysis of the Ethiopian case study. First, we provide an overview of compound risks in Ethiopia (Section 3.1). This is followed by a description of the events that characterize the 2017-2018 humanitarian crisis (Section 3.2). Then the impacts and related drivers are analyzed through a quantitative review of the literature (Section 3.3), together with possible early-warning signs and windows of opportunity for interventions (Section 3.4). Next, the driver/impact mechanisms are explored through the results of a survey (Section 3.5) and semi-structured interviews (Section 3.6). A glimpse of drivers and impacts that characterized the 2019-2020 humanitarian crisis in Ethiopia follows (Section 1.1). We conclude with a summary of the key findings and a discussion of the Ethiopia case study (Section 3.7).

In Chapter 4, the analysis for Kenya is presented with the same structure as above. First, an overview of compound risks in Kenya is provided (Section 4.1), then the events that characterized the 2017-2018 crisis in Kenya are described (Section 4.2). Next, the results of the literature review related to drivers/impacts and early signs & windows of opportunity for interventions are shown (Section 4.3 and Section 4.4), followed by the results of the survey (Section 4.5) and semi-structured interviews (Section 4.6). A glimpse of drivers/impacts characterising the 2019-2020 humanitarian crisis follows (Section 0) and finally, we conclude with a summary of the key findings and a discussion of the Kenyan case study (Section 4.7).

In Chapter 5, we discuss the main similarities and differences between the two case studies. General conclusions are drawn in the last chapter.

2. Methodology

We combined qualitative and quantitative methods to identify driver/impact mechanisms, windows of opportunity for interventions and early warning signs of the 2017-2018 compound crisis in Kenya and Ethiopia. A synthesis of the identified relationships was then presented using visual formats. Network graphs were employed to display event interactions, explored through online surveys and semi-structured interviews. In the following subsections, we describe the conceptual framework used, underlying the different steps we followed to answer the research questions listed in Section 1.2 above.

2.1 Conceptual framework

Below we present the steps followed to analyze the spatial and temporal interactions of the compound events that characterized the 2017-2018 humanitarian crises in Ethiopia and Kenya. These steps are also graphically summarised in Figure 2.

Drivers/impacts and their mechanisms during the 2017-2018 compound crisis

Several steps were taken to identify the drivers and impacts that characterized the 2017-2018 humanitarian crisis in Ethiopia and Kenya, and the driver/impact interactions. First, we constructed event timelines through a literature review (Step 1 in Figure 2). In the analysis, we considered physical (droughts, floods) and socio-economic (ethnic conflicts, political instability) events. We included both events at national scale and events at regional/county scales that, however, required national intervention. These events were first identified by carrying out a country profile, looking at major disasters and socio-economic conditions over the last 20 years. Then, the analysis of peer-reviewed articles, humanitarian bulletins and reports, describing the years under analysis, helped develop detail event timelines. These timelines were reviewed with relevant stakeholders through an online survey to make sure all-important events were included.

Subsequently, we carried out the risk analysis. Usually, risk analysis starts from the characterisation of the hazard, vulnerability, and exposure, and only then follows the identification of the related impacts (top-down approach). However, to better understand the interactions between drivers and impacts over time and space, we need to understand first the nature of the risks (Zscheischler et al., 2018). This suggests the use of a bottom-up approach in which impacts are identified first and then their main drivers are identified from the impact analysis. Therefore, we identified the main impacts felt during the years 2017-2018 through literature review, the use of open-source databases and the online survey (Step 2 in Figure 2). We looked at national databases and, when available, regional/county data. The impacts investigated were: food insecurity, displacement, conflicts and violence, disease outbreak and economic hardship.

Based on this analysis, in a third phase we traced back the drivers from the impacts (Step 3 in Figure 3). This was achieved by first identifying cited correlations between impacts and possible triggers through a quantitative review of the literature. We then further investigate the drivers that led to the experienced humanitarian crisis through the online survey and semi-structured interviews. Through the online survey, we asked the respondents to identify the impacts experienced in 2017-2018, identify the drivers of these impacts and finally think about the negative and positive interactions between drivers and impacts. This helped us develop one cognitive map of driver/impact interactions for Ethiopia and one for Kenya that we further validate through semi-structured reviews (Step 4 in Figure 2).

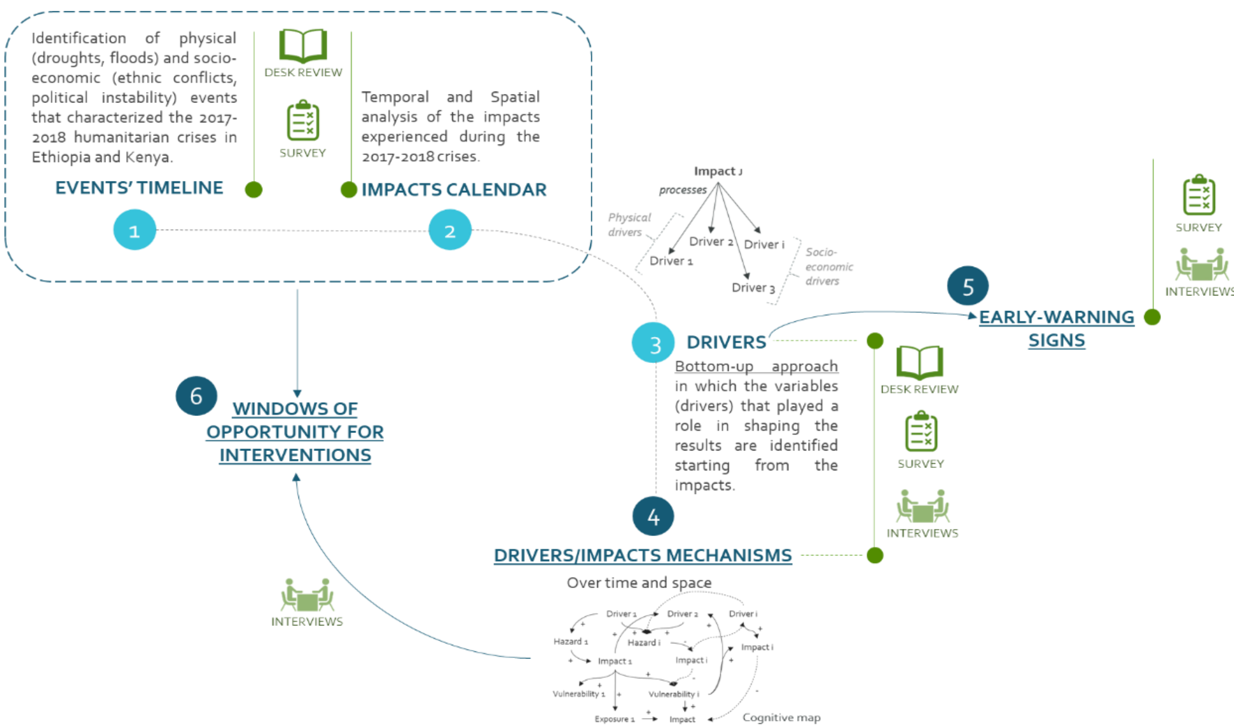
Early-warning signs

By knowing the drivers of the compound events that led to the experienced impacts, we identified the possible early-warning signs that appeared ahead of the compound crisis (Step 5 in Figure 2). These were then discussed with key stakeholders through the online survey and semi-structured interviews.

Windows of opportunity for interventions

Windows of opportunity for interventions were identified for each case study by comparing the events timeline with the impacts calendar (both developed in the previous steps). We also discussed possible temporal windows for interventions with interviewees by analysing the compound mechanism captured in the cognitive maps (Step 6 in Figure 2). Knowing the windows of opportunity for interventions, we identified possible early actions for each window using a literature review and discussing possible interventions with key stakeholders through interviews.

FIGURE 2. Analytical framework



2.2 Systematic literature review

In a first step, a quantitative literature review was carried out to analyze peer-reviewed articles, humanitarian bulletins and reports on the relevant events that characterized the Ethiopian and Kenyan humanitarian crises during the years 2017 and 2018, and then specifically on the impacts and related drivers.

To find eligible documents, the following search keywords were used: 'humanitarian' + 'crisis' + 'food insecurity' + 'Ethiopia' OR 'Kenya' + '2017' OR '2018'. This helped at first to identify the main events that occurred in the analyzed period. Other documents were then identified consecutively by exploring both references and with a new online search using the keywords: ‘conflict’ OR ‘ethnic clashes’, ‘displacement’, ‘drought’, ‘heavy rain’ OR ‘floods’ OR ‘landslides’ and ‘dam spillages’. With this research protocol, we identified 120 relevant documents for Ethiopia and 60 for Kenya. All the identified documents were used for conducting narrative reviews of the cascading events that took place in the analyzed years. Furthermore, the cited correlations between drivers and impacts were extracted and collected in a matrix, in order to quantify the frequency with which a certain correlation was mentioned

2.3 Stakeholder survey

An online survey was developed with the scope of better understanding how simultaneous and/or consecutive natural and socio-economic events in Kenya combine together, reducing or increasing the risk of national crises. Through open-end and multiple choices questions, we aimed to gain insights on the impacts and related drivers that have marked the humanitarian crises experienced in Kenya and Ethiopia. The survey had 5 sections: (1) respondent information; (2) events that occurred in the years 2017-2018; (3) impacts experienced; (4) root causes (drivers) of the impacts experienced; (5) interaction between drivers and impacts; (6) compound events in later 2019-2020; (7) information to tackle compounding risks.

For the Kenyan study, the online survey was distributed to around 150 stakeholders from national/international agencies in the field of Disaster Risk Reduction (DRR)/ Disaster Risk Monitoring (DRM), water management and socio-economy, NGOs and universities, individually contacted by email. Further, we disseminated the survey invitation through social media (Facebook, Twitter) and relevant mailing lists and newsletters. A friendly reminder was sent to all contacted stakeholders in order to enhance answers. The process resulted in collection of 24 completed surveys.

For the Ethiopian analysis, the survey was distributed to around 80 stakeholders from national/international agencies in the field of DRR/DRM and water management and socio-economy, NGOs and universities. A friendly reminder was sent to all contacted stakeholders resulting in the final collection of 16 surveys.

2.4 Stakeholders’ semi-structured interviews

The humanitarian crises under analysis were further explored through semi-structured interviews. In Kenya, seven individual interviews were carried out with professionals involved in DRR and DRM from national agencies, international organizations, private sectors and universities. In Ethiopia, four semi-structured interviews were carried out with professionals involved in DRR and DRM from national agencies and international organizations. Four main topics were addressed during the interviews: (1) driver/impact mechanisms of the 2017-2018 humanitarian crisis; (2) response, DRR policies and coping mechanisms; (3) windows of opportunity for proactive interventions; and finally (4) early warning signs of compound risks.

In order to explore possible windows of opportunity for proactive interventions, two cognitive maps based on the results of the literature review were developed. These were then reviewed by the interviewees. The process resulted in a participatory co-creation of cognitive diagrams used as qualitative mental maps of the perceived drivers and interactions.

3. Compound risks in fragile contexts: analysis of Ethiopia in 2017-2018

The following sections investigate the social factors and physical forces that led to the humanitarian crisis in Ethiopia in 2017-2018. A retrospective analysis of the aforementioned period allowed us to disentangle the complex hydro-social feedback that develops during compound events, outlining in particular the relationship between drought/floods, conflicts and political Instability in Ethiopia.

The first subsection presents an overview of compound risks in the country (Section 3.1). Section 3.2 then explores the main events that occurred in the period analyzed. We present an analysis of the temporal and spatial interactions between the identified social factors and physical forces, first through literature review (Section 3.3) and then via results from online survey (Section 3.5) and semi-structured interviews (Section 3.6). We also explore possible early warning signs of compound risks and windows of opportunity for interventions through the literature review (Section 3.4), and then through the results of the online survey and the semi-structure interviews (Section 3.5 and Section 3.6). A discussion and a summary of the key findings are provided in the last Section (3.7).

3.1 Compound risks in Ethiopia

Ethiopia is highly prone to multiple shocks, given its spatial heterogeneity both in terms of topography and ethnicity (Annex A). Weak institutional capacity (Desalegn & Solomon, 2021; Kenea, Teshome, & Yemane, 2020; Rice & Patrick, 2008), low-income diversification (Adem, Tadele, & Mossie, 2018), ethnic confrontations (Abbink, 2006), complex climate conditions (Tayea, Dyer, Charles, & Hirons, 2021), and human pressure on the environment (Doty, Grajeda, Phillips, & Shrestha, 2011) increase exposure and vulnerability of Ethiopian population to simultaneous and/or consecutive shocks such as climate-related hazards, ethnic conflicts and market failures.

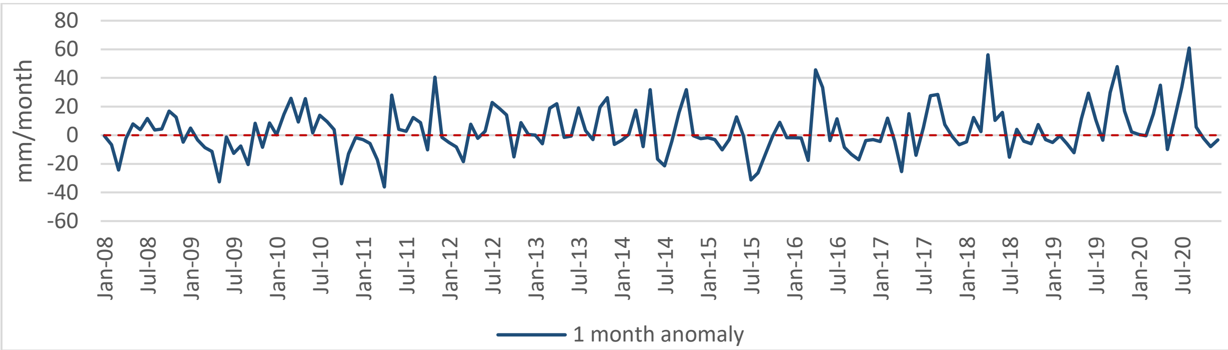
In the recent years, climate anomalies with regards to both drought and flood events are becoming more frequent and intense in terms of magnitude and people affected in Ethiopia. In earlier periods, the drought recurrence interval was every 8-10 years over the whole country, and every 3-5 and 6-8 years in northern and southern parts of the country, respectively (Shitarek, 2012). Over the past two decades, drought frequency and duration have increased (Liou, 2019). The drought of 2015-2017 that occurred over three successive years and affected nearly 10 million people is a prime example. At a finer spatial scale, the analysis of rainfall time series over the last 20 years shows that almost every year there was a mild annual drought in at least one area of the country (Viste, Korecha, & Sorteberg, 2012a).

Floods have also become an annual challenge in terms of losses with increasing frequency and severity in recent years (Weldegebriel and Amphune 2017). Flood events in Ethiopia can be classified as exceptional in the last five years, both in terms of recorded rainfall (Figure 3), and consequently, in terms of people affected (400,000) and displaced (200,000-300,000)[2]. Although the significant increase, flood events still

[2] Information collected from EMDAT and Desinventar datasets.

affecting overall less people than drought events, whereas the latter has numbers in the magnitude of millions.

FIGURE 3. Rainfall Anomalies in Ethiopia from January 2008 to July 2020 (WFP-CHIRPS). The rainfall anomalies were calculated with respect to the long-term monthly average rainfall values (computed over 30 years)



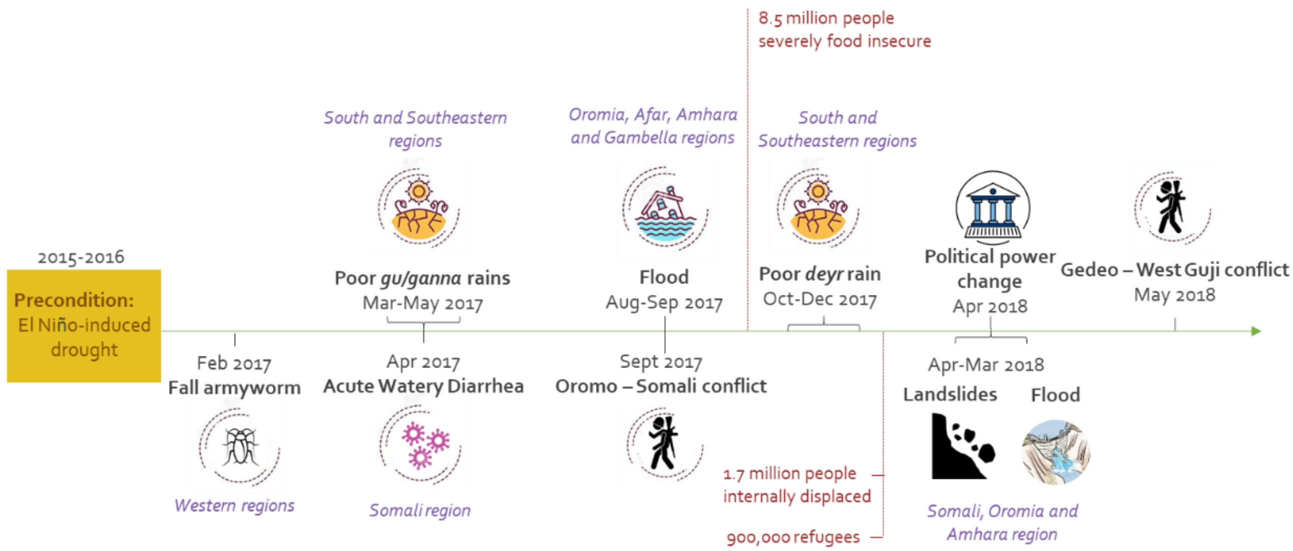
Additionally, simultaneous events of droughts and floods affecting two different locations within the country are not rare. This is due to the high heterogeneity in Ethiopian climate and often results in overstretched national resources for guaranteeing effective response in the affected areas (International Federation of Red Cross and Red Crescent Societies, 2017b). Finally, the time interval between flood and drought events has shortened in the last years. Communities affected by drought are likely to experience flooding before they have time to fully recover, with major impacts on smallholder farmers whose coping strategies are limited by consecutive shocks. One of the main coping mechanisms is the migration of pastoralists into cropping areas, and of farmers into pastoralist areas to access land (Yishak, 2019). However, these mechanisms further fuel tensions over scarce resources, especially along ethnic lines. Ethnic violence and conflicts are one of the main drivers of displacement in Ethiopia, bringing the number of displaced people to the order of millions in 2018 and 2020.

In addition to extreme weather events and conflicts, the impacts of crop pests, livestock diseases and government instability also contributed to recent humanitarian crises in the country. All these factors together strongly increase the food insecurity in Ethiopia, and lead to reinforcing mechanisms that erode people's ability to cope with these shocks.

Nevertheless, the number of people affected by food insecurity is still often attributed to just one of these factors, thus failing to take into account the mechanisms that arise from the interaction between physical and social factors. A clear example of a humanitarian crisis resulting from the interaction of multiple factors in Ethiopia is the one experienced by the Somali and Oromia regions in the years 2017-2018. This crisis followed and prolonged the impacts of the El Niño conditions in the previous years (2015-2016) which severely affected the western regions of Ethiopia. The 2017-18 crisis resulted in around 8 million people under food insecurity and over 1.5 million internally displaced mainly in the eastern regions. Still, there is a poor understanding of the interaction of the multiple factors that led to the experienced impacts. In this study, we aim to uncover the drivers and their interactions of the 2017-18 humanitarian crisis, understanding the links with the impacts experienced.

3.2 Events timeline in 2017-2018

FIGURE 4. Disaster events timeline in Ethiopia from January 2017 to July 2018



The resulting compounded events in Ethiopia during the years of 2017 and 2018 spawned a wave of displacement and increased food insecurity in the eastern Ethiopian regions (Figure 4). In the southern and eastern parts of the country, thousands of people have been forced to flee their homes due to impacts of the below-normal rainfall of 2017, which compounded with the 2015-2016 El Niño-induced drought and the following armyworm crop infestation. A subsequent wave of displacement was then caused by floods occurring in Aug-Sep 2017, which hit particularly the north-eastern and central regions of the country and hindered responses to drought in affected communities. Adding to these challenges, inter-ethnic conflicts erupted in different parts of the country (Somali and Oromia conflicts in late 2017, and Gedeo and Guji throughout the second quarter of 2018) and also in neighbouring countries, increasing the influx of refugees into Ethiopia. Additionally, the spread of acute watery diarrhoea (AWD) mainly in areas affected by drought further aggravated the humanitarian situation. In the following sections, we explore the events that characterized the years 2017 and 2018, with the aim of identifying the main drivers of these events.

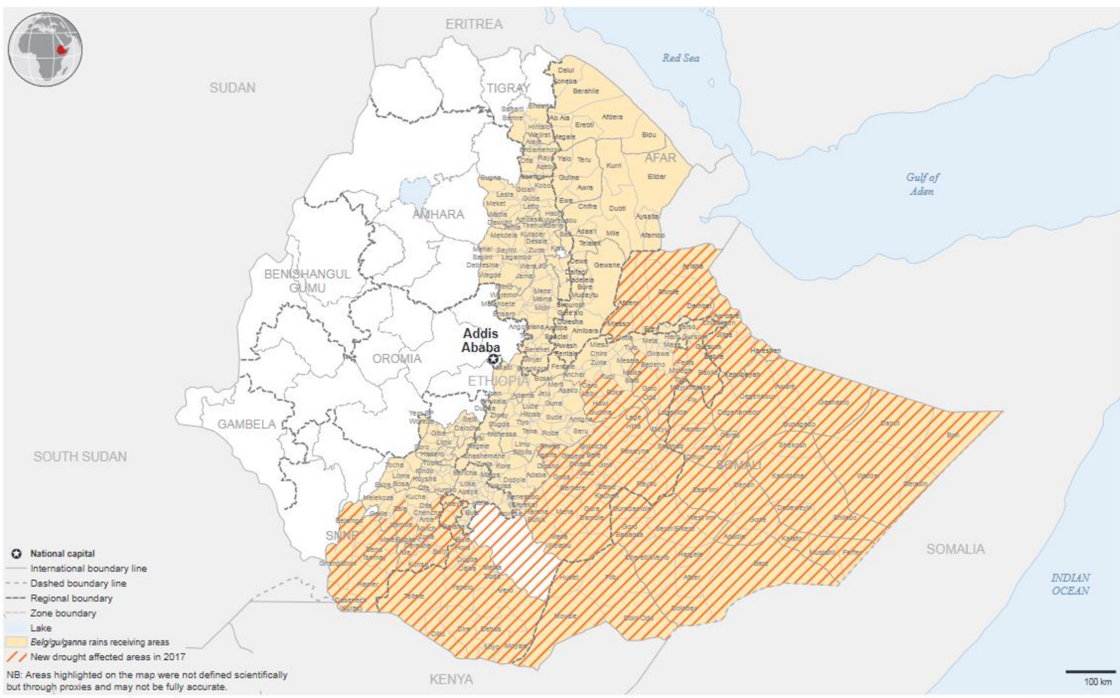
3.2.1 Drought and flood events

Drought: spatial patterns

Ethiopia suffered two distinct droughts that affected different geographic areas. First El Niño drought in 2015-16 affected the northern and central Ethiopian regions, followed immediately by the Indian Ocean dipole (IOD) drought in 2016-17, which affected the eastern and southern Ethiopian regions (Grunewald, Leon, & Levine, 2019).

Drier than normal conditions occurred during the 2015-2016 El Niño period, with weak Kiremt and Deyr rains (overview of Ethiopian rainy seasons in Annex A), in 2016, which worsened conditions in the northern and central regions already affected by the weak spring Belg rains in 2015 (OCHA, 2021a). The successive failure of rainy seasons in 2016 and early 2017 impacted pasture and water availability in the eastern regions, resulting in migrations, livestock deteriorations, and hence increasing vulnerability of livestock for animal diseases (FAO, 2017a). The erratic and weak rain continued in 2017 with below-normal values both during the Belg/Gu and Deyr rainy seasons, associated with IOD weather conditions (Figure 5; FEWS NET 2018). Above-normal rainfall rates during Kiremt's summer season in 2017 gave relief to crop plantations in the northern and central regions. In contrast, the improved performance of the Deyr/Hagaya rain in 2017 (October to December) was not enough to reverse the effects of drought in the eastern regions (FEWS NET, 2017a), which in the first quarter of 2018 were still experiencing severe crop damage and livestock losses (Weldegebriel & Amphune, 2017).

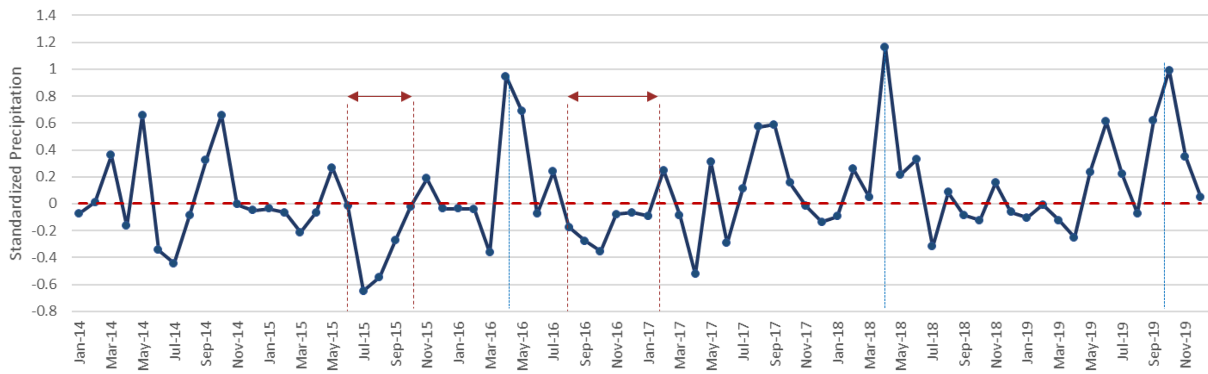
FIGURE 5. Area receiving Belg/Gu/Ganna rains and area affected by 2017 IOD induced drought (OCHA, 2017b)



Drought: temporal aspects

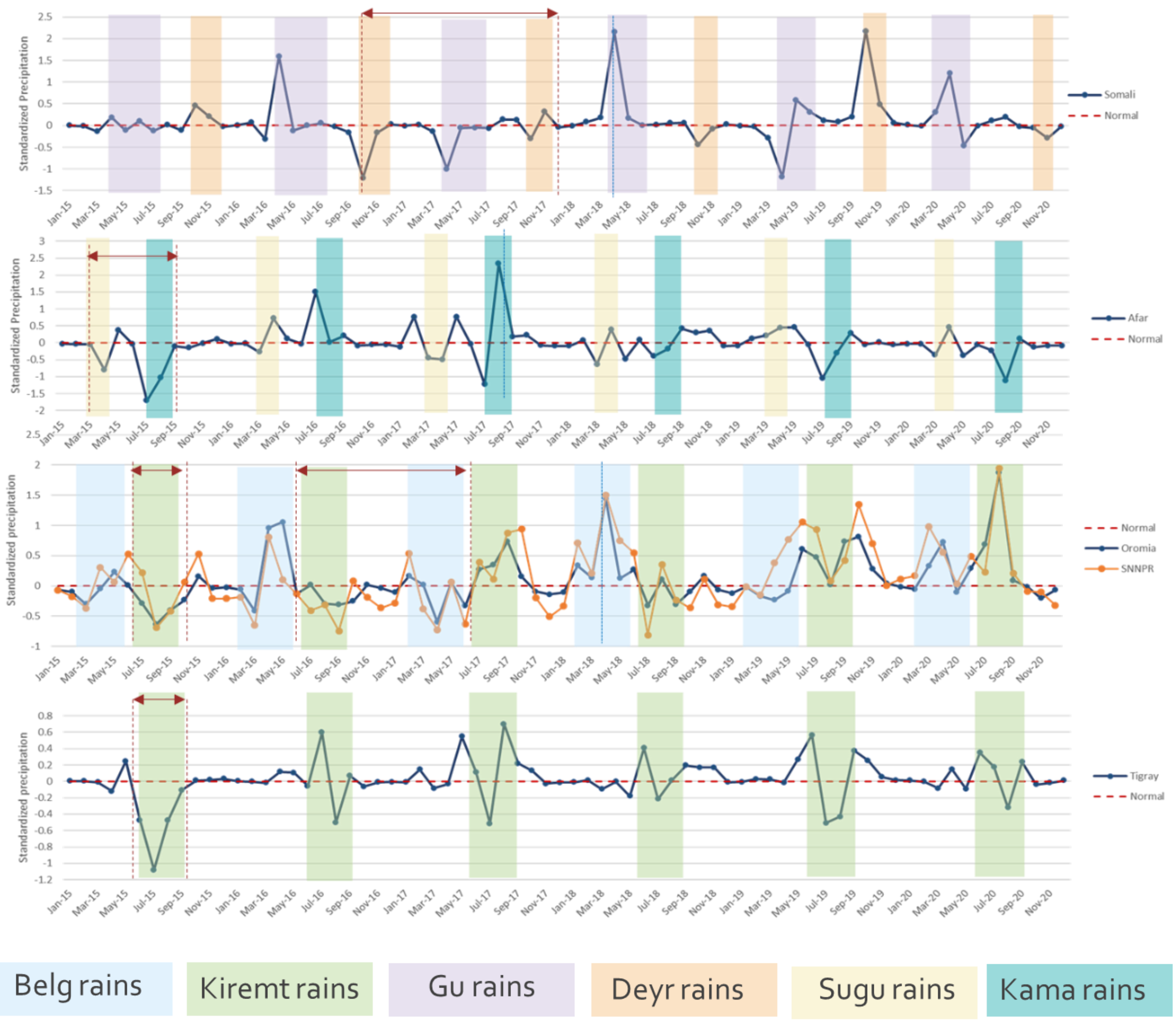
In relation to the climatological average, national rainfall values in the analyzed period reveal deficits recorded in mid-2015, and from July 2016 to May 2017 (Figure 6). On the other hand, the rainfall was above or close to the climatological average from November 2015 to June 2016, and from June 2017 to April 2018. In these periods, some areas experienced significant below-normal rainfall, but since other areas recorded values above the climatological average, their sum reached the climatological average or exceeded it (Lewis, 2017). From this, we can infer the large spatial variation in precipitation anomalies across Ethiopia, which could greatly differ from one region to another.

FIGURE 6. Standardized national precipitation anomaly from 2014 to 2019. Vertical dashed red lines indicate rainfall deficit periods; vertical dashed blue line indicates rainfall surplus periods



Therefore, drought periods can be better depicted by looking primarily at regional rainfall values rather than only at national rainfall values (Figure 7). For instance, between September 2016 and December 2017, there was a below-normal rainfall in the Somali, Oromia and SNNPR regions. As a result of these consecutive dry spells, there was no adequate water and pasture for livestock and people lost most of their animals (up to 50%) especially in the Somali region (Mera, 2018). On the other hand, the northern and western parts of the country received sufficient rainfall to support agricultural production, as can be seen from the monthly rainfall distribution in Afar and Tigray.

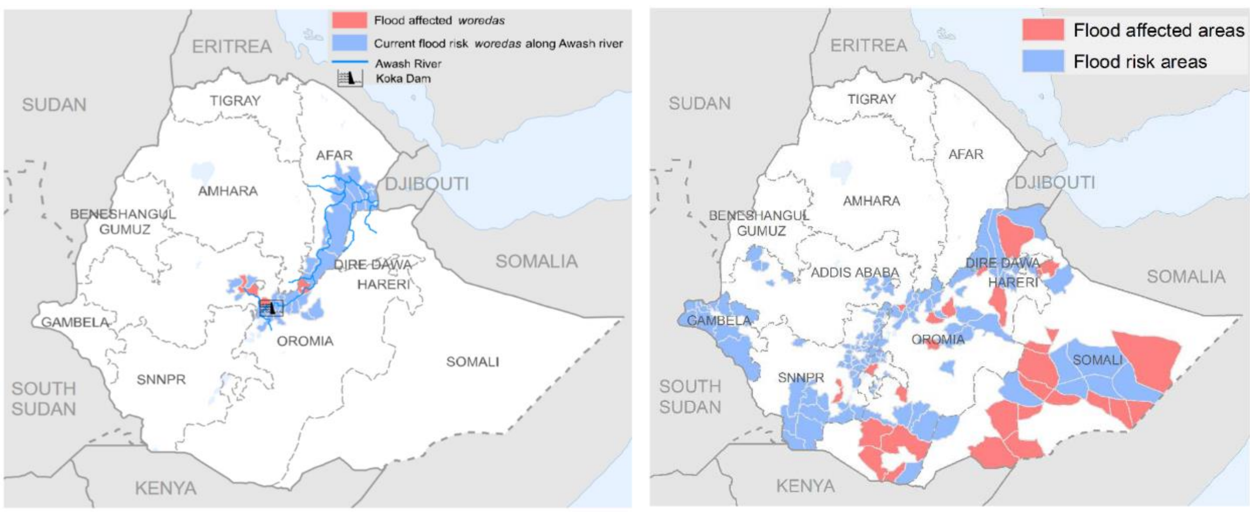
FIGURE 7. **Standardized precipitation anomaly per region from 2015 to 2020. Vertical dashed red lines indicate rainfall deficit periods; vertical dashed blue line indicates rainfall surplus periods**



Flood: spatial patterns

After a period of dry spells in the northern and central regions, abundant rains arrived during the Kiremt season of 2017 resulting also in widespread riverine floods (September 2017). Flood events also affected the eastern regions during the Belt and Gun seasons in 2018 (Figure 8). In detail, rainfall during the Kiremt season in 2017 resulted in extensive flooding in Afar and Oromia regions. A total of 93,140 people were affected, of which 36,350 people were displaced (International Federation of Red Cross and Red Crescent Societies, 2017b). In May 2018, heavy rains in the Belg/Gu late season resulted in widespread flooding in the regions of Somalia and eastern Oromia. The compacted soil resultant from the early drought in the area led to reduction in soil retention capacity, resulting in flash floods that exacerbated the impact of the intense rain (Emergency Response Coordination Centre (ERCC, 2018). The flooding led to further displacement, which added 100,000 people (OCHA, 2018c, 2018f) to the 500,000 already displaced by drought and conflicts in the Somali region (World Food Program, 2018). According to national reports, more than 350,000 people were affected by floods in May 2018 (World Health Organization, 2018), and around 30,000 hectares of land were destroyed. The flood occurred in the lowland plains along main rivers' banks (downstream plains of the Awasha river in Afar and Oromia, and the Shebelle river in Somalia). Flash floods affected mainly lowland areas adjacent to plateau that were struck by excessive rains (e.g., North Shewa zone in Oromia region, Jigjiga Town in Somali, Guraghe and Sidama zones in SNNPR). The heavy rains also resulted in landslides, especially in the Oromia region, which contributed to an increasing number of deceased and displaced people (GardaWorld, 2018; OCHA, 2018i).

FIGURE 8. Floods affected areas in Sept 2017 (left) and in May 2018 (right) (OCHA, 2017c, 2018h)



Although the 2018 heavy Belg/Gu rains led to further livelihoods disruption due to displacement and destruction of crop fields, at longer term it benefited agricultural activities. The rains increased atmospheric and soil moisture for Belg and long cycle Meher crops and perennial plants (OCHA, 2018g), as well as replenished the water sources and rejuvenating pastures of pastoralist and agro-pastoralist communities (OCHA, 2019).

TABLE 2. Climatic events and their related impacts in Ethiopia between September 2015 and May 2018

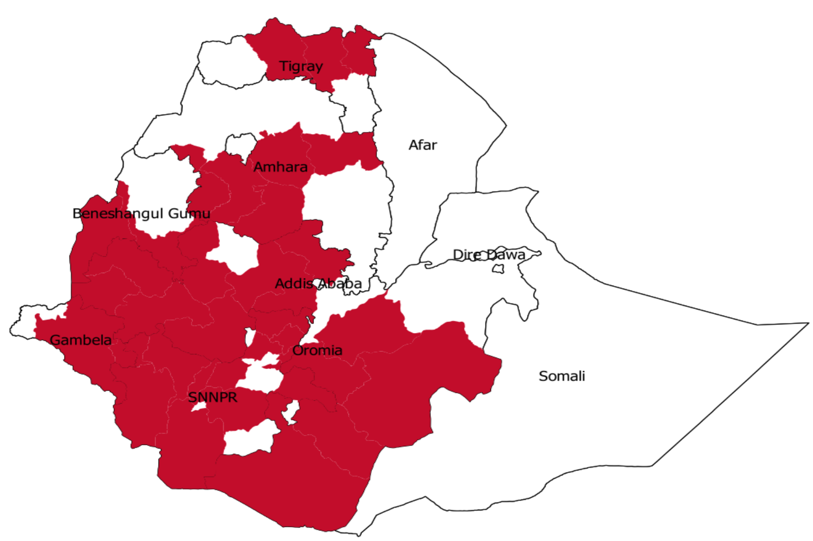
Date	Event	Impact	Location
Sept. 2015/March 2017	Drought • Failed spring Belg and summer Kiremt rains (western and central regions) in 2015 - El Nino • Weak summer Kiremt season (central regions) and weak Deyr (Oct-Dec) in 2016 (eastern and south-eastern regions) – El Nino and IOD • Weak belg/gu/ganna rains in 2017 - IOD (Inter-Agency Humanitarian Evaluation Steering Group, 2019)	• 9.7 million people under food insecurity (Nov. 2016) • 5.6 million people (April 2017) • 7.78 million people (May 2017) (FAO, 2016)	Western and central regions from 2015 to 2016. Eastern regions from 2016 to 2017
Sept. 2017	Heavy Keremt rains led to flash floods and riverine floods in Awash, Shebelle and Baro river basin	300,000 people were affected in Afar, Amhara, Gambella, Oromia, and the Somali regions, of whom at least 100,000 were displaced.(Ethiopia Humanitarian Fund, 2017; International Federation of Red Cross and Red Crescent Societies, 2017b; OCHA, 2017)	The Ambeira zone in Afar region, some areas surrounding Addis Ababa, and Jima, South-east Shewa, and South-west Shewa in the Oromia region (OCHA, 2017e; UNICEF, 2017b)
Oct. 2017/May 2018	Drought due to weak rains during the Deyr season (Oct-Dec) in 2017 end erratic and late rains during the Belg/Gu season (Mar-May) in 2018 *Weather condition attributed to the Indian Ocean Dipole (IOD)*	Below average planting and crop production, which resulted in increased maize prices (4 to 7 percent) compared to the same months over the last year (ECHO 2018; Inter-Agency Humanitarian Evaluation Steering Group 2019). This drought particularly affected livestock-herding communities in lowland areas(World Food Program, 2018). • 8.5 million of people under food insecurity (Oct 2017) (FEWS NET, 2018a) • 8.3 million of people under food insecurity (Feb 2018) (Earth Observatory NASA, 2018)	Southern and south-eastern regions (Oromia, Somali, SNNPR)

April/May 2018	Heavy rains resulted in widespread riverine floods and flash floods. This compounded with heavy rains and strong winds from the tropical cyclone SAGAR which made landfall in Ethiopia on 20 May 2018 (OCHA, 2018f)	313,000 people affected, of whom around 200,000 people are displaced (Earth Observatory NASA, 2018; FEWS NET, 2018a)	Mainly Somali region, but also eastern part of Oromia and south-eastern part of SNNPR (Emergency Response Coordination Centre (ERCC), 2018)
26 - 27 May 2018	Landslides triggered by heavy rains during the Belg season	23 deaths and 16 people injured in the Oromia region and 32 people killed and 23 injured in the Gamo Gofa and SNNPR (Sidama zone) regions. (GardaWorld, 2018)	Oromia and SNNPR regions (GardaWorld, 2018)

3.2.2 Fall armyworm outbreak

The impacts from the prolonged drought of 2015-16-17 were exacerbated by the fall armyworm outbreak. This pest was detected in February 2017 and quickly began spreading to several maize plantations in southern Ethiopia (Figure 9; Assefa 2018). Maize fields planted in the Belg and Meher seasons and the prevailing warm conditions resulted by the El Nino years (2015-16) and the negative Indian Ocean dipole in 2017 provided a favourable environment for the pest to multiply massively and spread to multiple areas (FAO, 2017c). In May 2017, southern regions reported between 10% and 30% of crops affected, for a total of about 53,000 hectares (ACAPS, 2018a). In June, this number doubled to 145,000 hectares of land affected (ACAPS, 2017).

FIGURE 9. Ethiopian areas hit by the spread of the fall armyworm in March 2017 (Assefa, 2018)



3.2.3 Political disruption

Ethiopia has a system of ethnic federalism, which divides the country into 11 regional states along ethnic lines (Inter-Agency Humanitarian Evaluation Steering Group, 2019). The federal government system has the original purpose to accommodate ethnic diversity. However, this also means that the system inserts an ethnic dimension to the actions of subnational governments and other local actors, which may favour the rights of the dominant ethnic group over individual rights (International Crisis Group, 2009; Taye, 2017). A case in point is the massive protest that took place from 2015 to 2016. Broken out in Oromia in November 2016 and spread to the Amhara region, the demonstrations resemble the concerns of the people of Oromia and Amhara, the country's two biggest ethnic groups (respectively 34.4% and 27% of the total population), of being excluded from the political process and economic development of the country since the Ethiopian People's Revolutionary Democratic Front took control of the government in 1991 (BBC News, 2016). In response to the wide-spread protests, the government imposed a 10-month state of emergency in October 2016 (Kishi, 2018). With the establishment of a command post, the government had the power to deploy the army nationwide, close lines of communication, restrict free speech, and make arbitrary arrests (Wight, 2020). Despite the government's heavy-handed response, protests started to arise again in late 2017, forcing the Prime Minister, Hailemariam Desalegn, to resign (Kishi, 2018). A national state of emergency was declared in Ethiopia just one day after his resignation, and in April 2018, Abiy Ahmed took office as prime minister (BBC News, 2018).

3.2.4 Ethnic conflicts

Conflict between ethnic groups has been escalating since the third quarter of 2017 in Ethiopia. Though small-scale localised displacements have always existed along regional borders, due to clashes between communities over grazing and water rights in pastoral and agro-pastoral areas, the extent and frequency of conflicts observed at the end of 2017 and 2018 were unprecedented (until the conflict in northern Ethiopia in 2020) (OCHA, 2019). Besides identity and competition for natural resources, there are other issues that trigger ethnic conflicts in the region, such as border disputes (Yishak, 2019). However, studies have often struggled in clearly identifying all the root causes for these conflicts. In the following subsections, we describe in more detail some of the main conflicts that characterized the years 2017-2018.

Oromo/Somali conflict

In September 2017, civil unrest started to escalate at the border between Oromia and Somali (ACLED, 2017a). Tensions between these two ethnic groups have been experienced over the past 25 years due to conflicts over resources, including land and water (Solomon, 2017). Since the Oromia and Somali communities living along the borders are largely pastoralist (Figure 64 and Figure 65 in Annex A) and cross borders in search for pasture for their animals, it is difficult to clearly demarcate their boundaries (BBC News, 2017).

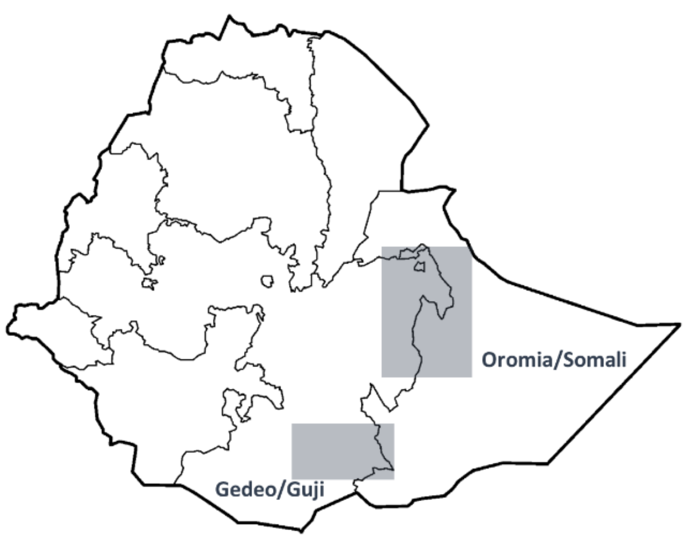
Between September 2017 and March 2018, over 790,000 people were displaced due to the conflict (World Food Program, 2018). The rapid escalation of this inter-ethnic conflict is the result of the involvement of the regional administrations and security forces of the regional states of Oromia and Somali, because of the incursion of the police into Oromia, with hundreds of Oromos killed in February and March 2017 (Hagmann & Abdi, 2020).

The conflict broke out at a time when the Somali region was experiencing severe drought conditions, while the Oromia region has seen large scale anti-government protests since November 2015, and was facing widespread river flooding in northern-central areas (VOA, 2017). The ongoing drought added further pressures on pastures and water resources, which may have contributed to increasing tensions between the two pastoral communities (DW, 2017a). In addition, the flood event exhausted the resources in the Oromia region to effectively assist persons displaced by floods and conflicts (International Federation of Red Cross and Red Crescent Societies, 2017b).

Gedeo/Guji conflict

On 13 April 2018, inter-communal violence took place along the borders of Gedeo (SNNPR) and West Guji (Oromia region) zones (Figure 10) (Yarnell, 2018). The fighting is one of several ethnic conflicts fuelled by grievances over land and water resources (Reuters, 2018). The Gedeo are primarily agriculturalists and the Guji are traditionally pastoralists. Tensions between the two groups have been centred around land, border demarcation, and ethnic minority rights (All Answers Ltd., 2018). However, as many other ethnic conflicts in the region, the exact triggers of this conflict remain unclear. A first attack in April 2018, organised by armed mobs and youth groups, forced around 300,000 people to flee their homes in Gedeo villages (IDMC, 2018). Government authorities responded with arrests and further declared the situation resolved, encouraging people to return home. A few months later, in June, violence erupted once again, displacing over 800,000 people (OCHA, 2018e; Reuters, 2018). In addition to internal displacement, the attacks have resulted in damage and loss of crops, livestock and private homes (UNHCR, 2019).

FIGURE 10. The areas affected by the Oromo-Somali (2017) and Guji-Gedeo (2018) conflicts (grey rectangles).



3.2.5 Refugee influxes

Extreme climatic events, ethnic conflicts, and government instability did not only affect Ethiopia in those years. Neighbouring countries like Somalia were struck hard by the El-Nino-induced drought of 2015-2016 as well (OXFAM, 2017), while southern Sudan faced several conflicts near the border with Ethiopia (specifically in the Maiwut, Mathiang and Pagak areas) (Ethiopia Humanitarian Fund, 2017). The events led to an increase in the refugee influxes into Ethiopia from the neighbouring countries affected by war and drought, which brought further pressure on the government system already overburdened in responding to the internal crisis (Figure 11) (World Bank, 2017). By the end of 2017, Ethiopia hosted nearly 900,000 refugees, mainly from neighbouring South Sudan, Somalia, Eritrea and Sudan (Figure 12) (UNHCR, 2018). This placed Ethiopia as the second largest host country for refugees in Africa in 2017 and 2018 (Humanitarian Information Unit, 2018).

FIGURE 11. Refugee influxes in Ethiopia (UNICEF, 2017a)

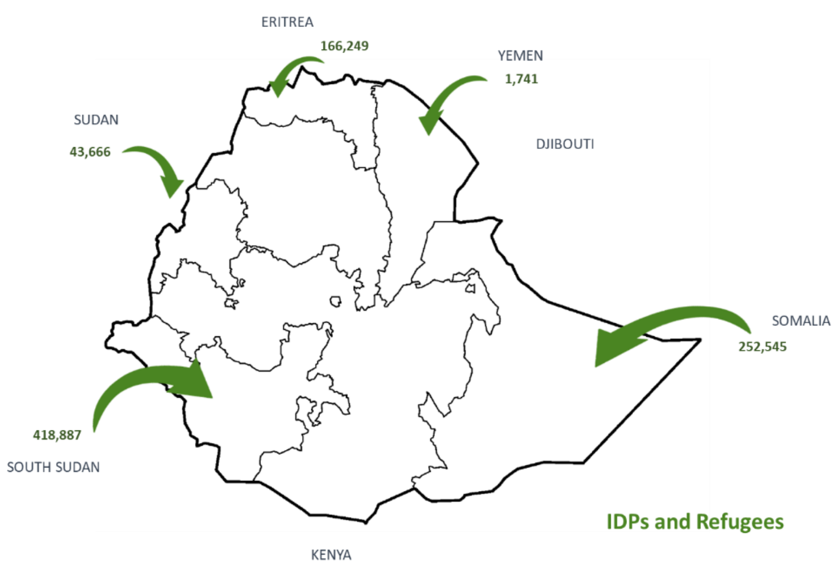
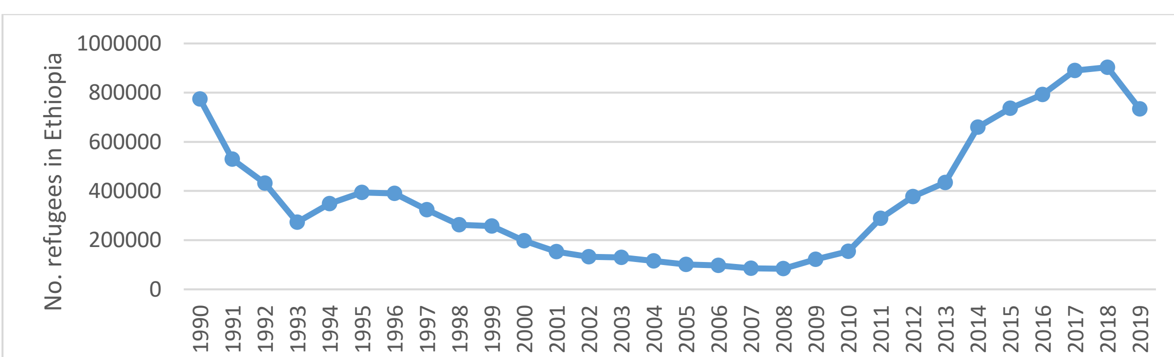


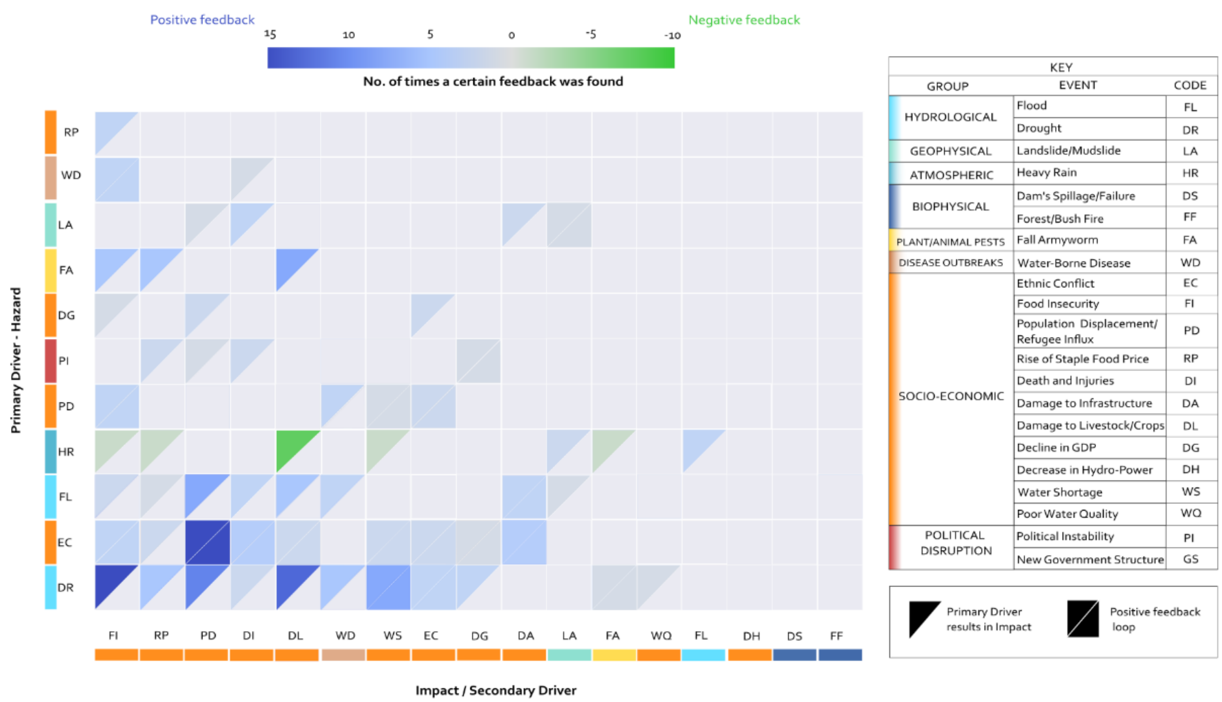
FIGURE 12. Refugee influx trend from 1990 to 2019



3.3 Literature review: interactions drivers/impact overtime

In order to identify and analyze the spatio-temporal interactions between drivers and impacts, the heatmap below (Figure 13) was developed based on the review of 100 documents comprising different reports, humanitarian bulletins, and published studies about Ethiopia's 2017-2018 crisis. The figure shows how many times a certain identified correlation between driver/impact was stated among the reviewed documents.

FIGURE 13. Heatmap of the cited correlations between Drivers and Impacts extracted from the literature review. The color increase intensity according to the frequency citation of the correlation. Positive correlations (blue) increase the impacts while negative correlations (green) decrease the impacts. Event classification modified from (Gill & Malamud, 2014)



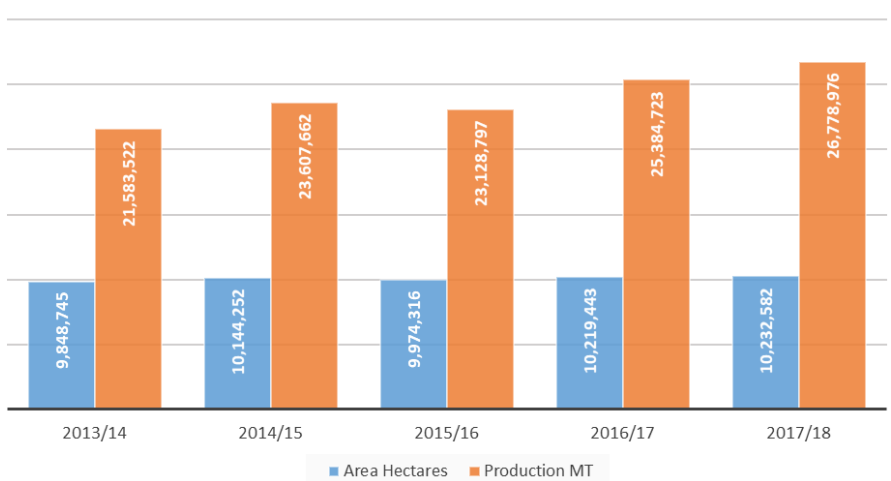
For instance, the couple *Drought* (driver) and *Food Insecurity* (impact) was the most cited correlation in the reviewed documents, together with the couple *Conflicts/Violence* (driver) and *Population Displacement* (impact). Whereas the couple *Drought* (driver) and *Crop Pests* (impact) was hardly identified (cited only one time) as well as *Crop Pests* (driver) and *Staple food prices' rise* (impact). On the other hand, *Heavy Rain* is the only driver that was identified with negative correlations with most of the investigated impacts (e.g. *Damage to livestock/crops* and *Water shortage*). However, these correlations were cited very few times in the reviewed literature. D*am spillage/failures*, *Forest/bush fires* and *Decrease in hydropower* were not cited as impacts (or secondary drivers) for the same period of analysis. Finally, given the larger number of correlations found in the literature, *Drought*, *Conflicts/Violence* and *Floods* can be identified as the main drivers of the compound events experienced in the analyzed period. On the subsequent sections, we further explore the Drivers/Impacts interrelations shown on the *heatmap*. In the last subsection, we discuss early signs of compound events and windows of opportunity for interventions based on the literature review we carried out.

3.3.1 Drought, crop pests, food prices and ethnic conflicts as drivers of food insecurity

The food security situation in Ethiopia worsened dramatically in 2017. The estimated number of people under food insecurity increased from 5.6 million in December 2016 to 8.5 million in August 2017 (World Health Organization, 2017b). According to the literature, the prolonged drought is among the main drivers of food insecurity, followed by conflicts, crop pest infestation, floods and diseases outbreak (Figure 13).

Poor rainfall over multiple seasons in late 2015–2016 and early 2017 created a knock-on effect, delaying planting and harvest cycles, and in turn reducing food production and availability (ACAPS, 2018a). Failed Belg and Kiremt rainy seasons in 2016 compounded with poor and erratic rains in 2015, resulting in losses in major crop yields (e.g. maize, wheat and sorghum) in the north-western and central regions of the country. These regions are the main agricultural production areas (Abate et al., 2015; Ofcansky & Berry, 1991), whose performance significantly affects national food production. A drop in the staple food production can indeed be noted in the national production trends (Figure 14). The late arrival of Belg rains in 2017 delayed the related harvest, which then delayed planting of the Kiremt rains for the Meher harvest. This forced the farmers to choose crops with shorter planting cycles but lower yields (UNICEF, 2017a). Overall, the favourable Kiremt rain in June-September 2017 resulted in a good Meher harvest. This is reflected in the values of national food production, which experienced an increase in 2017 reaching the highest value compared to previous years (Figure 14). However, this did not translate into a decrease in food insecurity, which instead increased to 8 million the number of people affected in comparison to 5.8 million at the end of 2016.

FIGURE 14. National crop production and hectares cultivated from 2014 to 2018 (WFP, VAM, & CSA, 2019)



With a closer look at agricultural production for individual regions, we can infer some differences in trends. For instance, the production of maize in Somali was lower in 2017 (Figure 15) compared to the previous years as a result of the poor and irregular Deyr in 2016 and Gu in 2017. However, the total crop losses did not significantly affect the national crop production in 2017, since the Somali agricultural production is only a very small fraction of it. The losses in the region did not only concern farmers, but mainly pastoralists. Between November 2016 and April 2017, more than 1.5 million head of cattle perished in southern and south-eastern areas of the country (Figure 16) (FAO, 2017a). Most of the Somali population relies on pastoral livelihood activities from which they derive their purchasing power and consequently their access to food (ACAPS, 2018a). The losses resulted in millions of smallholder farming households under food insecurity. As the drought affected areas that typically produce less cereals, there was a lower impact on national production and prices. The incidence of drought in 2017 was hence relatively local but had serious impacts on the livelihoods of smallholder farmers, making them unable to meet their food needs, even though, overall, the country was no worse off than any other years from an economic point of view. Therefore, climate extremes show to be an important driver of food insecurity in Ethiopia but mainly due to the high proportion of smallholder farmers whose livelihood depends on local rainfall. This translates in a dependence on local rainfall for both availability and access to food (Lewis, 2017). Scarcity of food was experienced not only due to lack of available products, but mainly due to lack of access and equitable distribution throughout the country.

FIGURE 15. Crop yield per region from 2014 to 2018

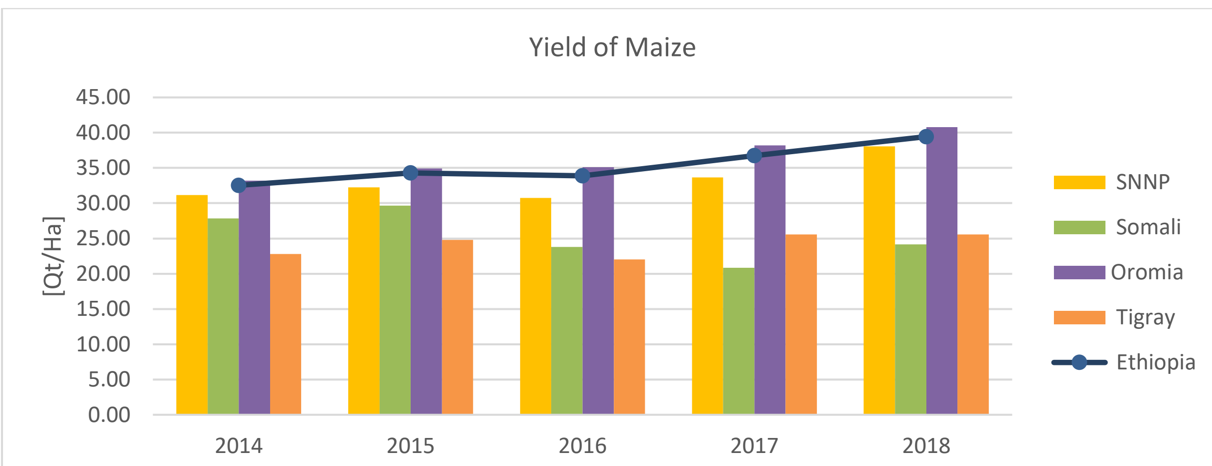
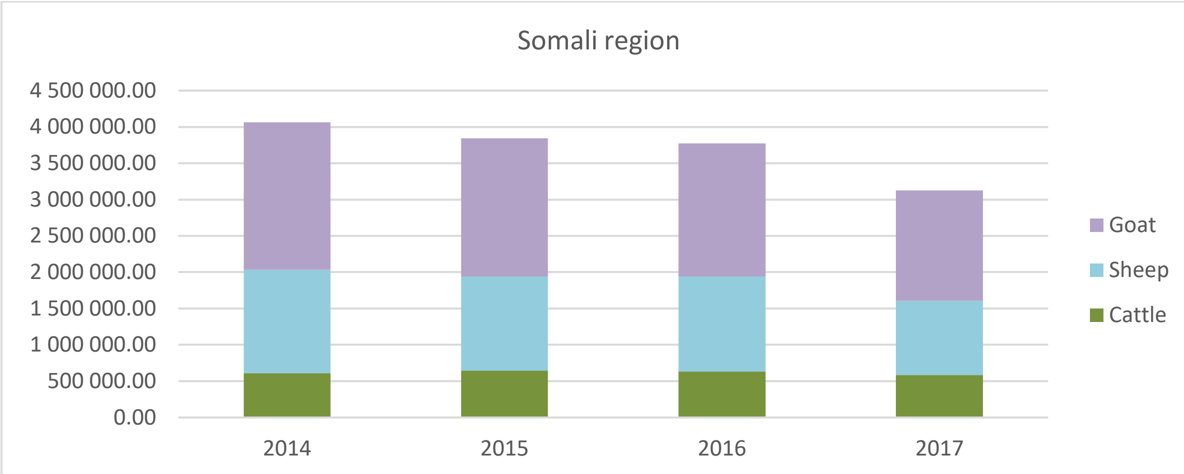
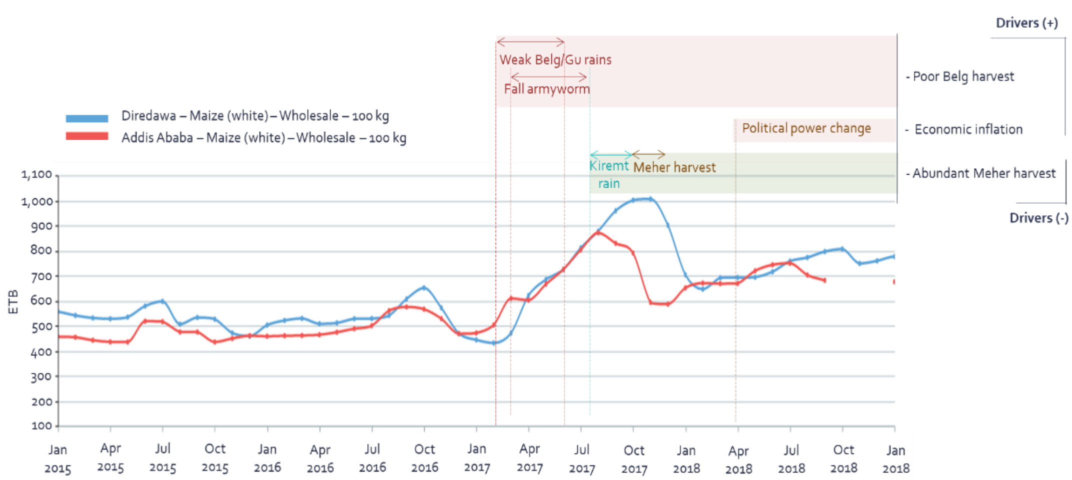


FIGURE 16. **Livestock production in the Somali region from 2014 to 2017.**



Another major driver of food insecurity were the ethnic conflicts that broke out in late 2017 and 2018. Violence at the Somali-Oromia border and in Gedeo/Guji resulted in damage to crops and homes, and limited access to cultivated fields. Disruption of livelihoods has led to the forced displacement of up to one million people (OCHA, 2018b). A series of riots and strikes disrupted the normal flow of commodities from surplus areas to deficit markets (WFP, 2018), further hindering the access of food aid to areas already experiencing food insecurity due to the drought. This reflected in a rise of staple food price in regional markets, which mainly affected city dwellers whose food insecurity is strongly correlated to volatility in food prices and market instability (ACAPS, 2018a). Staple food prices were also largely dependent on the performance of rain-fed agriculture during the Belg and Kiremt seasons. For instance, the rise in maize prices between January and September 2017 was in part driven by the poor performance of the Belg harvest and concerns over impact of fall armyworm on the main Meher harvest (Figure 17Figure 17) (FAO, 2017d). Prices began to decline in October with the start of the Meher harvest, although they remain 20-40% above their respective monthly average prices (WFP et al., 2019).

FIGURE 17. **Wholesale maize price in Diredawa (blue line) and Adis Ababa (red lines) markets (VAM Food Security Analysis - WFP, 2021b).**

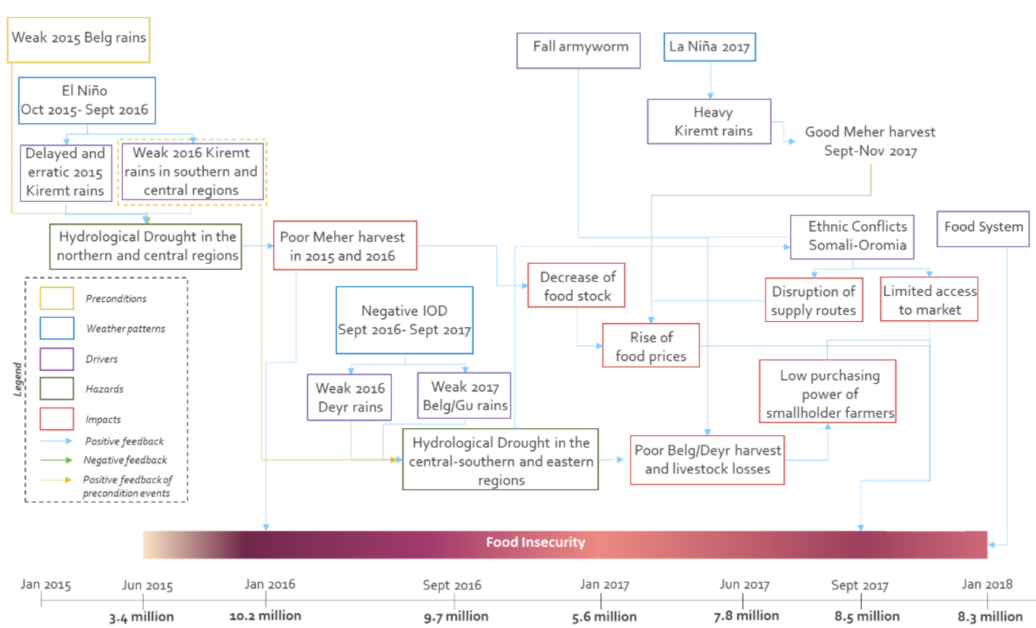


The rise of staple food prices also continued in 2018, although national agricultural production showed a full recovery at the end of 2017. Political turmoil in early 2018, the Gedeo/Guji conflict and inflation played a significant role in the food price variation. Inflation showed a remarkable increase over the end of 2017 until mid-2018, with price volatility more pronounced for food than for non-food products (WFP et al., 2019).

The main physical and societal mechanisms described in this section are summarised in Figure 18, where modulators (e.g., weather conditions), preconditions, drivers, hazards and impacts are identified. These are then presented according to the analytical framework for compound weather and climate events proposed by Zscheischler et al. 2020, which was adapted by us to include societal factors as well.

In Figure 18, we can observe that the drivers and mechanisms that led to food insecurity have changed over the time period under analysis. In that period, two peaks of food insecurity can be identified: one in January 2016 and one in September 2017 in which respectively 10.2 million and 8.5 million people suffered from food insecurity conditions. The graph shows that the first peak was mainly caused by the meteorological drought driven by El Nino, which mainly affected the central-western region (main producer of agricultural products). This was reflected in large crop losses and a slight increase in basic food prices in Ethiopian markets. The second meteorological drought was caused by the weak rains of Deyr and Belg/Gu which mainly affected the central-southern and eastern region, where most of the smallholder farmers and pastoralists live. The event caused a decrease in the purchasing power of the agro-pastoral communities living in the region. The abundant rain of Kiremt helped restore crops and pastures in the central-western regions. However, due to both local reduction in agricultural production and the Somali-Oromia conflict, local markets on the eastern side experienced a reduction in food stocks, which resulted in a sharp rise in food prices. This, coupled with the low purchasing power of smallholder farmers, led to an increase in food insecurity peaking at 8.5 million in September 2017.

FIGURE 18. Drivers of food insecurity in 2017 in Ethiopia (zoom of the upper left part of Figure 1). The color bar shows an increase in color intensity corresponding to an increase in food insecure people

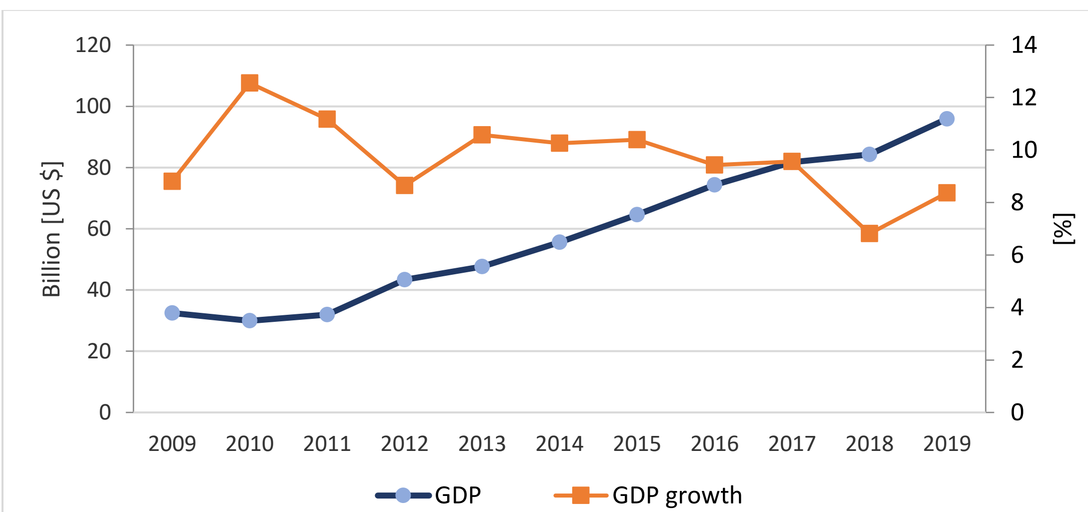


3.3.2 Economic conditions

Economic conditions can be analyzed both as drivers and impacts of the humanitarian crisis in 2017-2018. According to the literature, economic conditions worsened over the period under review due to the impact of drought on the agricultural sector, political instability, and multi-ethnic conflicts/violence in late 2017 and mid-2018. On the other hand, Ethiopia's economic downturn in 2017 and 2018 has also been seen as a driver of ethnic-based grievances and conflicts (Yusuf, 2019).

In the period of 2016-2017, total gross domestic product (GDP) of Ethiopia increased almost at the same pace as the previous years (Figure 19). Only the 2017-2018 period marked a change in slope, indicating slower growth. Looking at the percentage of GDP growth per year, an 8% decline in 2016 can be observed (Figure 19), resulted from the low performance of the agricultural sector related to the 2015-2016 El Nino period (The World Bank, 2018). Rain-fed agriculture plays a significant role in the Ethiopian economy through its high share of GDP and employment (Teshome & Lupi, 2018). Around 60% of the sector output is derived from crop production, 27% from livestock and 13% from other areas of agricultural production (VAM Food Security Analysis - WFP, 2021a). With agricultural recovery, GDP growth rebounded in the financial year of 2017 (VAM Food Security Analysis - WFP, 2021a). In 2018, Ethiopia's economic growth again fell to around 7% due to the reduction in public spending to address the growing current account deficit and indebtedness (IMF News, 2018). In particular, in the last quarter of 2017 and in the first half of 2018, inflation rose to double-digit levels compared to previous years, after the currency devaluation by 15% in October 2017 (VAM Food Security Analysis - WFP, 2021a).

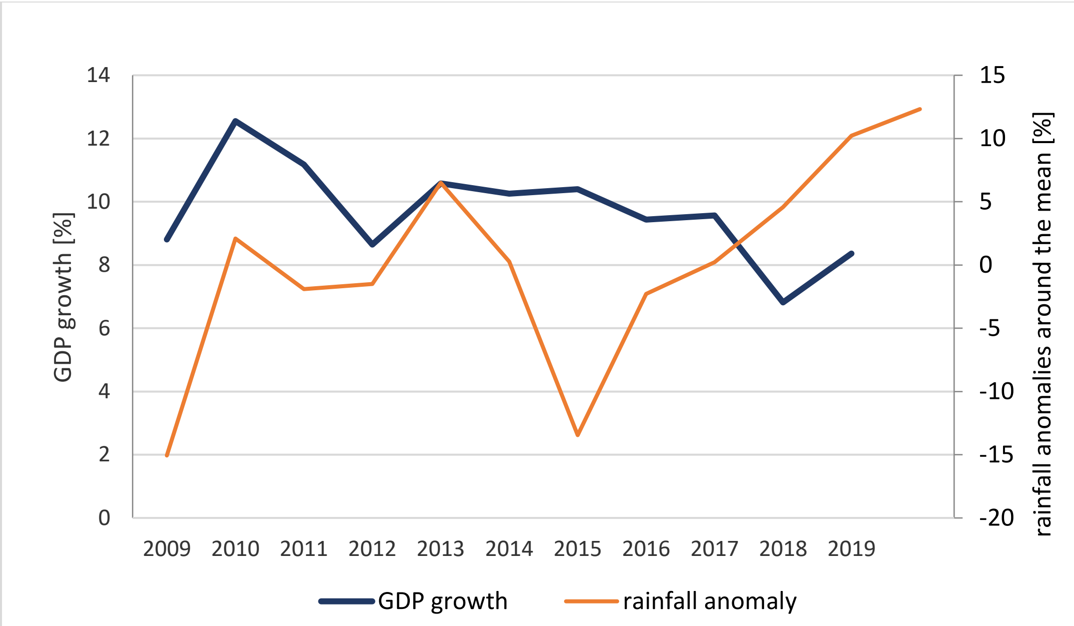
FIGURE 19. GDP and GDP growth for Ethiopia from 2009 to 2019 (World Bank)



As shown in the country profile, the Ethiopian economy is heavily dependent on agricultural production, which in turn depends on rainfall patterns. However, in the analyzed period, declining GDP due to poor agricultural sector performance could only be observed in 2016. Instead, the impacts of drought suffered by the eastern and south-eastern regions during 2017 are not well reflected in the GDP trend, even if these events have led to a substantial impoverishment of the population. Even though the country's economy is highly dependent on climate fluctuations, GDP growth and rainfall trends do not show a strong correlation on an annual and national scale (Figure 20). This can be explained by the heterogeneous

Ethiopian climate whose anomalies are not well captured in the national rainfall patterns. However, it can also be explained by the large percentage of smallholder farmers and pastoralists, who do not make a significant contribution to the national GDP, but their livelihood depends significantly on the performance of the rainy season.

FIGURE 20. GDP growth and rainfall anomaly around the mean



3.3.3 Conflicts and violence as driver and impact of socio-economic conditions

In the heatmap (Figure 13), social conflicts appear both as a driver and an impact. According to the literature, conflicts are a major driver of food insecurity, population displacement, rising of staple food prices, damage to livestock/crops and infrastructure, epidemics, water shortages and deaths in the 2017-2018 humanitarian crisis. The impacts listed are not independent of each other as some of them are the result of a ripple effect. Conflicts are also identified as impacts of drought, poor economic conditions and displacement.

By analysing the interplay between climatic extremes and conflicts, their mutual and reinforcing impacts on the humanitarian crisis of 2017-2018 becomes clear. The drought period from 2015 to 2017 led to competition for scarce resources among communities, exacerbating existing tensions along ethnic lines and encouraging migration, which in turn affected the ethnic demographic balance of some regions (e.g., Somali-Oromia) (International Federation of Red Cross and Red Crescent Societies, 2017c; Yishak, 2019).

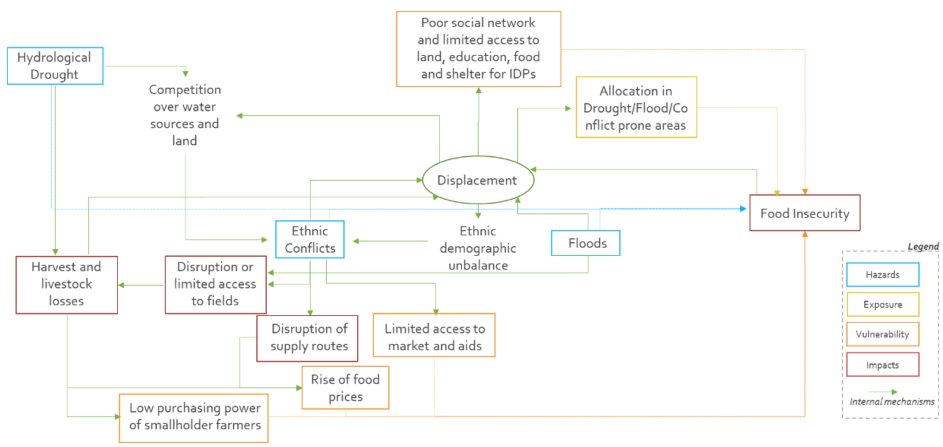
On the other hand, conflict among communities in Oromia, SNNPR and Somali regions exacerbated the impacts of drought by limiting households' access to agriculture and pastoral livelihoods either through direct threat of violence, or destruction of crop fields (FEWS NET, 2019). Conflicts were also major drivers of forced displacement increasing the vulnerability of people to cope with climate extremes, as explored in detail on the next subsection. The upsurge of displaced people in host communities often resulted in increased competition over land and water resources.

3.3.4 Displacement

In Ethiopia, a strong link between conflicts, extreme weather events and displacements could be observed, as highlighted by the events that characterized the years 2017-2018. As of September 2017, 1.3 million people were displaced due to conflicts and drought (UNICEF, 2018a). Most were displaced in the Somali region, which was home to over 700,000 internally displaced people (IDPs) (IOM, 2021). In mid-2018, the number soared, with 2.6 million people internally displaced due to conflict, drought and floods, mainly along the borders between Oromia and Somali and SNNP regions. This number was recorded as the third-highest number of displaced people in the world (IDMC, 2019).

A graphic summary of the interlinkage between *Displacement* and *Drought*/*Floods*/*Conflicts* is shown in Figure 21. In the graph, the events are differentiated into hazard, exposure, vulnerability and impacts. The mechanisms that take place between them are described in detail in the following paragraphs.

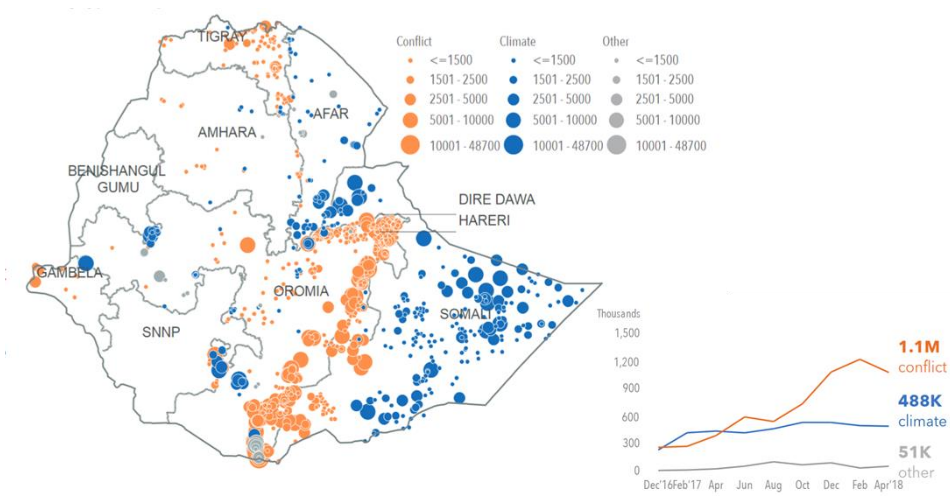
FIGURE 21. Interlinks between Drought, Floods and Conflicts through Displacement in 2017-18 in Ethiopia (all arrows show positive mechanisms)



Displacement as impact of conflicts

According to the International Organization for Migration (IOM), a significant portion of people displacements are conflict-induced (Figure 22), largely related to ethnic and border-disputes. The violence that arose on the border with the Oromia-Somali regions led to a wave of displacement, which reached its peak in late 2017, with some 700,000 people displaced (OCHA, 2018b). But higher figures were reached with the Gedeo and Guji conflict, where nearly 900,000 people were displaced in less than 2 months (OCHA, 2018e). On the top of the landscape of Ethiopia's high mobility characteristic, the additional number and rate of forced repatriations also contributed to a further increase in the number of people affected by second displacement due to new conflicts in the area of returnees (Yarnell, 2018).

FIGURE 22. IDPs by type of displacement as of mid-April 2018 (OCHA, 2018d)



Displacement as impact of flood and drought

A large part of the displacement was also induced by the impacts of extreme weather conditions. The prolonged drought caused by the 2015-2016 El-Niño event and the subsequent 2016-2017 IOD weather condition had severe consequences in the southern and south-eastern parts of the country, particularly for agricultural and pastoral communities. The disruption of livelihoods caused by the weak harvest and the reduction of grazing for livestock have led many to migrate in search of better pasture, or in search of aid to rebuild their livelihoods. According to Ethiopia's National Disaster Risk Management Commission (NDRMC), at least 1 million people have been displaced by the drought (International Federation of Red Cross and Red Crescent Societies, 2017c; Maru, 2017).

However, while some areas experienced low rainfall, others received a surplus of rain in the form of heavy rain events during the 2017 Kiremt rainy season and the 2018 Belg season resulting in riverine and flash floods. These events displaced 100,000 people in September 2017 and 170,000 displaced in April 2018, mainly in the Somali, Oromia and SNNPR regions (Earth Observatory NASA, 2018; Ethiopia Humanitarian Fund, 2017).

Displacement exacerbated conflicts

According to Ethiopia's NDRMC the wave of displacement caused by drought worsened conflicts in Oromia and Somali regions due to competition of pastoral communities over grazing land and water wells (International Federation of Red Cross and Red Crescent Societies, 2017c). Pastoralist in Ethiopia are subjected to frequent seasonal migration in order to guarantee adequate pasture and water to their grazing. However, the experienced drought in 2017 increased pastoralist movement especially in the Somali region, leading to conflicts over land incursions, competition on access to water and other resources (Maru, 2017).

Internal displacement crises also increased tensions between IDPs and host communities due to a limited availability of resources (OCHA, 2018a). For instance, the nearly one million people displaced due to the conflict in Gedeo and West Guji, sheltered in already overcrowded areas increasing competition for scarce resource (IDMC, 2018).

Furthermore, internal displacement can affect the demographic balance and consequently the power relations between ethnic communities, which is seen as a threat to the right of lands in an ethnic federalism. As shown in Section 3.2.3, Ethiopia is organised according to ethnic federalism, where power is shared in direct proportion to the size of the ethno-cultural populations in each individual regional state. Therefore, in ethnic federalism, migration (forced or spontaneous) could result in reversals of power in ethnic state-state and state-federal relationships (Maru, 2017).

Internal displacement increased vulnerability and exposure to people to weather extremes

According to NDRMC estimates, some 857,000 conflict-displaced persons settled in areas experiencing already ongoing drought-related humanitarian need (sites across Oromia, Somali and Harar regions) (Figure 23) (Ethiopia Humanitarian Fund, 2017; UNICEF, 2018b). The same occurred to people displaced by conflicts and droughts, who were then allocated to areas that subsequently suffered floods (Figure 24) (Hajžmanová, 2018). Moreover, drought and floods have had a major impact on the livelihoods of IDPs, given their scarce economic resources, poor social network and limited access to land, education, food and shelter (Yigzaw & Abitew, 2019).

FIGURE 23. **Conflict-induced IDPs location (Displacement Tracking Matrix – IOM) and areas affected by food insecurity (FEWS, Dec 2017)**

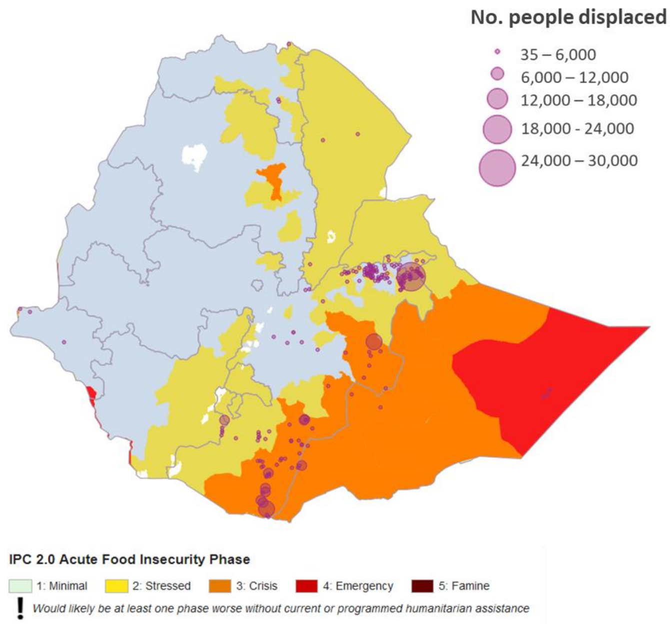
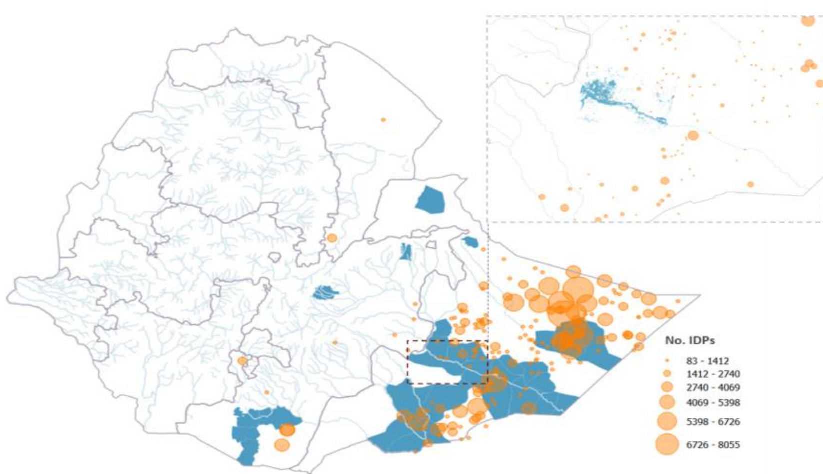


FIGURE 24. **Drought-induced IDPs & areas affected by floods (blue areas) in April/May 2018 (Sentinel 1)**



3.3.5 Disease outbreaks

Several outbreaks of acute watery diarrhoea (AWD) occurred in drought- and flood-affected areas in 2017-2018 (Medicins Sans Frontieres, 2017). This was mainly due to inadequate water supply, poor water quality and lack of hand washing facilities, water shortages, and aggravated by disruption of infrastructure and contaminated water sources due to the flood event (WHO, 2017b). A peak of number of AWD cases was reported in the Ethiopia Somali region in March 2017, with over 60 cases registered in one week (WHO, 2017a). AWD coupled with malnutrition posed the Somali population at high risk of morbidity and mortality (OCHA, 2017f). The overcrowded living conditions at the IDPs sites have favoured the spread of diseases (OCHA, 2018e).

3.3.6 National and international response

National and international responses to the events aforementioned have been essential to prevent a longer and severe food insecurity in the country. However, more timely actions could have significantly improved the efficiency of the measures taken. On the other hand, many interventions led to mechanisms that further exacerbated food insecurity in the country. In the sections below, we will explore some of the measures adopted by the National agencies and International community, and their impact on food insecurity.

Drought warnings and response

Concerning the 2015-2016 drought, public warnings of a potential food crisis in southern Afar and northwestern Somalia were issued in May 2015, due to below-average Belg rain (February-May 2015; FEWS NET, 2015a). The warnings were followed by a declaration in June 2015 of failed Belg rains from the Ethiopia's National Meteorological Agency (Jjemba, Singh, & Arrighi, 2016). In December 2015, the Famine Early Warning System (FEWS) reported a major food security emergency in central and eastern Ethiopia, which was expected to continue through much of 2016 (FEWS NET, 2015b).

Despite these forecasts, there was a delay on the part of the government in acknowledging the emergency, especially to the international community. The government was accused of downplaying the severity of the crisis with the aim of protecting the narrative of Ethiopia's remarkable economic rise over the last decade (Jeffrey, 2017). Further, the occurrence of national election in May 2015 may also have hampered early recognition of the crisis (Grunewald et al., 2019). The government and humanitarian agencies' drought response has been reported as being better organized and coordinated than the 2011-2012 drought crisis (Grunewald et al., 2019; Mera, 2018). However, responses followed a reactive approach, with a predominant focus on providing emergency food assistance (Mera, 2018). Furthermore, unbiased distribution of aid among drought-affected communities was challenged by protests and widespread violence in 2016 with the risk of aid being used to favour one community or sector over others (Desportes, Mandefro, & Hilhorst, 2019).

Concerning the 2016-2017 drought, warnings of a scatter Belg/Gu rain season and erratic Deyr rains in 2017 were issued already some months before the respective rainy seasons by regional forecast, highlighting possible impacts on the eastern regions (World Meteorological Organization, 2017). Also, the Famine Early Warning System (FEWS) issued an alarm in early 2017, marking the transition from a stressful situation to a crisis situation in the western areas (Figure 25) (FEWS NET, 2017c). In the analysis, FEWS took into consideration the compound effect of the forecasted dry spells with the already low soil moisture in the eastern regions caused by the Deyr's poor rainy season of 2016 (FEWS NET, 2017b). The transition from a crisis situation to an emergency situation was reported by FEWS in May 2017 with food security forecasts from June to September 2017 (Figure 26) (FEWS NET, 2017d). Government appeal to international aid timely occurred in January 2017. However, the Oromio-Somali conflict and the Gedeo/Guji conflict hindered effective drought response, limiting access to drought-stricken communities (Yishak, 2019). Further, the 2017 crisis closely followed the humanitarian crisis that affected the northern and eastern regions of Ethiopia in 2015-2016. It was hence hard for the international communities to issue another humanitarian appeal and find available budget after the aid provided in 2015-2016 (FEWS NET, 2017d; Grunewald et al., 2019).

FIGURE 25. Food insecurity situation in Dec 2016-Jan 2017 and forecast for Feb-May 2017 (FEWS NET, 2017c)

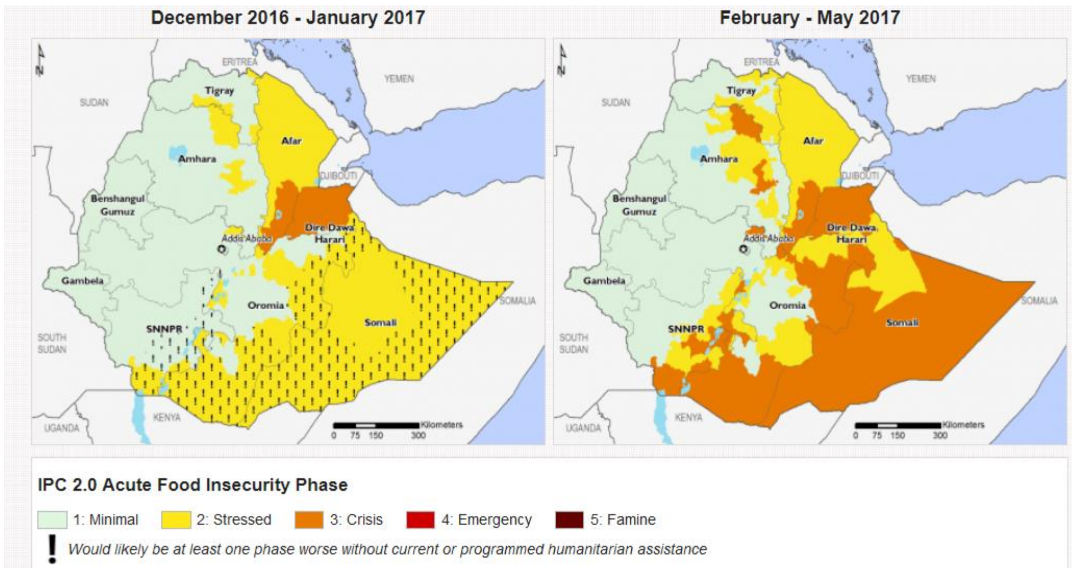
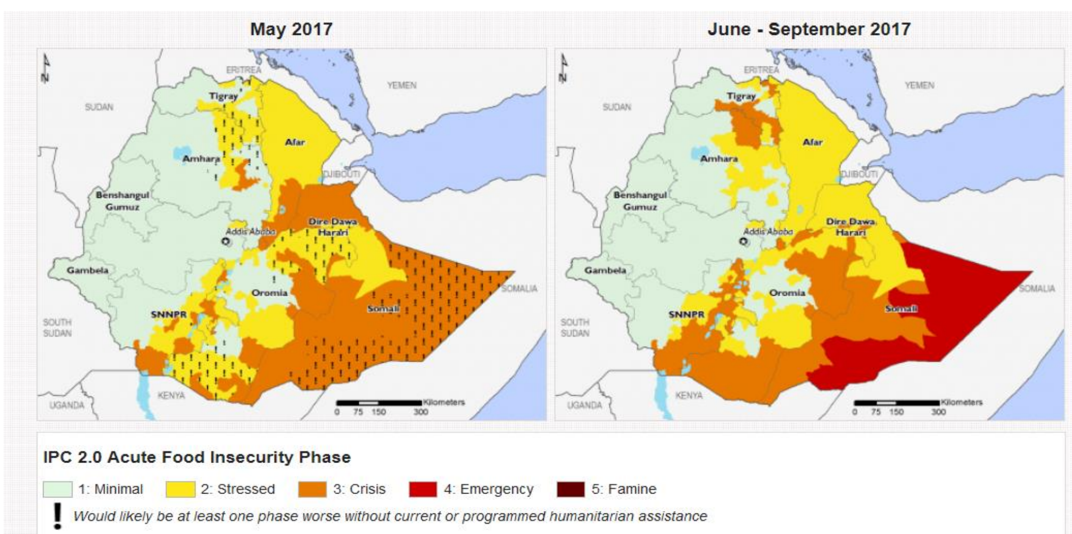


FIGURE 26. Food insecurity situation in May 2017 and forecast for June-Sept. 2017 (FEWS NET, 2017d)



Response to conflict and displacement

In response to the conflicts and the resulting displacement, the Ethiopian government put in place a series of political and humanitarian measures, favouring the following options: (1) voluntary return to areas of origin and (2) voluntary resettlement and integration with host communities (OCHA, 2018b). However, government agencies mainly encouraged the former option, fearing that tensions could arise between IDPs and host communities. This resulted in limiting aid in displaced areas, with a promise to provide assistance only after the IDPs returned home (Yarnell, 2018). The government's pressure for an early return slowed possible aid, which had to be relocated to where people were returning. It also placed those people at risk of violence and hence, second displacements as conflicts did not stop (Yarnell, 2018).

Impacts of simultaneous drought and conflict on the response

The simultaneous and consecutive occurrence of extreme weather conditions and conflicts largely undermined the effectiveness of the humanitarian response. The outbreak of conflicts in drought-stricken areas led to access restrictions for humanitarian aid that provides food to drought-affected communities and disruption of supply routes (OCHA, 2018b). Alike, the floods limited access of aid to communities affected by drought and conflict. Furthermore, the concomitant events in different parts of the country led to overstretched national resources. For example, the flood event of September 2017 occurred simultaneously with the outbreak of the conflict at the Oromo-Somali border. Although the events took place in two different areas of the Oromo region, their contemporaneity overstretched the regional and national capacity in being able to effectively respond to both disasters (International Federation of Red Cross and Red Crescent Societies, 2017b).

Flood warnings and response

The first flood alert was issued by the NDRMC in April 2018 based on the mid-season forecast for the Belg/Gu/Ganna season (April to May 2018), which was provided by the National Meteorological Agency (NMA) (Federal Democratic Republic of Ethiopia [FDRE], 2018). The flood alert was subsequently updated in May given the geographic shifts of the rain from the southeaster parts of the country to the western central regions. Despite timely forecasts, many people were affected, mainly in rural areas and especially in the Somali regions. The high number of people affected was not only due to the exceptional flood event, but also because pastoralists had moved to near water sources in search of water and pasture during the dry period, which increased their exposure to this hazard. At the same time, conflict-affected people were displaced to lowland areas prone to flood.

3.3.7 The impacts of heavy rain in 2018

In Section 3.2.1, we have extensively discussed the negative effects of heavy rains in April/May 2018. However, the surplus of rainfall also had positive effects on the country. First, it led to the replenishment of surface water and groundwater sources (OCHA, 2018f), allowing for a complete recovery in the Somali and south-eastern regions from previous drought conditions. Second, heavy rains played an important role in reducing the spread of the fall armyworm by washing off the eggs from the leaves and lowering temperatures to levels unfavourable for this pest to spread. Third, it increases hydroelectric production in the Oromia region These positive effects have contributed to reduce the number of people affected by food insecurity but did not have significant reflections on the national economy, which was still recording a substantial decline in 2018 and 2019.

3.4 Literature review: early signs and windows of opportunity for interventions

Looking at the chronology of the impacts described above, we can see that the compound events that characterized the humanitarian crisis in 2017 and 2018 in Ethiopia affected different sectors at different times. Likewise, different drivers take on a certain relevance at different times. This implies that by monitoring the main drivers, early actions could have been implemented to target specific sectors in different time windows. For example, looking only at the period between late 2016 and early 2018, with indications of a Kiremt dry season in 2016, early actions could have been already taken in all socio-economic sectors in the northern and central regions. These regions, in fact, already presented high vulnerability to drought conditions due to the previous weak rainy seasons. Early actions could have included: the rehabilitation of strategic wells, cash transfer, and the promotion of drought-tolerant crops. Given the large presence of water reservoirs in the area, actions aimed at raising awareness of water-saving could also have been implemented.

The situation was different in the eastern regions, where vulnerability to shocks is generally high given the types of livelihood (smallholder farmers and pastoralists) and the arid/semi-arid ecosystem. With the indication of low Deyr rainfall in 2016, early actions could have been taken to target water and pasture conservation, as well as using drought-tolerant crops. However, with indications of a second dry season (Belg/Gu rains), early actions could have been scaled up to all sectors. These actions could have focused on maintaining strategic water points used by large numbers of people and livestock during dry seasons, and also on planning pastoral migration patterns to avoid possible conflicts. When the impacts of the poor Belg and Gu rain were evident, early action could have been taken in favour of direct market interventions (to reduce the price of staple food prices) and cash transfer in the eastern and southern regions.

Finally, with the forecast of another unfavourable Deyr season in early September 2017 and the increase in food insecurity in the eastern regions, early actions could have aimed at feeding livestock, their vaccinations and, once again, cash transfers. The increase in political tensions between the border with Somalia and Oromia should also have given the first signs of possible conflicts. The establishment of community assemblies to providing effective information on climatic conditions could also have stimulated discussion for a peaceful resolution of the ethnic tensions. Besides the climate forecast and the number of violence and clashes, other socio-economic indicators could have provided early signs of the compound crisis such as the number of IDPs and staple food prices.

3.5 Survey results

This section summarises the key outcomes of the online survey undertaken by 16 respondents (refer to Section 2.3 for the methodology). It investigates the main drivers/impacts of the 2017-2018 humanitarian crisis in Ethiopia and the compound mechanisms that developed. The majority of respondents work at the national and regional state level and have a varied background predominantly in science and research, followed by technology and engineering.

3.5.1 Impacts experienced in 2017-2018

According to the survey respondents, the Ethiopian population experienced a larger variety of impacts in 2017 respect to 2018 (10 impacts selected by more than 8 people in 2017 compared to 3 selected by more than 8 people in 2018). The impacts experienced in 2017 were mainly in the categories of ‘socio-economic impacts' and 'damage to natural systems'. Specifically, the most selected impacts were: 'displacement of the population' (13/16), 'food insecurity' and 'increase in social conflicts' (12 each).

For the period from January to June 2018, respondents mainly identified the impacts of the categories: 'damage to infrastructure', 'socio-economic damage', and 'damage to natural systems'. In particular, most of the respondents selected: damage to homes and buildings (10/16), population displacement and food insecurity (9/16). Comparing the impacts selected in 2017 and 2018, we can see that: (1) the decrease in hydroelectric power generation was slightly perceived by more respondents in 2017 (4/16) than in 2018 (2/16) but in both cases the number of respondents who selected this impact was low; (2) food insecurity, population displacement and increasing social conflicts both in 2017 and 2018 by almost the same number of respondents (12-10); (3) all the impacts contained in the 'damage to infrastructure' category were more often selected in 2018 than 2017. Finally, when respondents were asked to identify the four main impacts among those selected in the previous section and rank them on a scale from one to four in order of importance, food insecurity scored higher, followed by displacement of the population, increase of social conflicts, and increase of staple food prices (Figure 28)

FIGURE 27. Impacts experienced in Ethiopia in Jan-Dec 2017 and in Jan-Jun 2018, according to the survey respondents. At the bottom, a timeline of the main events reviewed by the respondents

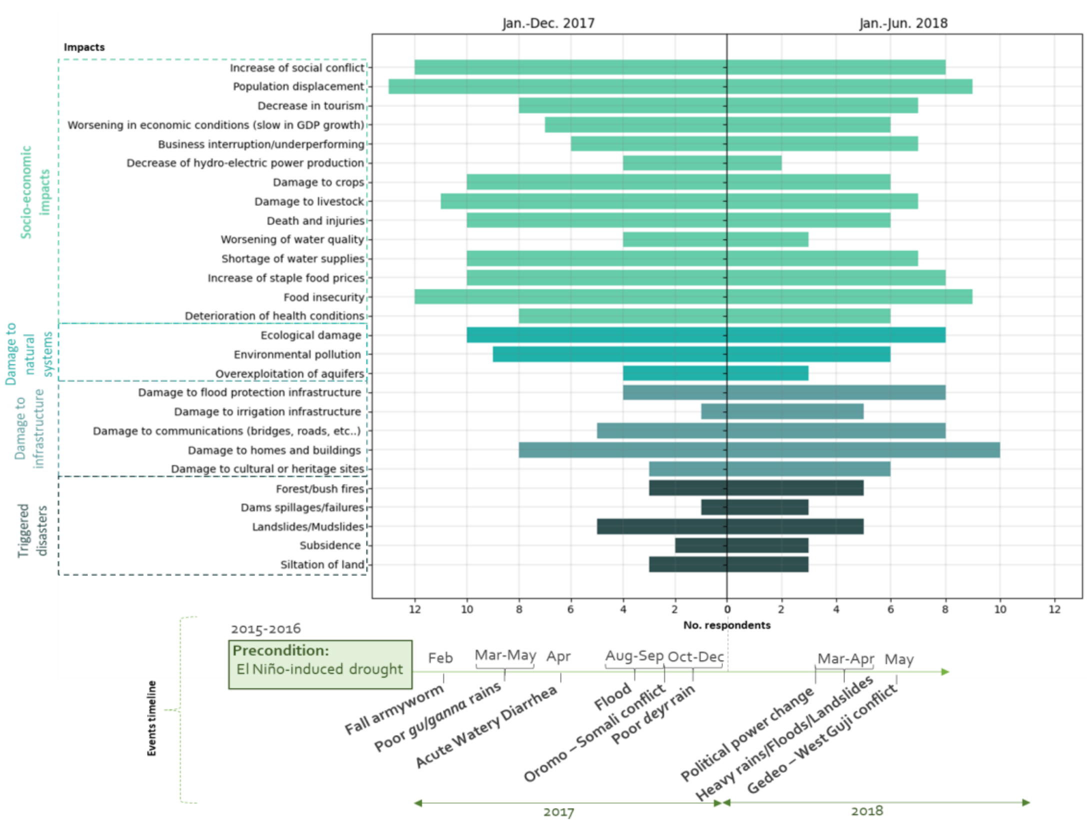
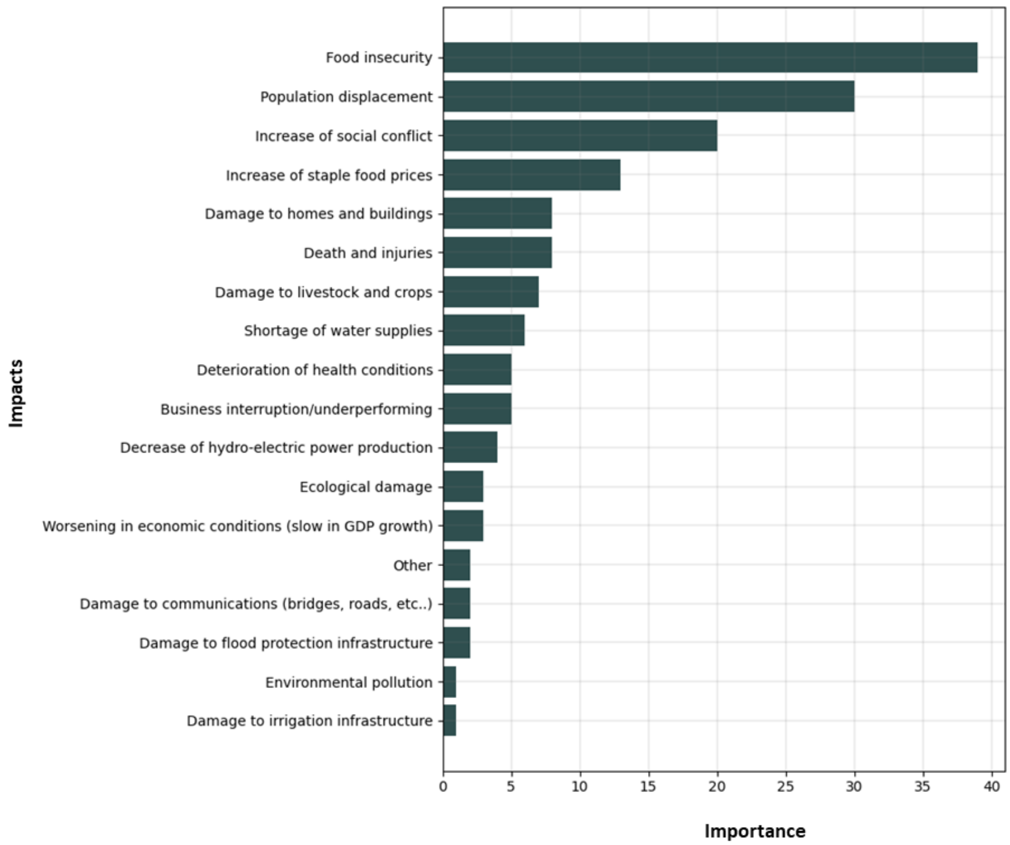


FIGURE 28. **Major impacts experienced in Ethiopia in 2017-2018 according to the respondents**[3]

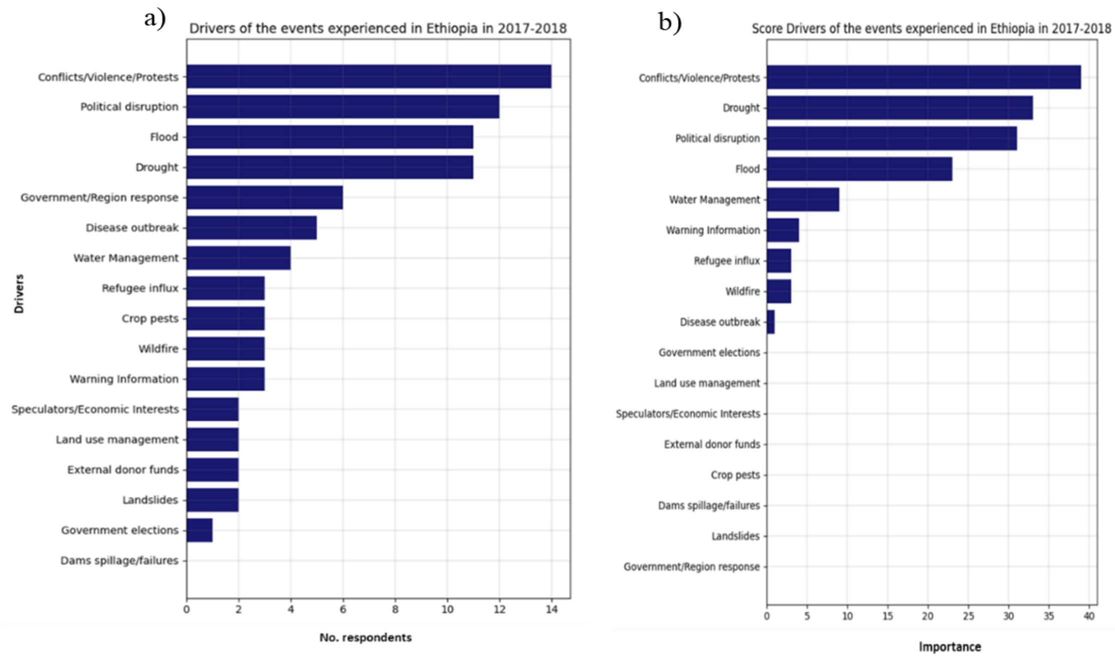


3.5.2 Drivers of the impacts experienced in 2017-2018

In order to explore the potential drivers of compound risks over the analyzed period, we asked respondents to identify the main drivers that led to the previously selected impacts. We then asked to identify four main drivers among the selected ones and to rank them from zero to five based on their influence on the impacts. The drivers selected by the majority of respondents were: conflicts/violence/protests (14/16), political unrest (12/16), floods and droughts (11 each/16) (Figure 29a). For the identification of the main drivers, there was broad agreement on conflicts/violence/protests, droughts, political disruptions and floods (Figure 29b).

[3] The level of importance was obtained by assigning a score of four to the impacts classified at the first level, a score of three for the second level, two for the third level and one for the fourth level. After that the scores obtained for each impact have been added up, so as to obtain a level of importance.

FIGURE 29. **a) Drivers of the impacts experienced in Ethiopia in 2017-2018, and b) their score, according to the survey respondents**

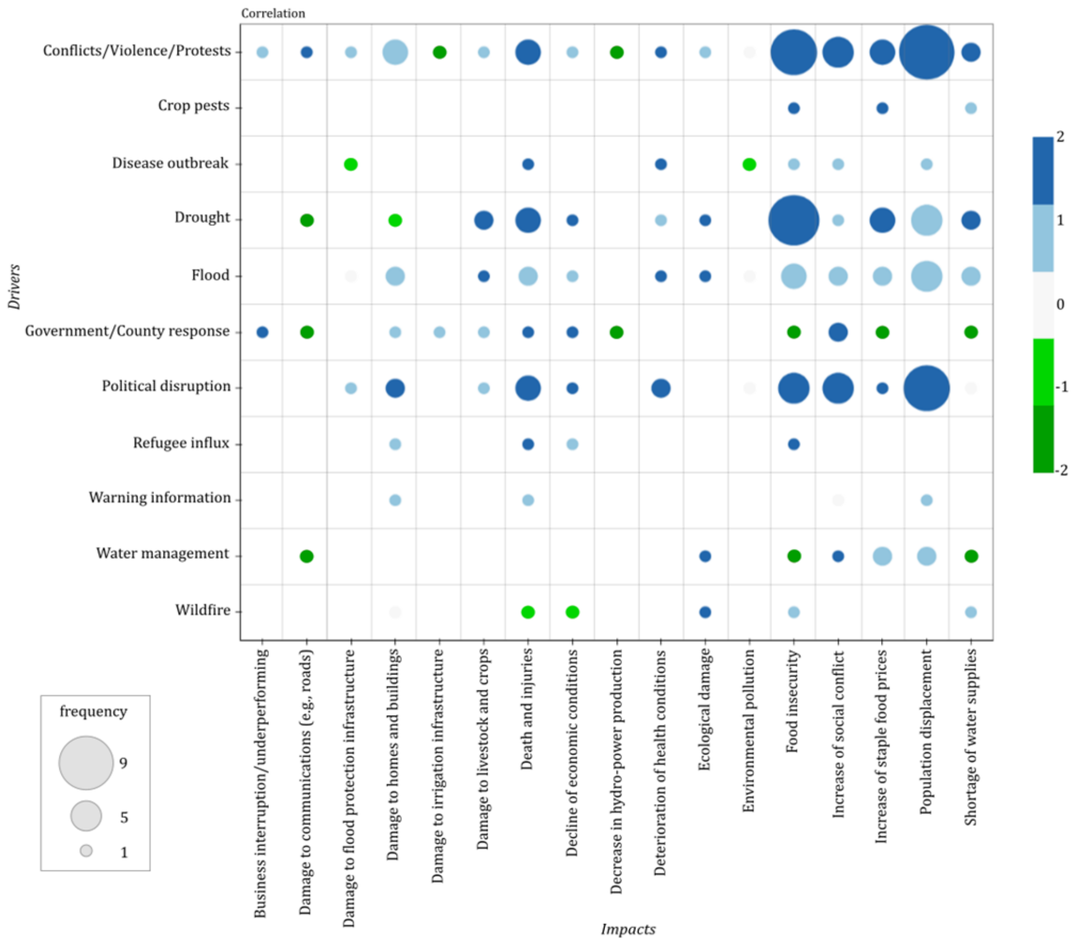


3.5.3 Interactions drivers/impacts

Finally, we asked the respondents to indicate in a matrix whether the main drivers selected had amplified or reduced the major impacts they experienced, in order to understand the interaction between drivers and impacts. The results are summarised in the heatmap in Figure 30.

According to the heatmap, food insecurity has been largely amplified by droughts, crop pests, refugee inflows, conflicts, and political disruption. Food insecurity was instead only slightly amplified by disease outbreak, wildfire and floods. In specific, floods were mainly associated with the impacts of deteriorating health conditions, damage to livestock and crops, and ecological damage.

FIGURE 30. **Heatmap of the correlations between Drivers and Impacts in Ethiopia in 2017-2018, made by the respondents. The color increases according to correlation intensity. Blue indicates a positive correlation, while red colors represent a negative correlation. Legend: +1 (slightly amplified), + 2 (largely amplified), -1 (slightly reduced), -2 (largely reduced)**



Water management was perceived by one respondent as having largely reduced the experienced food insecurity, water scarcity and damage to communication (e.g., bridges, roads). While the lack or ineffectiveness of warning information and the political disruptions were reported instead as amplifying factors of the impacts experienced. In particular, respondents related political disruption with the deterioration of health conditions, food insecurity, damage to homes and buildings, deaths and injuries, decline in economic conditions, displacement of the population and social conflicts. The latter, apart from the political disruption, were caused also by conflicts/violence/protests. Finally, the main drivers related to multiple impacts are conflicts, political disruption, droughts and floods. In detail, looking at the number of impacts amplified by each of these factors, we have that the conflicts and political disruptions were correlated with the amplification of eight impacts each, while drought was correlated with the amplification of seven impacts and floods only three.

3.6 Semi-structured interviews

The evolution of compound events in Ethiopia during 2017-2018 was further studied through semi-structured interviews addressing four main topics: 1) driver/impact mechanisms of the 2017-2018 humanitarian crisis; (2) DRR/DRM policies and response; (3) windows of opportunity for proactive interventions, and finally (4) early warning signs of compound risks in Ethiopia. In the following sessions, we summarised the respondents' answers on each topic.

3.6.1 Drivers/impacts mechanisms

According to the interviewees, the humanitarian crisis experienced in 2017-2018 was the result of cascading disasters, mainly triggered by droughts and floods. The interviewees often mentioned drought as the main event that affected Ethiopia in the analyzed period, both in terms of magnitude and extension of the impacts experienced. This can be explained by the great dependence of the agricultural sectors on the performance of the rainy seasons. In specific, the agriculture sector constitutes both a large portion of GDP and represents the main economic activity for many families. Given the high socio-economic vulnerability to drought, according to the respondents, these drought events have led to other disasters through a ripple effect: such as disease outbreaks (due to poor sanitation resulting from scarce water sources or the proliferation of malaria for the favourable climate), small ethnic conflicts (due to competition for resources) and crop pests (favoured by the dry weather).

“Once droughts and floods occur, the other conditions are secondary.
Once we deal with droughts and floods, we can prevent other secondary events from occurring.”
(climate & disaster risk management experts)

The fact that droughts and floods occurred simultaneously in two different locations or one after the other in the same location in the years 2017-2018 is not a unique case. Ethiopia often experiences compound drought-flood events (both simultaneous and consecutive) given its very diverse climate across the country and alternating rainy seasons. For the same reason, Ethiopia has a very diverse land cover and therefore, different regions are also affected differently by hazards (different areas experience different types of hazards and impacts). An increase in rainfall in the western part of the country has no significant impact as the areas have dense vegetation cover. However, in the eastern part of Ethiopia, only a small amount of rain can lead to floods as the soil is bare and dry. Therefore, it is very important to be area-specific when talking about certain climatic conditions (e.g., El Nino) as they may result in different events depending on the area concerned.

Among the primary drivers of impacts in 2017 and 2018, the relevance of conflicts and political disruption in the escalation of the impacts was only mentioned by one of the four interviewees. The other respondents did not want to address this topic specifically, mentioning ‘ethnic conflicts’ only a few times when talking about the impacts of climate variabilities and related water resource competition.

The incidence of fall armyworm was considered to be underestimated by the government according to the respondents. The parasites first spread to Ethiopia in March 2017. Given the fact that was the first time that this event occurred in the country, it was very difficult to predict their impact and identify effective response actions.

"During 2017 and 2018, fall armyworm was a very serious case...
It was a very new event for us and very difficult to handle."
(disaster risk management expert)

The main difficulty was also the identification of interventions that would not give rise to negative effects (e.g., identification of pesticides not dangerous for plants, animals or groundwater).

Finally, respondents cited both the negative and positive effect of heavy rains, mentioning both the impacts of flooding on crops and pastures and the replenishment of water sources, and related increase in hydropower production, especially in the central-western regions. These areas can largely benefit from the heavy rains thanks to the dense vegetation cover, which reduce possible soil erosion and floods in contrast with the bare soil in the Somali region that is usually disproportionately affected by the heavy rains.

3.6.2 Coping mechanisms

Coping mechanisms to shocks can vary from place to place in Ethiopia. In conflict-prone areas, communities often hold peace conferences, where elders and religious leaders are invited and lead the discussion on issues and on mechanisms that need to be promoted to prevent future conflicts. In flood-prone areas, farmers are engaged in activities such as building canals, terraces and other environmental protections to divert floods. These mechanisms are not always effective, especially when recurring droughts, floods and conflicts occur.

Additionally, some people may adopt coping mechanisms that may actually exacerbate impacts, promoting, for example, the spread of diseases or instigating ethnic conflicts. The latter occurs mainly in areas where pastoralist livelihoods prevail and is mainly the result of competition for natural resources between migrated pastoralists in search of water and grazing and host communities.

Regarding drought events, if communities are informed in a timely manner of an impending dry spell, the communities contribute financially as a group to the construction of ponds. Another activity is to destock before the forecasted poor rainy season.

3.6.3 Response/DRR policies and coping mechanisms for the 2017-18 humanitarian crises

According to the respondents, financial resource constraints and communication are the main issues that need to be addressed in order to be able to respond effectively to compound events. The financial constraint is hindering not only the technical capacity (skills, human resources), but also the investments in risk analysis, essential for the development of DRR/DRM policies and plans. The development of local risk profiles would improve the general understanding of the risks affecting a given area, supporting disaster risk management activities at any level (prevention, mitigation, preparedness, response, recovery and rehabilitation). A better understanding of the nature of disasters and the characteristics of an area are essential for the development of contingency plans. These plans were often cited by stakeholders as an important tool to effectively prepare and optimise resources for interventions during compound events. Contingency plans should be at both national and regional level and should include contextual analysis of a given area, the climate situation, potential hazards to that area, vulnerability and capacity. The plan should also contain possible multi-risk scenarios and based on them, the response activities can be identified with the partners on the ground, the resources available and the necessary budget. The contingency plan can greatly facilitate the response once an alert is issued. A multi-sectoral task force can use it to plan response activities based on the situation, estimating the number of people affected and displaced.

"Financial mechanisms and contingency plan for each area are essential for an effective and timely response."
(disaster risk management expert)

In addition to national and local plans, the importance of regional plans was also mentioned during the interviews. This is because many disasters are cross-border (e.g., floods, droughts, desert locusts or even market failure, given dependences on imported goods from neighbouring countries). These disasters most often require a cross-border response. Integrated disaster management at the regional level would allow for the early anticipation of most events and coordinated response strategies.

"Policies at country level are good but not enough. If you take the armyworm infestation as an example, the outbreak could be hypothetically starting in another country but then due to the Intertropical Convergence Zone (ITCZ), these insects can easily reach Ethiopia. If we have information of these outbreaks in time, all the countries can prepare ahead of time".
(disaster risk management expert)

In order to effectively use the small resources available, the national disaster department is prioritising the intervention area by identifying hotspot areas according to six multi-sectoral indicators (agriculture, health/nutrition, WASH, market, education, protection and others). Using these indicators, they can rank the areas under analysis in priority: 1, 2 and 3. If an area has three out of six indicators with priority 1, it will be classified as a hotspot area with priority one. Given the limited resources, the national disaster management authority tries to provide a response to areas with priority 1. If they still have resources, they will provide support to areas with priority 2 and then 3.

As with single disaster events, four things must be in place for effective disaster risk management of compound events: proactive early warning system, contingency plan, contingency budget, and institutional arrangement based on the disaster.

3.6.4 Windows of opportunity for proactive interventions

In the discussion of the windows of opportunity for interventions, interviewees often mentioned the importance of adopting measures that take maximum advantage of heavy rains (e.g., water harvesting). These interventions could limit the impacts of heavy rain while storing water to withstand any subsequent droughts.

We further discussed three main windows of opportunity with respondents: (1) before compound events; (2) immediately after the forecast; and (3) between the events and the peak of their impacts. On the basis of each window, several interventions were cited as follows:

1. **Before the event**: development of risk profile analysis at national and regional level and the development of national and regional contingency plans, installation of irrigation systems, rainwater harvesting, dams;
2. I**mmediately after the forecast**: use of drought-resilience crop, installation of barriers on the riverbanks.

3. **Between the events and the peak of their impacts**: interventions for slow and long-onset disasters must be classified. The compound mechanisms that develop during long-onset disasters and their time frame are different from slow-onset ones.

3.6.5 Early warning signs

In agreement with the identification of droughts and floods as major drivers of compound events, weather/climate forecasts were considered essential to timely predict compound events.

"Weather indicators are vital for this country given it is strong economic dependence on climate conditions."
(climate and weather expert)

Climatic factors can also be used to predict outbreaks of water-borne disease (e.g., identifying malaria risk areas based on monthly rainfall, maximum and minimum temperature, and humidity) or desert locust breeding sites (through values of temperature, rain, soil characteristics and moisture content) and predict their migration to other areas (through the direction of the wind). Physical and socio-economic contextual information of the analyzed area is also considered important for predicting the development of compound mechanisms. For example, in arid and semi-arid regions even a minimal excess of precipitation compared to the normal value can cause devastating impacts for both hazards (e.g., floods) and for the prevalence of small-holder farmers whose vulnerability to shocks is large. Some of important socio-economic factors are livelihood types and the market condition.

Conflicts driven by political factors could instead be difficult to forecast, due to the suddenness of the events. However, there are some early signs that help predict possible upcoming conflicts such as the growing tendency to seek additional financial resources or the increase in violence and tension. Furthermore, conflicts usually arise during particular political events such as elections, when some parties could be disappointed with the electoral results.

3.7 Summary & Discussion

Drivers/Impacts mechanisms

The revised literature and the results of the online survey identified drought and conflicts as the main drivers of food insecurity experienced in Ethiopia in 2017 and early 2018. The survey also showed that political disruptions played an important role in the escalation of the events. This did, however, not emerge from the semi-structured interviews in which discussions on both political upheaval and conflict were frequently avoided. In the interviews, however, the importance of climate shocks on the Ethiopian socio-economic context was clearly underlined.

Although the food security crisis was mainly attributed to drought and to conflict, it would be misleading to consider them simply as single/independent consequences of rain failure and violence. The interaction between rainfall shortages, political crises, mobility and conflicts was crucial in shaping the impacts described in the previous sections. Across the region, the people most affected by food insecurity were not necessarily located in areas with the largest rainfall anomalies, but rather in areas that had been affected also by conflict or were marginalised. The combination of several consecutive weak rainy seasons with structural poverty, political marginalisation, and conflict hindered the adoption of coping capacities by the affected communities, increasing food insecurity.

In the years 2017-2018, conflicts compounded with the fragile conditions of the eastern regions and the drought impacts, resulting in large displacements of people. Due to the resulting disruptions and limited access to some villages, the conflicts have also hindered the response to the drought, further aggravating the humanitarian crisis.

Besides, acute food insecurity in the eastern and southern regions of Ethiopia was a feature of how food was accessed. This resulted from the high percentage of smallholder farmers whose livelihoods depend on sufficient rainfall and from a food system sensitive to local climatic anomalies. Consequently, the availability of food in the markets located in the areas affected by the decrease in rainfall was scarce, despite the increase in national food production in 2017 and 2018. Even if national food production was unaffected, Ethiopian eastern regions were unable to access food through the market. Staple food prices blew up, especially in the markets located also in conflict areas where food trading was further hindered by the limited accessibility.

In response to livelihood insecurity, migration was one of the main coping mechanisms adopted by the rural eastern and southern communities. This, however, further exacerbated existing ethnic tensions while increasing the vulnerability and exposure of these communities to other hazards (e.g., floods, droughts).

Only the heavy rains during the Belg and Gu seasons in early 2018 helped break the drought cycle by restoring water sources and pastures. However, the event resulted also in widespread floods and landslides hitting mainly drought/conflict-affected communities. The heavy rain after the long drought not only increased the vulnerability of people struggling to cope with flooding after being hit by the drought, but also increased the risks of flash floods and landslides due to dry and compacted soil.

The above mechanisms are graphically summarised in the cognitive map in Figure 31. The map shows both positive and negative feedback that led to food insecurity. With solid and dashed arrows, we identified immediate and long-term effects, highlighting the variability of driver/impact mechanisms over time. However, aside the immediate effect of heavy rain on decreasing armyworm infestation, all other negative feedback loops only occurred over a longer period of time (1-2 months).

The complex chain mechanisms showed in the map were further affected by the national/international response and coping mechanisms adopted by the population. Some of the response and coping mechanisms to droughts, floods and conflicts led to mechanisms that actually exacerbate impacts rather than reduce them. Furthermore, response measures that addressed each hazard individually resulted in both positive and negative impacts on the risk of other hazards (e.g. displacement of people to flood/drought-prone areas).

Early signs

From the cognitive map above and from the previous chapters we have seen that compound mechanisms vary in time and space. Therefore, it is important to take these two dimensions into account when monitoring compound risks.

Importance of spatial variations

The temporal variability of country-averaged rainfall proved to be not necessarily a good indicator of food insecurity in Ethiopia, nor did the temporal variability of local rainfall when analyzed individually. Soil types and land uses, as well as the socio-economic conditions of the potentially affected communities, are important factors that need to be taken into account when natural hazards and related impacts are assessed. The latter largely vary in Ethiopia given its heterogeneous climate, vegetation and topography. The large spatial variability of rainfall anomalies across Ethiopia can cause localised droughts and floods impacting rain-sensitive livelihoods and compounding with the impacts of conflicts, displacement, and governance instability. The arid and semi-arid areas of the eastern regions show a high vulnerability to climate shocks due to both the dry soil and the poor socio-economic conditions of the people living in the area. The heterogeneous climate could be seen as both an advantage and a burden for Ethiopia. Most climate shocks are localised and therefore, a drought or flood is unlikely to occur across the whole country at once. However, this could also give rise to two simultaneous hazards, such as floods in the central region and concurrently drought in the eastern region.

Even national GDP and country-averaged food production are not good early signs of the compound mechanisms that led to the food insecurity experienced. These factors vary highly across the national territory. Therefore, a regional analysis is fundamental to identify possible signs of crisis. These factors should be analyzed together with migration patterns, local market staple food prices, political agenda and frequency of clashes and violence. The latter may support the forecast of ethnic conflicts driven by political reasons, along with other signs such as the growing tendency to seek additional financial resources.

Importance of temporal variations

Environmental, economic and social pre-conditions can increase or decrease the thresholds necessary for certain events to become disasters. In Ethiopia, compound events proved to rapidly increase the vulnerability of different sectors to hazards over time and this must be taken into consideration when forecasting compound mechanisms. For example, previous periods of drought can reduce soil moisture, increasing the ecosystem's vulnerability to subsequent weak rainy seasons. Just as previous conflicts and droughts increase the economic and social vulnerability of communities to other disasters. Therefore, it is important to analyze not only current conditions and forecast future ones, but also to take into account past events that may still impacting communities and/or ecosystems.

Windows of opportunity for interventions

In Figure 32 and Figure 33, we have graphically summarised the possible windows of opportunity for interventions and the related early actions. The former was obtained by coupling the crop calendar with the impacts described in the literature review. In defining possible early actions, we also took into account the considerations raised by the interviewees and extracted from the surveys. Three main considerations were taken into account: (1) the importance of providing medicine and vaccine to livestock, especially during the transition between extreme dry and wet periods; (2) the importance of market interventions to reduce the price of agricultural inputs, such as fertilizers or pesticide; and (3) early actions during the lean season when vulnerability of the agro-pastoral communities to shocks is at the highest level. Additionally, interviewees frequently cited the importance of structural measures such as the enhancement of local risk analysis and the development of local contingency plans, that comprehensively look at the hazards and that identify possible response actions and related financial budget.

FIGURE 31. **Cognitive map of the humanitarian crisis in 2017-18 in Ethiopia**

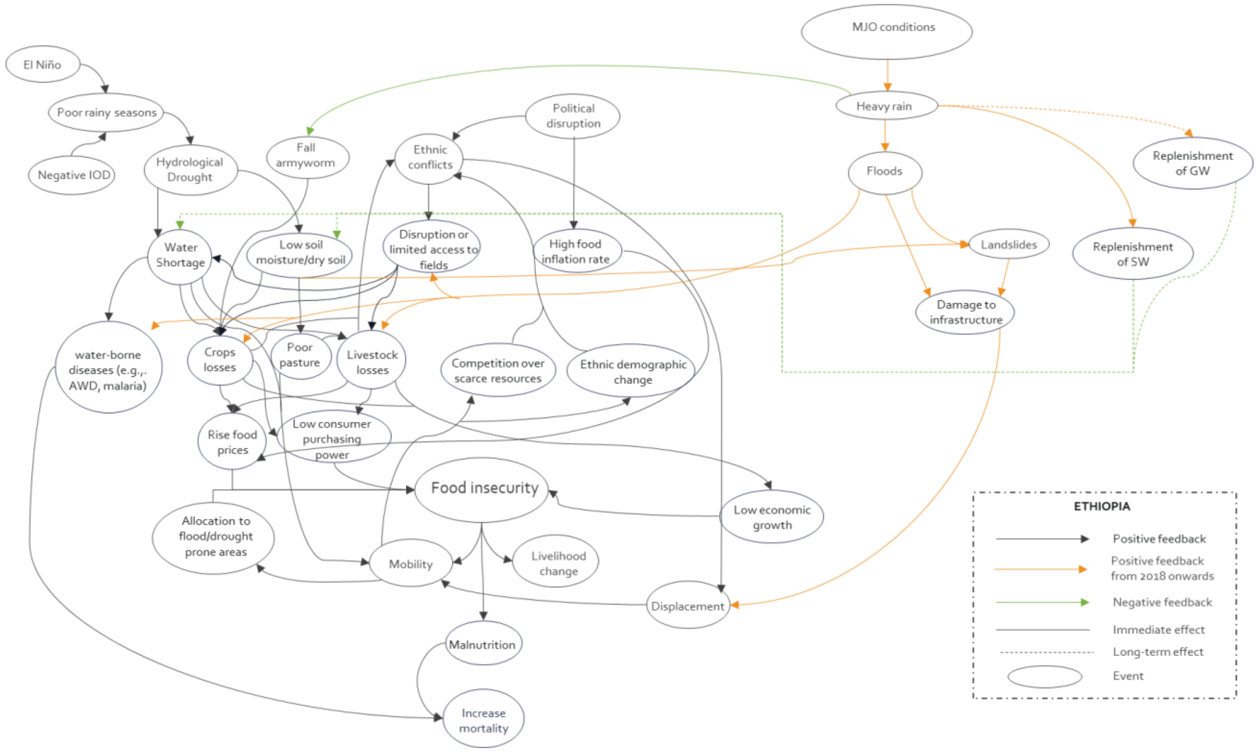
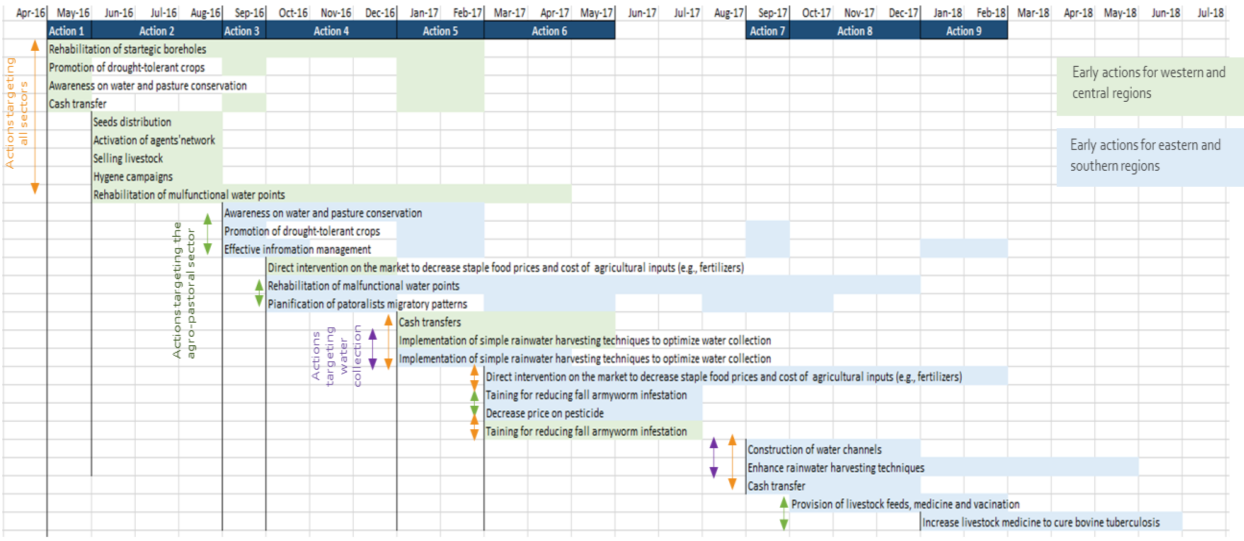


FIGURE 32. **2016/2017/2018 impact calendar with trigger indicators and possible windows of opportunity for implementing early actions (scheme re-adapted from E. Mwangi, Arango, and Abdillahi, 2020)**

Month	Sep-15	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17	Jan-18	Feb-18	Mar-18	Apr-18	May-18	Jun-18	Jul-18
Climate	Kiremt Rain Season	Deyr Rain Season				Belg Rain Season				Kiremt Rain Season				Deyr Rain Season				Belg Rain Season				Kiremt Rain Season				Deyr Rain Season				Belg Rain Season				Kiremt Rain Season	
Rainfall forecast release	Below average rainfall								Below average rainfall				Below average rainfall				Below average rainfall				Above average rainfall				Below average rainfall				Above average rainfall						
Crop calendar		Harvesting				Planting				Harvesting / Planting				Harvesting				Planting				Harvesting / Planting				Harvesting				Planting				Harvesting / Planting	
IMPACTS																																			
Crop yield														Poor Meher harvest								Poor Belg harvest				Abundant Kiremt harvest			Poor Deyr harvest	1,000 hectares of farmland destroied in Somali region				Abundant harvest	
Pasture																						Poor pasture									19,000 livestock losses				Good pasture
Water security																	Low in central and western regions					Low in Somali region									Low in flood hit counties				Highly improved
Food security					10.2 million people food insecure							9.7 million people food insecure				7.8 million people food insecure						7.8 million people food insecure			8.5 million people food insecure				8.3 million people food insecure						Food security situation
Health condition														Cholera outbreaks			Cholera outbreaks			AWD outbreak							AWD outbreak					- Upsurge AWD and cholera cases; - Floods damage to health facilities.			
Death and injuries																									Deaths due to the Somali-Oromia coflict				Clashes in Oromia due to political disruption			50 injured and 60 dead due to floods and landslides			
Population displacement															800,000 people displaced due to drought and ethnic clashes										1.2 million people displaced mainly due to conflicts and drought				1.7 million IDPs		+ 300,000 IDPs due to floods and landlsides				
Conflicts-Violence				Increase in violence due to political disruption																					Somali-Oromia conflict			Ethnic clashes		Increase in violence				Gedeo/Guji conflict	
INDICATORS &TRIGGERS									Forecast blw avg Kiremt rainfall and high vulnerability from previous season	Poor rain + biophysical indicators			Forecast of blw avg. rainfall + increased vulnerability from previous season	Poor rain + Biophysical indicators + rise of IDPs + market			Forecast of blw avg rain + increased vulnerability from previous season + IDPs		Poor rain + Biophysical indicators + rise of IDPs + market						Blw. rainfall forecast + high vulnerability from previous season				Above rainfall forecast + high vulnerability from previous season + arid soil						
EARLY ACTIONS									Action 1	Action 2			Action 3	Action4			Action 5		Action 6						Action 7				Action 8						

FIGURE 33. Possible early actions to implement in Ethiopia during the humanitarian crisis in 2017-2018 according to the available windows of opportunity. The coloured cells represent the time frame in which these actions can be carried out



4. Compound risks in fragile contexts: analysis of Kenya in 2017-2018

The following sections investigate the social factors and physical forces that led to the humanitarian crisis in Kenya in late 2016 to early 2018. The analysis shows how societal factors such as government elections and ethnic conflicts compounded with drought and flood events, resulting in around 4 million people experiencing food insecurity. The spatio-temporal interactions between the drought and the flood events, and their interconnections with anthropogenic actions, resulted in both negative and positive feedbacks on the Kenyan population. For instance, the flood initially exacerbated food insecurity caused by the long drought, but in the long term it helped alleviate related water shortages.

The first section (Section 4.1) presents an overview of compound risks in Kenya. The second section then describes the main events that occurred in the period analyzed (Section 4.2). An analysis of the complex temporal and spatial interactions between the identified social factors and physical forces follows (Section 4.3). This is carried out on the basis of literature review as well as the early understanding of possible early signs and windows of opportunity for interventions (Section 4.4). In Section 4.5 and Section 4.6, the results of online surveys and semi-structured reviews are shown. Finally, we discuss the main outcomes and summarise the key findings in the last section (Section 4.7).

4.1 Compound Risk in Kenya

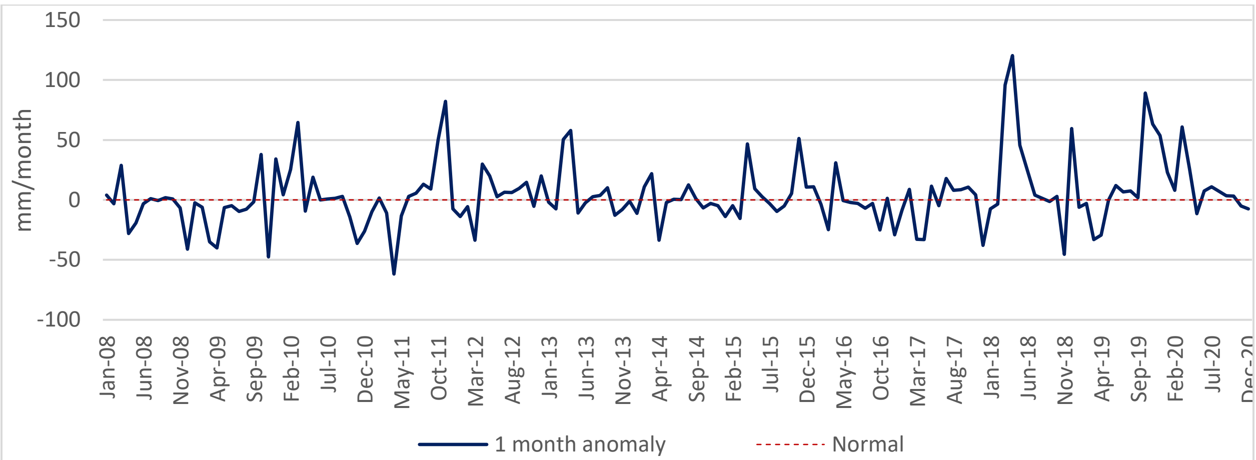
Social fragmentations (Kenya Human Rights Commission, 2018), poor livelihood diversification (Alobo Loison, 2019), and economic marginalisation (Rohwerder, 2015) pose a serious challenge to Kenya's social system and create an ideal context for the development of compounding risks. These are often triggered by natural and/or societal shocks such as climate-related hazards, crop pests and conflicts. Contributing to the country's emergency, there is also a high vulnerability to climate shocks, determined by the prevalence of agro-pastoral rain-fed activities, especially in the arid and semi-arid regions.

Communal conflicts have occurred in Kenya over the past decade, largely related to natural resources, land and political differences (Roz Price - Institute of Development Studies, 2019). Election-related violence often results from a combination of factors including politicisation of ethnicity, and inequitable development (Halakhe, 2013). Political unrest contributes not only to violence but also to the instability of markets and the economic slowdown (especially for the tourism and manufacturing sectors) (ACE, 2013; Porhel, 2009). Competition over natural resources is another common form of conflict in Kenya (Rohwerder, 2015), especially in the drylands of Kenya where many pastoralists live. These events are usually triggered by stress factors such as environmental degradation and water insecurity (Rohwerder, 2015). Depleting surface and sub-surface water basins due to droughts (Ministerie van landbouw natuur en voedselkwaliteit, 2021) and water supply disruption due to floods (Opere, 2013) are a few examples of the impact of climate-related disasters on water insecurity in Kenya.

Droughts and floods are not new phenomena in Kenya (Ayugi et al., 2020), but the rapid transition between these two extremes and their increased frequency and magnitude have only been experienced in recent years (M. Huho & Kosonei, 2014). Drought cycles in Kenya date back to more than four decades ago with major droughts occurring about every 10 years, and moderate droughts every three to four years (Parry, Echeverria, Dekens, & Maitime, 2012). Currently, drought cycles have reduced further down to every 2-3 years for major events, while dry spells are experienced annually (Mateche, 2011; Ongoma, Guirong, Ogwang, & Ngarukiyimana, 2015). The shorter time interval between drought events hampers the coping capacity of Kenyan farmers whose livestock and agricultural production depend on seasonal rains (Huho & Mugalavai, 2010).

Over the past decade, Kenya has also experienced more frequent and extreme rainfall (roughly every two years), with the past three years outstanding in terms of high magnitude and short time interval (Figure 34). These latest events resulted in flash/riverine floods and landslides, affecting around 800,000 people each, far above the average of 70,000 people usually affected by floods in the previous 20 years[4].

FIGURE 34. Rainfall Anomalies in Kenya from January 2008 to July 2020 (WFP-CHIRPS). The rainfall anomalies were calculated with respect to the long-term monthly average rainfall values (computed over 30 years)



Although these last two flood events have been exceptional in terms of impacts, the number of people affected by floods is far less than those affected by drought events, the latter affecting roughly ten times more than the former[5]. Analysing these hazards distinctly, drought remains the most prevalent hazard in Kenya in terms of human and economic costs. However, drought and floods are caused by extremes of the same hydrological cycle and hence are correlated by dynamic feedback, strongly interlinked with human processes (Ward et al., 2020). Treating droughts and floods as independent phenomena, while ignoring their interaction with societal forces, leads to incomplete/distorted understanding of the processes that led to the impacts experienced, and hence to possible future risks (Raymond et al., 2020; Zscheischler et al., 2018).

One example of these compound events was the humanitarian crisis in Kenya in 2017-2018, where a severe drought, which occurred over the span of around 18 months, was followed by an extensive flooding during the 2018 March-May rainy season (the wettest season recorded in 70 years) (Rateb & Hermas, 2020). The burden imposed by the two hydro-climatic extremes combined with the Kenyan volatile social-economic context (e.g. ethnical conflicts) has impacted the livelihood of around 4 million people, with severe consequences for the economy of the country (Daily Nation, 2019).

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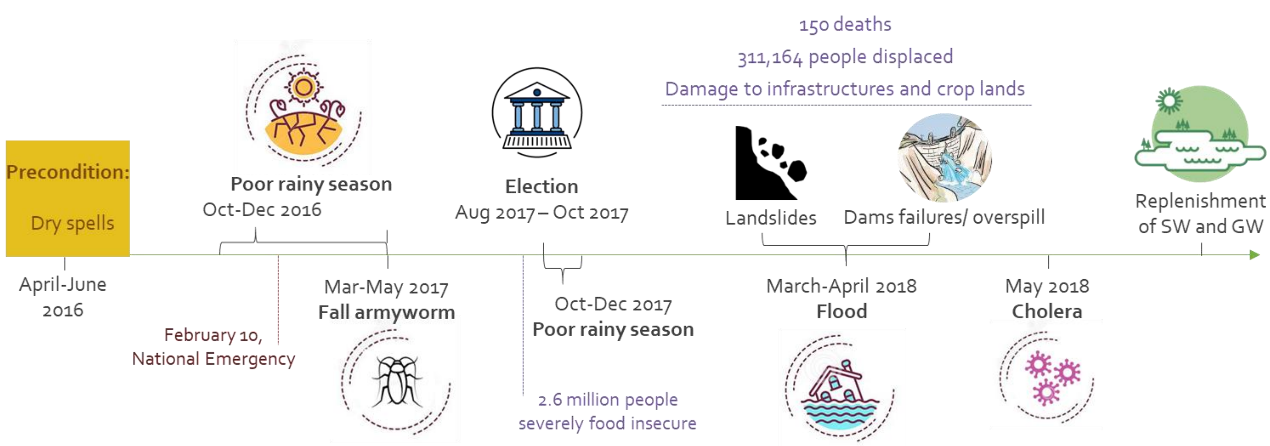
[4] Information collected from EMDAT and Desinventar datasets.

[5] Information collected from EMDAT and Desinventar datasets.

4.2 Disaster events timeline in late 2016-early 2018

The events experienced between the end of 2016 and the beginning of 2018 brought about 4 million people in Kenya into food insecurity (Figure 35), one of the highest values in the last 10 years (Statista, 2019). A series of weak rainy seasons had serious repercussions on pastures and crops, which together with an armyworm infestation resulted in significant economic losses for the agro-pastoral sectors (OCHA, 2021b). With no time to recover from the impacts, drought-affected communities were then hit by widespread flooding (Hajžmanová, 2018), which further aggravated food insecurity, disrupting water supply infrastructure, agro-pastoral fields and limiting access to villages for aid. The consecutive dry and wet climates, along with reduced water quality, has led to optimal conditions for the spread of waterborne diseases (UNICEF, 2018). This has resulted in several cholera outbreaks and malaria cases across the country. Furthermore, alongside these events, governmental elections took place in Kenya in August and October 2017, with related violence and further increase in the budget deficit. In the following sections, we further investigate the events that occurred between October 2016 and May 2018, with the aim of identifying the main drivers of the experienced food insecurity.

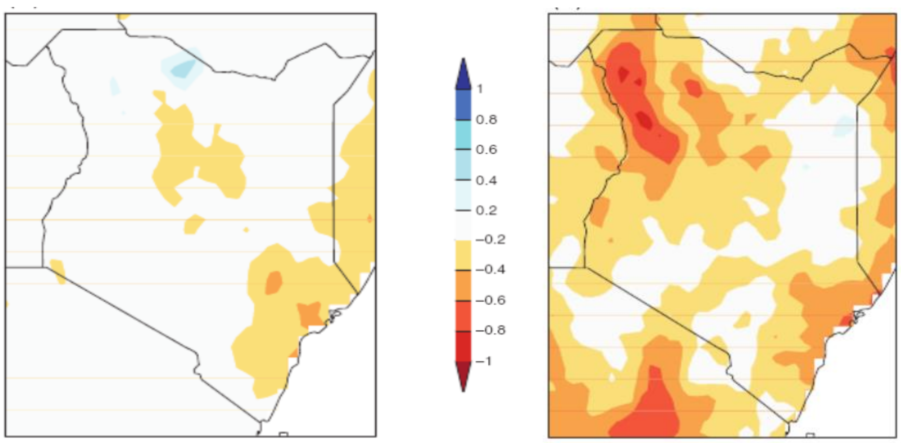
FIGURE 35. Disaster events timeline in Kenya from April 2016 to July 2018.



4.2.1 Drought and flood events

The 2016-2017 drought was one of the most significant climate-related events over the last two decades in the country (Uhe et al., 2018). Although 2016 does not seem to be an extremely dry year according to the spatial rainfall average (Figure 36a), some regions within Kenya received little or no rain that year (Uhe et al., 2018). Declines in rainfall rates were experienced especially during the short rainy season (October-December) of 2016 (Figure 36b). According to a study carried out within the framework of CDKN (Uhe et al., 2017) (Uhe et al., 2017), this event can be partially explained by La Niña conditions, accounting for 16% of the short rainy season variance.

FIGURE 36. Spatial anomalies over Kenya from the CHIRPS data set for:
(a) January-December 2016 relative precipitation anomalies (with respect to 1986–2009);
(b) October-December 2016 relative precipitation anomalies (with respect to 1986–2009) (Uhe et al., 2018)



However, the late onset, poor distribution, and early cessation of the 2016 short rains alone do not explain the drought condition experienced. The event compounded with the precondition of dry spells caused by low rainfall at the beginning of that year (International Federation of Red Cross and Red Crescent Societies, 2016a), and most probably temperatures above normal in 2016 might have also accelerated water depletion across most of the pastoral and marginal agricultural areas (Daily Nation, 2019).

On 10 February 2017, the government declared a national drought emergency (FAO Kenya, 2017), which was further exacerbated by the poor rainfall rates over the long rainy season (March-April-May; Figure 37) in the same year (Uhe et al., 2018). The drought conditions lasted until May 2018 even though several wet events occurred in between (Table 3). Only the heavy rain in early 2018 interrupted the drought cycle, but at a high social and economic cost. The extreme rainfall occurring between March and May (MAM) 2018 led to flash floods and widespread riverine floods, landslides and dam spillage/failure, resulting in around 150 deaths and 300,000 displaced people (MacLeod, 2019). The rain events also caused damage to infrastructure (houses, health facilitates, roads), transport service disruption, reduced access to markets, destruction of cropland (around 50,000 acres) and livestock losses (over 19,000 head of cattle) (Weingärtner et al., 2019). These impacts took place while the population was still recovering from the long drought period (International Federation of Red Cross and Red Crescent Societies, 2018b). For instance, comparing Figure 38 and Figure 39, we can see that the heavy rains occurred in some of the counties previously affected by the drought of 2016-2017, such as Mandera, Turkana, Tana River, Kilifi, Isiolo, resulting in additional livelihood damage in such locations. With the exception of Kilifi, these counties have also the highest poverty gap in the country and hence lower resilience and capacity to recover from the combined impacts.

FIGURE 37. March-May 2017 rainfall anomaly (percent of the 1981-2010 average) over Kenya (FEWS-CHIRPS) (FEWS NET, 2018d)

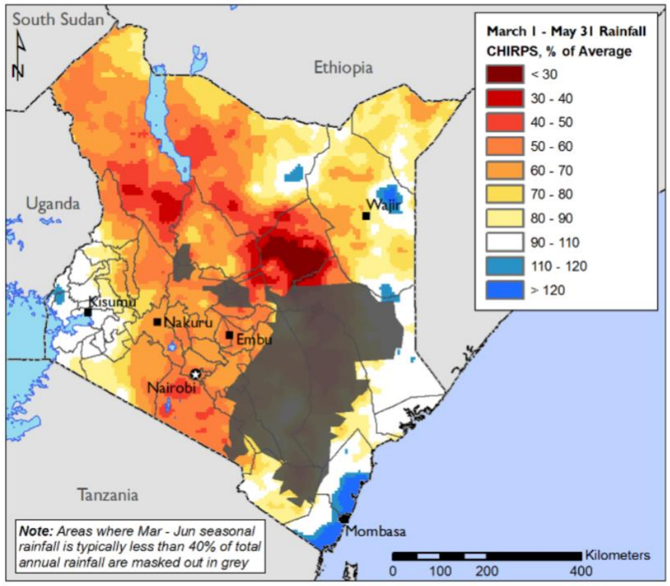


FIGURE 38. Food insecurity phases in Kenya during: a) March-May 2017 (left), b) June-September 2017 (middle) and c) March-May 2018 (right). (FEWS NET)

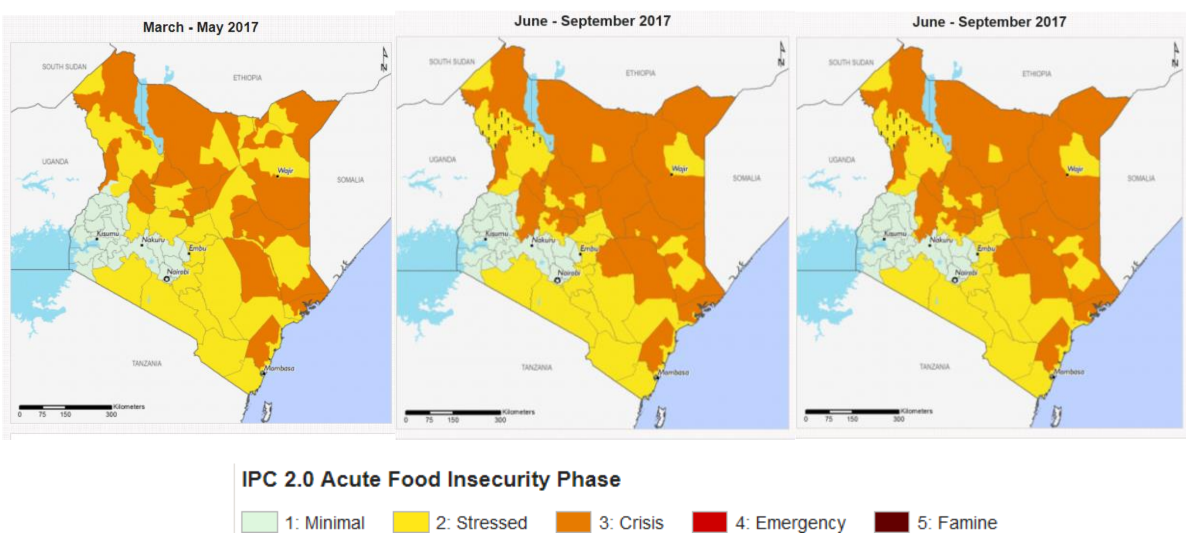
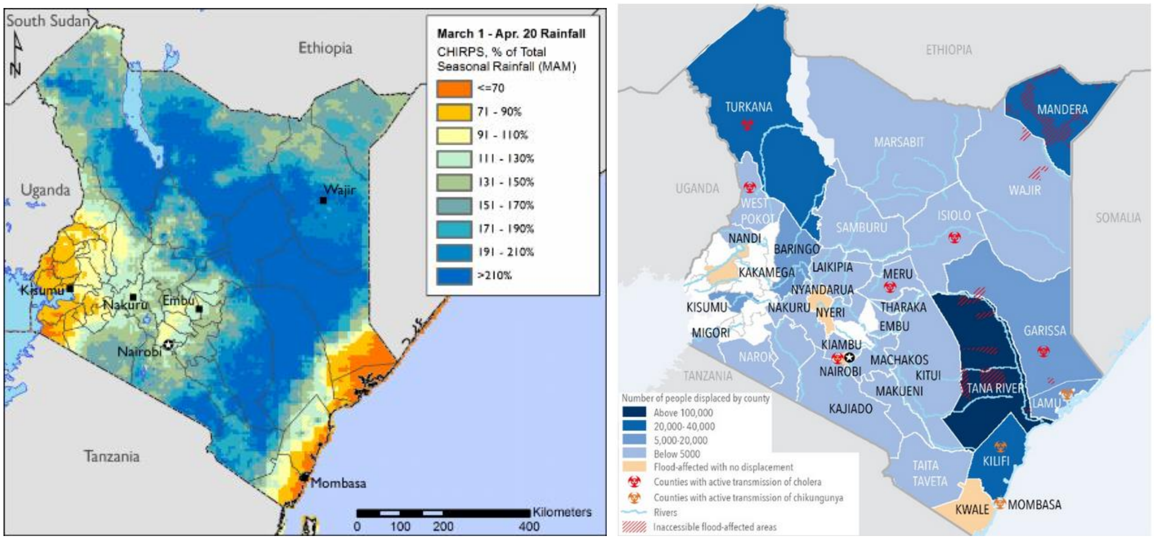


FIGURE 39. **Food insecurity phases in Kenya during: a) March-May 2017 (left), b) June-September 2017 (middle) and c) March-May 2018 (right). (FEWS NET)**



The heavy rain experienced in the long rainy season of 2018 can be associated with a complex combination of intra-seasonal variability, such as the Madden Julian Oscillation (MJO), and synoptic scale weather events, including the effects of tropical cyclones off northern Madagascar, which modified the atmospheric circulation over the Western Indian Ocean (Kilavi et al., 2018; MacLeod, 2019). The complexity of the event resulted in shorter forecast lead times. As such, the long lead seasonal climate forecasts did not provide enough indication of the exceptional rain that was coming (Rateb & Hermas, 2020; Weingärtner et al., 2019).

TABLE 3. **Climatic events and their related impacts in Kenya between October 2016 and May 2018**

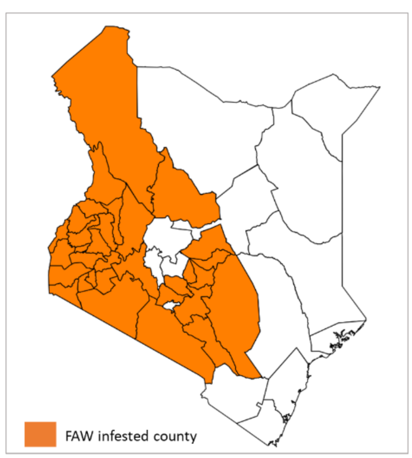
Date	Event	Impact	Location
Oct-Dec 2016 *(only declared a national drought emergency on 10 February 2017)*	Drought	2.6 million suffered from severe food insecurity (as of 26 May 2017) (ACAPS, 2016; Uhe et al., 2018)	North-western and eastern areas: Turkana, Marsabit, Kwale, Kilifi
May 2017	Extreme rainfall led to flash floods and landslides	26 people died and 25,000 had been displaced. Flood waters sweep away almost 9,000 cattle in northern and coastal Kenya (FloodList, 2017a; Macleod et al., 2021; OCHA, 2017d)	Coastal and western Kenya (Taveta, Lunga, Dadaab, Mombasa, Taita, Kwale)
Oct-Nov 2017	Heavy rain	4 people died and about 200 families were affected (FloodList, 2017b)	Central and northern areas (Marsabit, Meru, Turkana, Tharaka-Nithi)

Date	Event	Impact	Location
Mar-May 2018	The MAM 2018 seasonal rainfall led to widespread riverine floods, landslides and dams' spillage. Dam's failure in Nakuru County (Patel Dam).	150 people died and 311,164 had been displaced. Cropland and irrigation infrastructure, such as pumps and pipes, had been extensively damaged in Coast province, together with the water supply systems. About 28% of the total crop in Turkana was destroyed. Crop failure was also experienced around the Tana River region (10,000 acres), in Embu, Kitui and Makueni (12,355 acres), in Taita Taveta (1,507 acres), and in Kilifi (4,500 acres). Extensive damage to health facilities and roads. (OCHA, 2018j; Rateb & Hermas, 2020)	Turkana, Tana River, Garissa, Isiolo, Kisumu, Taita-Taveta, Mandera, Wajir, Marsabit, West Pokot, Samburu and Narok

4.2.2 Fall armyworm event

The fall armyworm infestation in Kenya was an additional stressor for crop production during the drought event of 2016-2017 (KNBS, 2017a, 2017b, 2017c). The pest was first detected in Kenya in March 2017 and was held responsible, along with the drought, for the decrease in the production of maize and sorghum (the crops preferred by the parasite) (De Groote et al., 2020). The worms also targeted wheat and barley crops, which grow mainly in the western counties together with maize (Figure 40). By July 2017, it had infested 40% of farms, affecting around 200,000 hectares of land in the main maize-producing counties (OCHA, 2017a). The infestation seemed to have stopped at the beginning of 2018 with a resurgence only in early 2019.

FIGURE 40. Counties with FAW infestation in 2017 (FAO, 2017b)



4.2.3 Government elections

The year 2017 was also marked by government elections, which took place first in August 2017 and then again in October 2017 since the Supreme Court nullified the results of the first election (The Carter Center, 2018). The electoral campaign was one of the most expensive for both the public and private sector, and its period was marked by violence and unrest (Gadjanova, 2017), fuelled by the harsh conditions resulting from the drought (International Federation of Red Cross and Red Crescent Societies, 2017d).

The 2017 election cycle proved to be one of the most divisive in Kenya's recent history, along with the 2007 election period (Cheeseman, 2008; Kenya Human Rights Commission, 2018). Ethnic violence during the election period has been perpetuated in Kenya, and the year of 2017 was not an exception, reinforcing evidence on the link between ethnicity and politicisation (DW, 2017b). Ethnic identity served as a tool for political mobilisation with existing ethnic tensions instrumentalised for political gain (Roz Price - Institute of Development Studies, 2019). Political parties tend to be seen as ethnic enclaves and elections are sometimes considered to be a measure of the numerical strength of ethnic groups. The appointments to public service are seen as strongly related to the result of the elections (Kenya Human Rights Commission, 2018), determining the maximum attention and effort of ethnic groups in support of the electoral campaign. In 2017, a high level of electoral competition at the national and county level (The Carter Center, 2018) was accompanied by widespread violence, resulting in property destruction, and cases of sexual abuse and police brutality (Kenya Human Rights Commission, 2018).

4.2.4 Ethnic conflicts

Violence and unrest in 2017 were not only the result of the electoral period, but also of natural resources competitions, aggravated by the drought. Conflicts over scarce natural resources find fertile ground in Kenya given a climate characterized by ethnic tensions and an unstable political and economic context (Roz Price - Institute of Development Studies, 2019). During the long drought period in 2016-2017, cattle raiding, gender-based violence (OCHA, 2017) and clashes (Craig, 2017) increased, especially in the Northern pastoralist area. Raids are usually conducted not only to compensate drought-related livestock losses but to protect or gain control over scarce pasture and water resources (Roz Price - Institute of Development Studies, 2019). These also occurred after the extreme flood event in March-May 2018 (International Federation of Red Cross and Red Crescent Societies, 2019), together with inter-clan tensions.

In 2017 and 2018, voluntary (and often-temporary) migration due to drought and environmental degradation related to floods has been reported as one of the main coping strategies adopted by the pastoralists (Roz Price - Institute of Development Studies, 2019). The movement of these people has resulted in increased conflicts mainly due to the tension over the distribution of limited resources. The people who suffered violence were mainly those who moved outside their traditional ethnic community region (Linke, Witmer, O'Loughlin, McCabe, & Tir, 2018)

4.2.5 Decentralisation

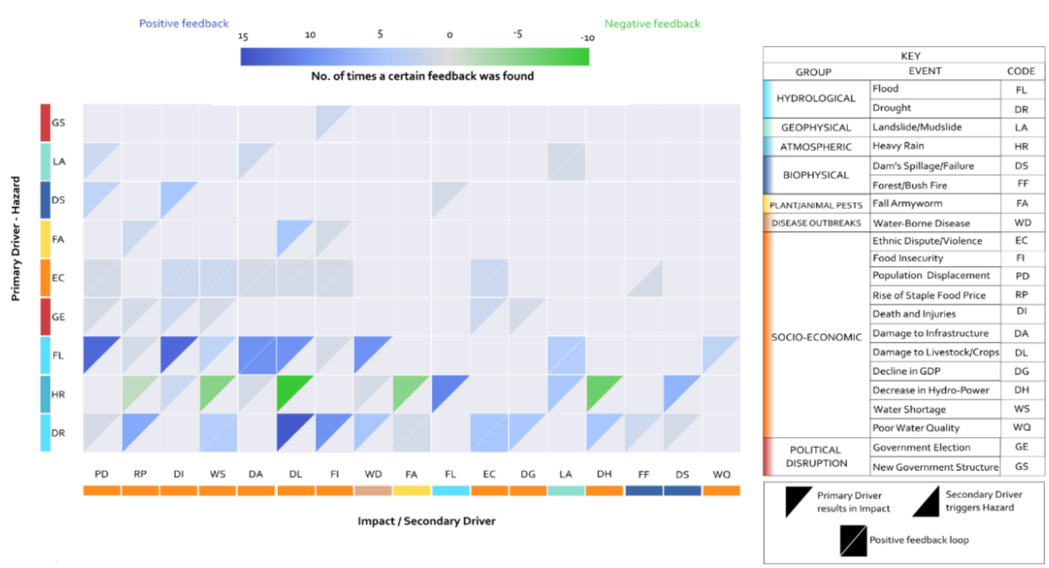
In 2010, Kenya passed a new Constitution that led to the decentralisation of political power and the creation of 47 county governments. With this change, the county-level governments have become responsible for providing various services (including water and health), while certain functions remain at the national level (e.g. most aspects of water resources management). The new governance system aimed to increase civic engagement, improve the quality and delivery of services, as well as achieve equality across the state (Lumbasi & Trinity, 2016).

As the process only went into effect in 2013, the 2017 drought was the first major crisis since decentralisation. Therefore, the response to drought at the local level has seen the active engagement of county governments. However, local coordination skills and experience were still relatively underdeveloped (Grunewald et al., 2019).

4.3 Literature review: interactions drivers/impacts over time

To understand the complex temporal and spatial interactions between drivers and impacts during the period under analysis, an extensive literature review of 60 documents comprising different reports, humanitarian bulletins, and published studies was carried out. The identified correlation between driver/impact was recorded in a matrix and graphically summarised in the form of a heatmap (Figure 41). The figure shows how many times a certain identified correlation between driver/impact was cited among the reviewed documents. The analysis showed complex correlations between the impacts and their cited drivers, where the occurrence of one event can strongly influence (or cause) others and drivers/impacts can easily change role. This means that a driver can have a positive feedback to a certain impact, while it can help with the (natural) mitigation of other(s) (i.e., a negative feedback). Nevertheless, an impact can become a driver of a subsequent event.

FIGURE 41. Heatmap of the cited correlations between Drivers and Impacts extracted from the literature review. The color increase intensity according to the frequency citation of the correlation. Positive correlations (blue) increase the impacts while negative correlations (green) decrease the impacts. Event classification modified from (Gill & Malamud, 2014)



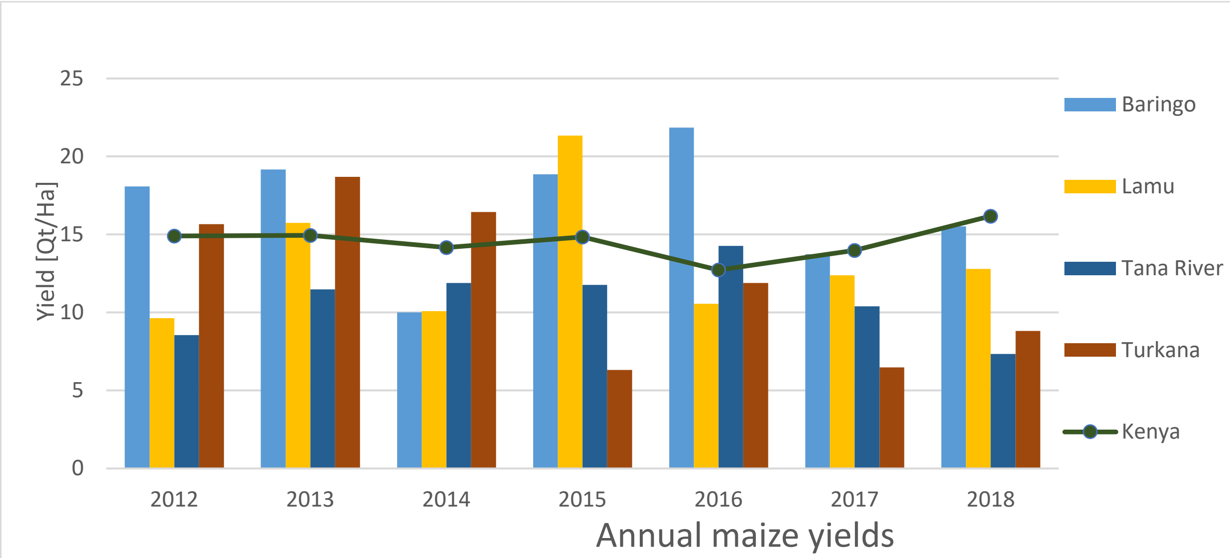
For instance, the couple *Drought* (as driver) leading to *Damage to livestock/crops* (as impact) was clearly identified in many of the reviewed documents, similarly to the couple *Floods* (as driver) and *Population displacement* (as impact) (each cited more than 15 times). Whereas the couple *Government elections* (driver) and *Water shortage* (impact) was hardly identified (cited only one time). On the other hand, *Heavy rain* (driver) was identified with a negative correlation for *Decrease in hydropower* (impact) and for *Damage to livestock/crops* (impact) in several studies (cited around 10 times), meaning that rainfall reduced the (drought-induced) damage to livestock/crops and decrease in hydropower energy production. Only a few studies cited a positive correlation existing between *Floods* (driver) and *Staple food prices' rise* (impact) as well as with *Food insecurity* (impact). In the literature, *Dam's failure* (impact) was mainly explained by the poor maintenance of the dams by farmers during the dry period. This has been related by some literature to the limited financial resources of farmers caused by the long *Drought* (driver). Finally, given the larger number of correlations found in the literature, *Drought*, *Floods* and *Ethnic Disputes/Violence* can be identified as the main drivers of the compound events experienced in the analyzed period, each related to 12, 10 and 8 impacts. In the subsequent subsections, we further explore the Drivers/Impacts interaction shown in the heatmap according to the findings of the review process. In the last subsection, we discuss early signs of compound events and windows of opportunity for interventions based on the literature review we carried out.

4.3.1 Drought, crop pests, ethnic conflicts and floods as drivers of food insecurity

In 2017, the food insecurity experienced by the Kenyan population reached alarming figures. In late December 2016, about 1.8 million people were in acute food insecurity (International Federation of Red Cross and Red Crescent Societies, 2016b), reaching a peak of around 3.4 million people in late 2017 (International Federation of Red Cross and Red Crescent Societies, 2017a), and about 3 million in the first months of 2018 (International Federation of Red Cross and Red Crescent Societies, 2017). According to the literature review, the prolonged drought is among the main drivers of food insecurity, followed by floods, increase of conflicts, crop pest infestation and the new decentralised county government (Figure 41).

However, food insecurity cannot be explained by the poor rainfall experienced over the short rainy season in 2016 alone. The event compounded with erratic rainfall in the previous long rainy season (March-May), together with a rise in temperatures above normal values. The sequence of dry spells continued in early 2017, leading to below-normal rainfall during the long rainy season. The subsequent fall armyworm infestation at the beginning of March 2017 was particularly detrimental to the production of staple crops and the livestock, triggering food insecurity mainly in rural and pastoral areas (KNBS, 2017a). A substantial decrease in maize production was observed mainly in Uasin Gishu (contributing about 10% to the annual average national production), West Pokot and Meru (about 2% each), Baringo (1% each), Tana River and Turkana (0.2-0.1%), Mandera and Marsabit (0.02-0.01%). Some counties experienced a sharp decline in maize production as early as 2016 (Lamu in Figure 42). An increase in agricultural production was evident in 2018 thanks to the abundant rainfall during the long rainy season. However, not all counties benefited in the same way from the heavy rain. Tana River, for example, was the main hit by widespread flooding that led to the destruction of crops and the loss of livestock, which can be observed in the decrease of maize yields in 2018 (Figure 42).

FIGURE 42. **Crop yield per county from 2012 to 2018 (Ministry of Agriculture Livestock and Fisheries, 2018)**

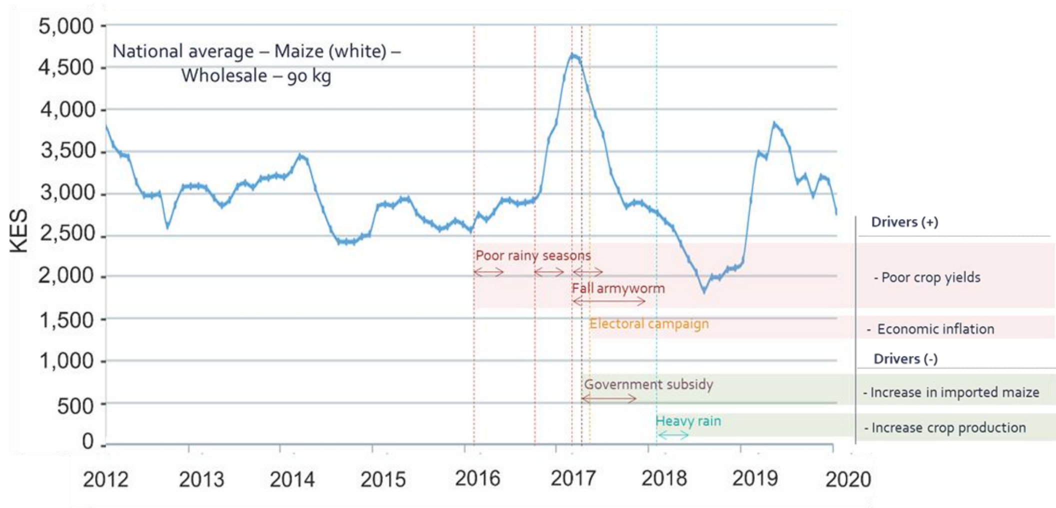


In response to the poor crop yields and livestock lost, staple food prices rose steeply in late 2016 and early 2017 (KNBS, 2017b). Wholesale prices of food such as beans, maize flour, rice and potatoes rose markedly during the first quarter of 2017 (Figure 43). The same sharp price increase was observed on milk products as a reflection of livestock losses (KNBS, 2017a).

This overall sharp rise in food prices in 2017 was not only driven by the combination of the aforementioned events (e.g., poor rain seasons, crop pest) but also by other non-meteorological causes, such as the government election. The insecurity and ethnic violence brought by the electoral campaign, which stirred up pre-existing ethnic tensions, played an important role in rising inflation rates (The National Treasury, 2018). This increased frequency of clashes further complicated the drought response, decreasing humanitarian access to affected areas (ACAPS, 2018b). Apart from the disruptions to aid delivery, violence also led to trade disruptions, affecting access to food products and food prices in specific markets (C. W. Mwangi, 2020).

To respond to the sharp rise in food prices (especially maize), the government subsidised maize prices (from May to October 2017) and waived duties on imported maize, wheat, milk and sugar (from June 2017) (World Bank Group, 2017). The measures allowed to contain the retail prices of the commodities, while trying to ensure better publicity in view of the election period (FAO, 2017). The widespread floods in March-May 2018 and the related destruction of crops and livestock were not incisively reflected in the food prices' trend, which continued to decline slowly until mid-2018 when there was a sharp decline in price. This could be explained by the abundant harvest resulting from heavy rains which led to the replenishment of surface and groundwater sources. The benefit of heavy rains has outweighed the impacts caused by floods and landslides, especially in the central-eastern counties, important agricultural areas of Kenya.

FIGURE 43. **National average wholesale maize price in Kenya from 2012 to 2020**



4.3.2 Economic condition

The analyzed period has also seen a significant decline in GDP in 2017 (Figure 44) related to both the uncertainty associated with elections and the effects of adverse weather conditions (Figure 41) (The National Treasury, 2018).

FIGURE 44. Crop yield per county from 2012 to 2018 (Ministry of Agriculture Livestock and Fisheries, 2018)

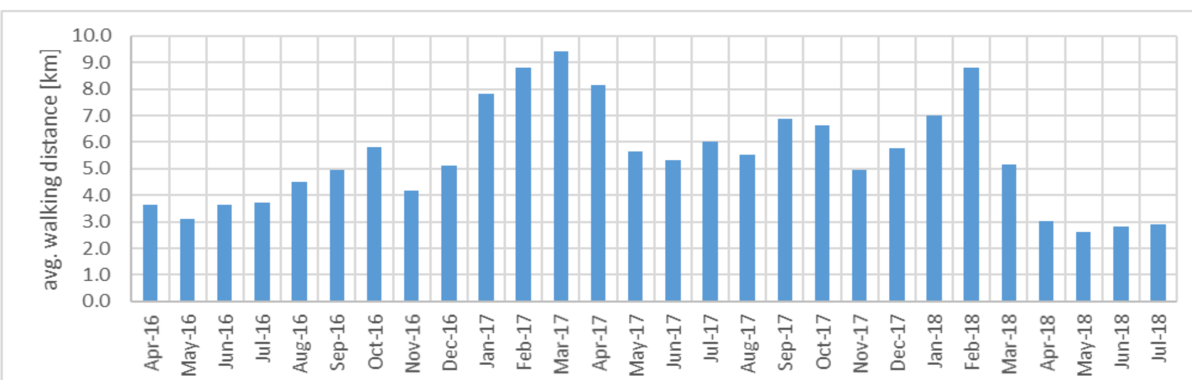
The decrease in GDP in the first two quarters of 2017 was mainly determined by a reduced contribution of the agricultural sector, which accounts for about 34% of the total GDP. Specifically, its contribution to the GDP growth dropped to 0.4% points compared to a historical average of 1% points. Similarly, the industrial sector contributed only 1.1% points compared to an average of 1.6% points. Both activities in the agricultural and manufacturing sub-sector were indeed impacted by poor agricultural harvests and a prolonged election period that weakened agribusiness activities and increased market uncertainty, respectively (Driop et al., 2018).

Besides, the insufficient rainfall in the last quarter of 2016 and over the whole year of 2017 strongly affected the growth in the electricity sub-sector (KNBS, 2017a). The substantial declines (34.9%) in hydro-electricity generation led to an increased use of thermal sources (highly input intensive and therefore relatively expensive) (KNBS, 2017b). A marked growth in hydropower generation was around March 2018 as a result of the heavy rains that prevailed during that month (KNBS, 2017a).

4.3.3 Disease outbreak

From 1 January 2017 through 29 November, 20 of 47 counties in Kenya have reported cholera cases (WHO Regional Office for Africa, 2017). A surge in Acute Watery Diarrhoea (AWD) cases was also observed during the years 2017-2018 (OXFAM, 2018). In that period, disease outbreaks were exacerbated by several factors among which the regional drought and conflicts in remote areas played an important role by limiting access to clean water (Figure 41) (World Health Organization, 2017a). At the beginning of 2017, the average walking distance to reach the water sources almost doubled and maintained a high value (between 6-9 km) throughout 2017 and early 2018 (Figure 45). As of March 2018, the distance to water points started to register decreasing values, reaching an average of about 4 km in April and May, most likely correlated with the abundant rains during the long rainy season. However, the heavy rain further aggravated access to water points in many rural villages located in arid and semi-arid regions, where the events resulted in violent floods that disrupted the water supply system (e.g. boreholes) (OCHA, 2018j).

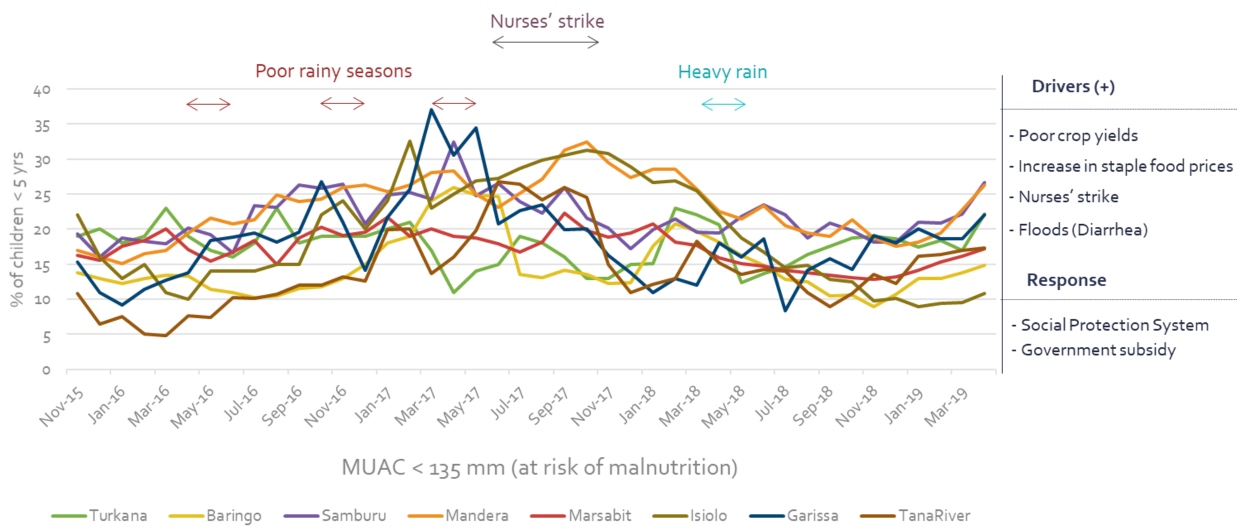
FIGURE 45. Average walking distance to water sources for the counties of Turkana, Baringo, West Pokot, Samburu, Mandera, Marsabit, Wajir, Isiolo, Garissa, Lamu, Tana River from April 2016 to July 2018 (UNICEF)



The heavy rain and floods further aggravated the cholera and AWD outbreaks also through the extensive damage to health facilities and contamination of water sources (International Federation of Red Cross and Red Crescent Societies, 2018a; Turman-Bryant, Nagel, Stover, Muragijimana, & Thomas, 2019). Additionally, the increased precipitation coupled with the warm conditions created a conductive environment for mosquito-borne diseases, which led to an increase in the malaria cases (International Federation of Red Cross and Red Crescent Societies, 2018; Kamau et al., 2020).

The up-rise in disease outbreak augmented the number of children at risk of malnutrition, especially considering AWD cases (OCHA, 2018j). The increasing number of children below five years old at risk of malnutrition was reflected on the UNICEF data on Mid-Upper Arm Circumference (Figure 46). Several peaks in number of children with a mid-upper arm circumference below 135 mm were observed in Garissa, Mandera and Tana River during and after the poor rainy seasons of 2016 and early 2017. Another factor that contributed to the increase on child malnutrition rates was the nurses' strike that took place between June and November, leading to a general lack of childcare and hospital support (Njuguna, 2018).

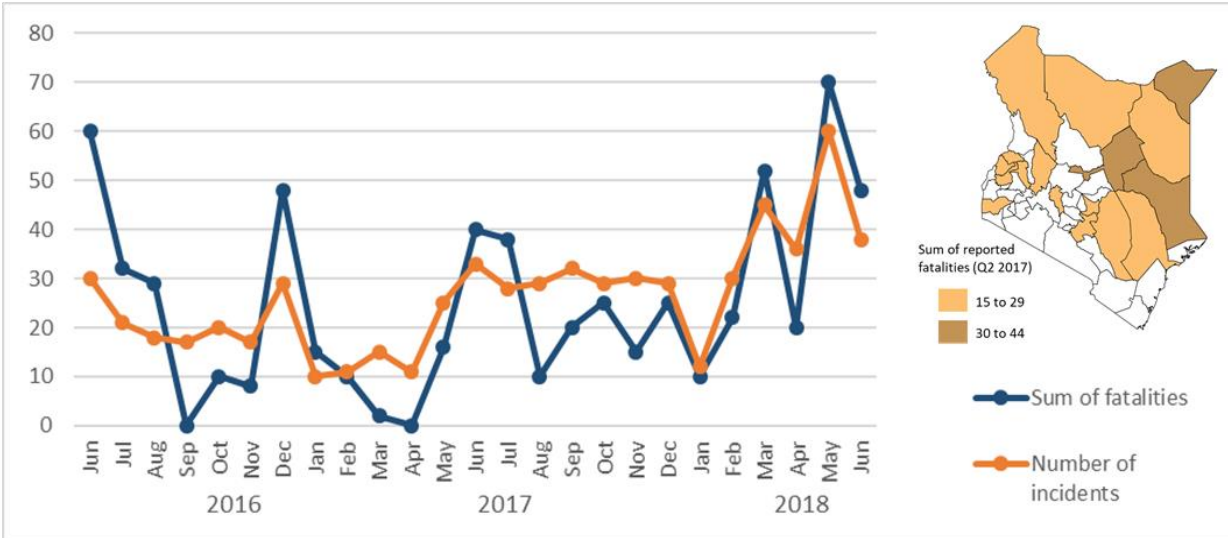
FIGURE 46. Percentage of children with Mid-Upper Arm Circumference (MUAC) under 135 mm between November 2015 and May 2019 (UNICEF)



4.3.4 Ethnic conflicts and violence

The year 2017 have also seen a rising in violence and conflict incidents nationwide. Conflicts have been depicted in the reviewed literature as both drivers and impacts (Figure 41). Most ethnic violence occurred in counties such as Turkana, Marsabit, Isiolo, Garissa and Tana River (Figure 47) and were often linked to competition over land, exacerbated by scarcity of water and pasture experienced during the drought period (ACLED, 2017b). Throughout 2017, the impacts of drought and conflict were mutually reinforcing. Drought affected the migratory patterns of pastoralists, aggravating resource-based conflict and the inter-communal competition over natural resources. This resulted in an increased insecurity, which restricted access of humanitarian aids in the country (NDMA, 2018), contributing to the larger impacts of drought at local levels. Additionally, clashes among different ethnical groups were stirred up by the political tensions stemming from the upcoming election (ACLED, 2017).

FIGURE 47. Development of conflict incidents from June 2015 to June 2017 (Acled data)



4.3.5 Political disruption

Government election played an important role in the escalation of the events that took place in 2017-2018. According to the literature, the electoral period contributed to population displacement, rise in staple food prices, increase in water shortage, economic decline and, increase in ethnic conflicts and deaths (Figure 41). The impact of the government election on increasing water and food insecurity is briefly summarised as follows. First, the expensive electoral campaign and re-vote, together with the lack of resources normally triggered by the drought conditions, contributed to additional budget shortfall for the county water offices that reflected on the poor management of boreholes (Turman-Bryant et al., 2019). The malfunction of the boreholes contributed to the increasing lack of access to water resources (KNBS, 2017a).

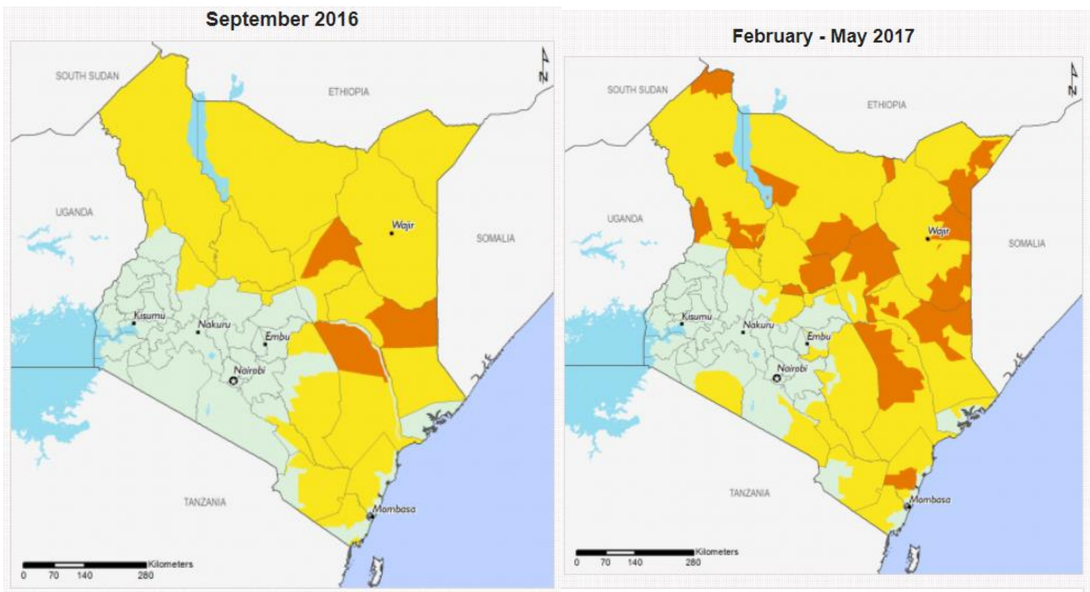
Secondly, the uncertainty associated with political environment (prolonged election period) also contributed to the economic inflation. This, coupled with effects of adverse weather conditions, slowed down the performance of the country's economy (KNBS, 2017c; World Bank Group, 2017).

Thirdly, the increase in violence stirred up by the electoral period has also led to insecurity and, consequently, to the displacement of people. The increased level of insecurity has also resulted in reduced humanitarian access and, therefore, in a less efficient response to drought (Inter, 2017). Finally, the upcoming elections may have held back the government from recognising the national drought emergency.

4.3.6 National and international response

Although appeals for the drought emergency had already been launched by the Kenyan Red Cross Society in November 2016 (Grunewald et al., 2019) and by The Famine Early Warning System (FEWS) in October 2016 (Figure 48), the government officially proclaimed a national emergency only in February 2017. This then allowed to unlock a series of mechanisms for response and recovery which was rather effective in decreasing the soaring prices of staple food. Since the government was in the spotlight because of the elections, large investments were made to stabilise local consumer prices and, hence, to reduce general discontent.

FIGURE 48. On the left, the actual food insecurity situation in September 2016 in Kenya. On the right, food insecurity phases for February-May 2017 forecasted in October 2016 (FEWS-NET)



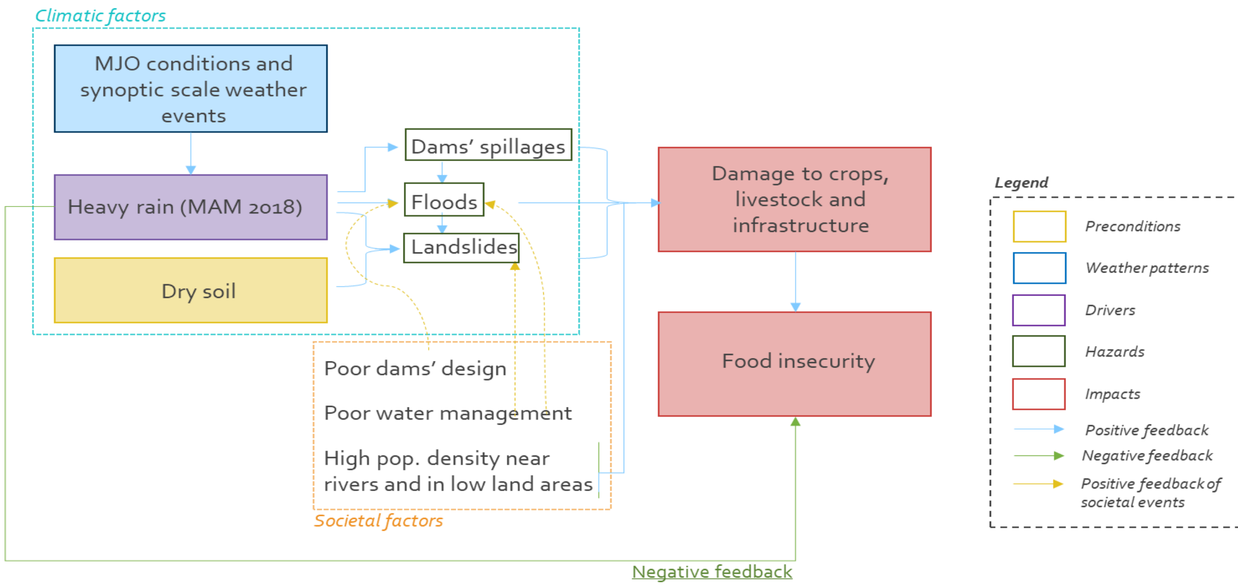
The international humanitarian appeal was also issued late, only on 16 March 2017: five weeks after the government declared the emergency (Grunewald et al., 2019). The delay could be explained by the general concern that humanitarian aids would be politicised by the government's campaign.

Besides, the new decentralised government structure also played a role in the drought preparedness and response. While it improved the quality of local early warning information, it also brought many disadvantages. Some counties functioned very poorly in the drought response as they were struggling with coordination at their initial phase (Grunewald et al., 2019). As expected, this also undermined the response of international agencies, which struggled to figure out with whom they should coordinate with in order to assist with the situation.

4.3.7 The impacts of heavy rain in 2018

At national level, the 2018 heavy rain resulted not only in negative impacts, but also in benefits. Some of the negative impacts led by cascading and concurrent events such as floods, landslides and dam spillage/failure were previously listed. In some counties, these events compounded with the previous experienced drought (Figure 49), resulting in impacts larger than expected. First, the dry soil compounded with heavy rain leading to landslides events. Second, dam operational strategies were set for drought conditions, which together with the low reliability of the long rain season forecast, led to the necessary and sudden overspills during the heavy rains (Weingärtner et al., 2019). Finally, the spatial correlation of the drought and flood impacts on cropland severely affected remote farmers and their coping capacities to respond to the flood.

FIGURE 49. Main elements of the compounded events that led to damage of crops, livestock and infrastructure in Kenya in March-May 2018



However, it is important to underline that overall, the heavy rain resulted in favourable conditions for the economic recovery of the country by interrupting the drought cycle (KNBS, 2017b). The rain events led to a full recovery of the water resources, important for both hydropower generation and other domestic uses. The rains also led to an increase in maize and wheat production, relieving the food insecurity in the country (Figure 51) (Weingärtner et al., 2019).

FIGURE 50. **At the bottom, drought impacts' factors that exacerbated the impacts of the heavy rain. On the top, the positive impacts of the heavy rain on drought**

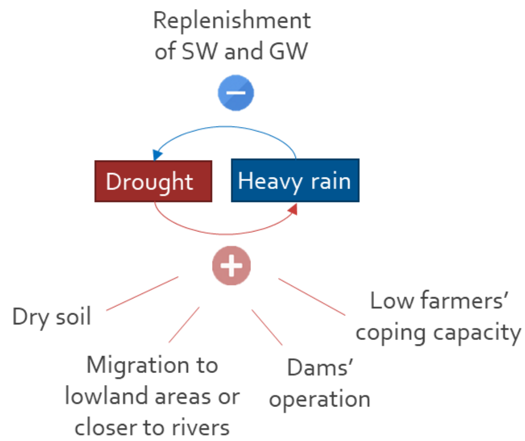
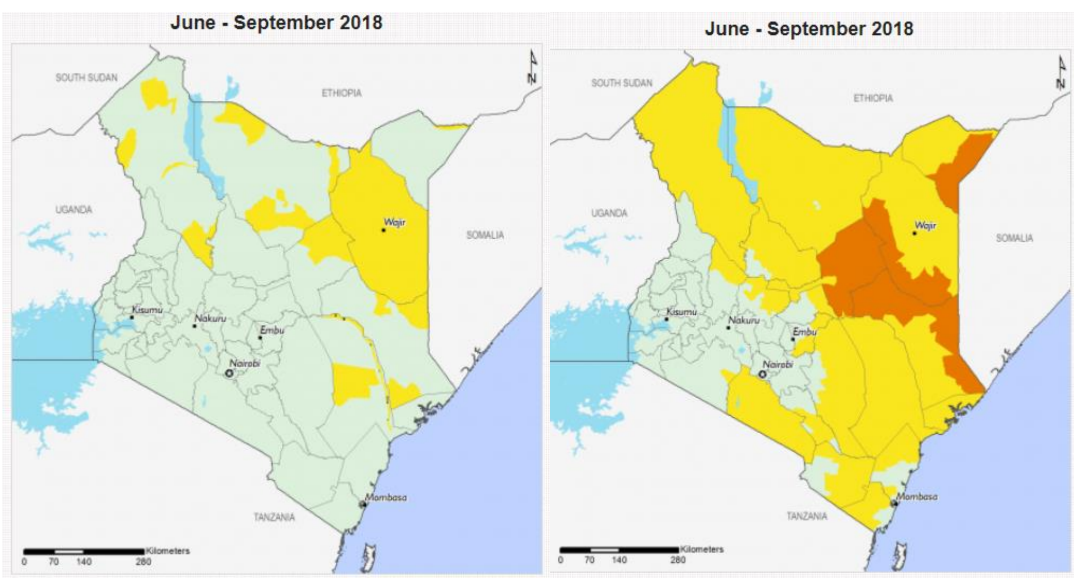


FIGURE 51. **On the left, food insecurity phases for June-September 2018 forecasted in February 2018. On the right, the actual food insecurity situation in June-September 2018 in Kenya (FEWS)**



Additionally, some reports (De Groote et al., 2020; D. K. Mwangi, 2018) suggest that the heavy rains helped to break the life-cycle of fall armyworm, by washing off the eggs from the leaves onto the ground. Indeed, the percentage of infested crops reduced from 40% to 10% in 2018 also thanks to government interventions (e.g., farmer trainings, distribution of pesticides) (De Groote et al., 2020).

4.4 Literature review: early signs and windows of opportunity for interventions

Looking at the chronology of the impacts described above, we can see that the compound events that characterized the humanitarian crisis in 2017 and 2018 in Kenya affected different sectors at different times. According to the heatmap (Figure 41), main drivers of the compound crises were the drought, the floods and the government election. This means that by considering both the climate forecast and the government agenda, the compound crises could have been timely forecasted. According to the time windows provided by the forecast, several actions could have been implemented. With indications of a first dry season in late 2016, early actions could have targeted preservation of water and pasture, as well as increase yield by planting drought-resistant crops. However, with indications of an expected sub-sequent dry season, early actions could have been scaled up to all sectors including servicing strategic water points that are used by large numbers of people and livestock during dry seasons.

4.5 Survey results

This section summarises the main results obtained through the online survey with 24 respondents (refer to Section 2.3 for methodology). It investigates the main drivers/impacts of the 2017-2018 humanitarian crisis in Kenya and the compound mechanisms that developed. Of the 24 survey respondents, 10 work at the national level, 7 at the regional level, 6 at the county level and 1 at the local level. Most of the respondents have experience in science and research while fewer are in the fields of politics, regulation and governance, technological engineering and economics/finance.

4.5.1 Impacts experienced in 2017-2018

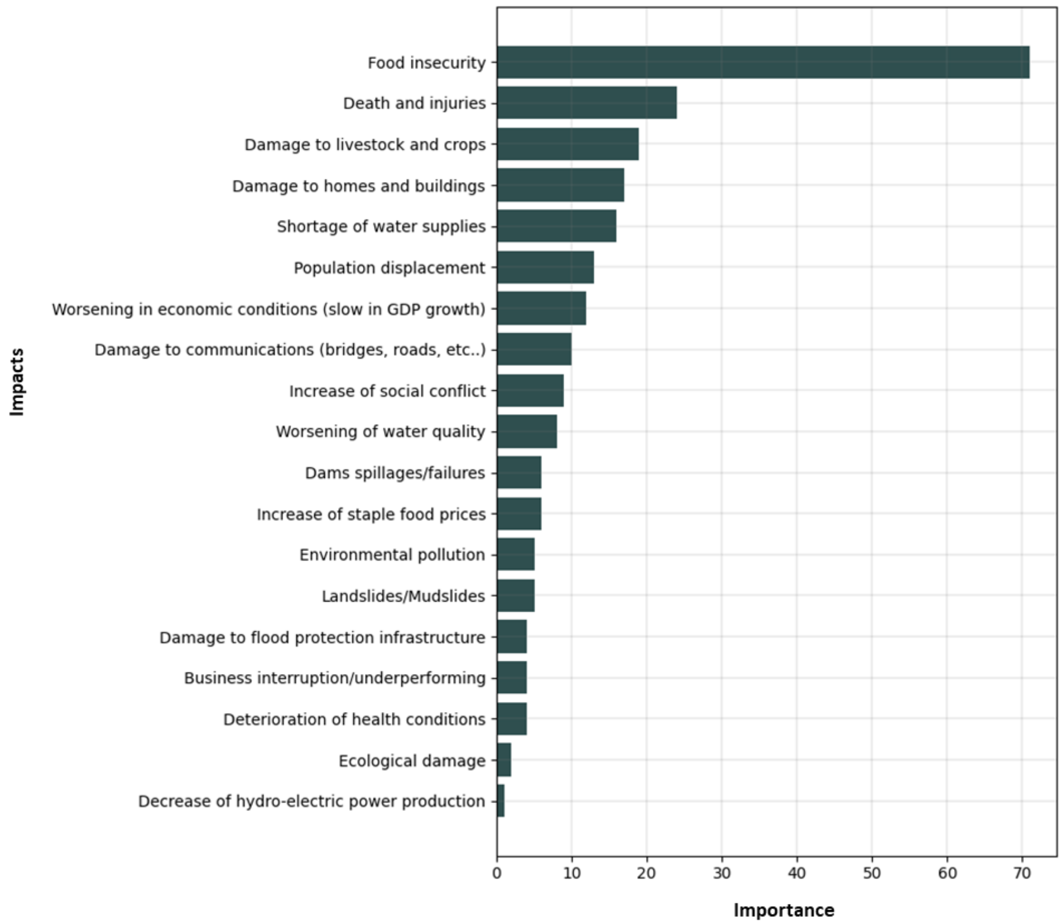
The number of impacts suffered in Kenya during 2017 was higher than in 2018 according to the survey respondents (Figure 52). In 2017, the Kenyan population experienced mainly impacts from the category of: 'socio-economic impacts' and 'damage to natural systems'. In particular, most of the respondents (21/24) selected food insecurity, followed by water shortage and ecological damage (20/24). Damage to livestock was perceived by slightly more respondents (18) than damage to crops (15). Also, environmental pollution, population displacement and worsening in economic conditions were considered relevant by 15 respondents. By analysing the period of Jan-June 2018, the respondents selected mainly impacts from the categories of damage to infrastructure, damage to natural system and socio-economic impacts. The impacts selected by the largest number of respondents for that time period are the damage to homes and buildings (18/24), followed by damage to crops and damage to communications (14 each).

Comparing the responses obtained for 2017 and 2018, we can see that: (1) the impacts of the category 'triggered disasters' were selected mainly for the year 2018 as well as the impacts in the category 'damage to infrastructure'; (2) crop damage was perceived as an impact both in 2017 and 2018 by almost the same number of respondents (14/15, respectively); (3) damage to livestock was perceived as a significant impact mainly during 2017 as well as decrease in hydropower production. The decrease in hydro-electric power generation was selected only by 2 people in 2018 compared to 10 in 2017, most likely in relation to the heavy rains recorded in March-May 2018, which led to a rapid increase in the water level of the tanks as previously shown in the literature review.

By asking respondents to identify the four main impacts experienced in 2017 and 2018 section and to rank them on a scale from one to four in order of importance, food insecurity substantially prevailed over others, followed by deaths and injuries, damage to livestock and crops, and damage to homes and buildings (Figure 53).

FIGURE 52. Impacts experienced in Kenya in Jan-Dec 2017 and in Jan-Jun 2018, according to the survey respondents. At the bottom, a timeline of the main events reviewed by the respondents

FIGURE 53. **Major impacts experienced in Kenya in 2017-2018 according to the survey's respondents**[6]

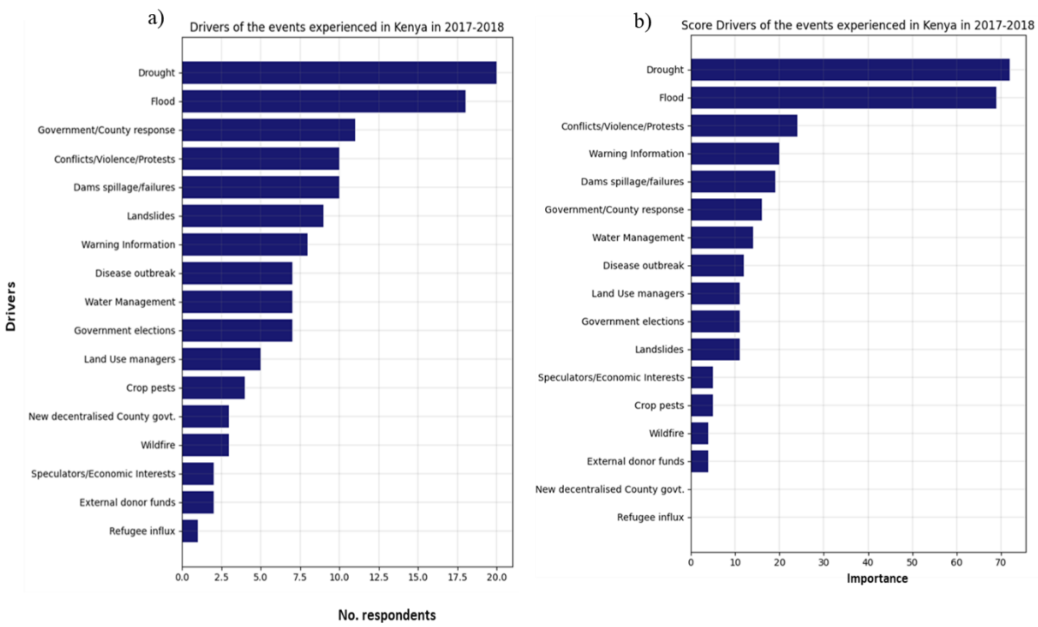


4.5.2 Drivers of the impacts experienced in 2017-2018

With wide agreement, both drought and flood events were selected as drivers of the previously identified impacts (Figure 54a). These were followed by the government/ county response, conflicts/violence, dam spillage/failure and landslides. Once the respondents were asked to identify the largest drivers among the previously selected drivers in terms of effect on identified impacts, again drought and floods scored the highest, followed by conflicts/violence, warning information and dam spillage/failure (Figure 54b).

[6] The level of importance was obtained by assigning a score of four to the impacts classified at the first level, a score of three for the second level, two for the third level and one for the fourth level. After that the scores obtained for each impact have been added up, so as to obtain a level of importance.

FIGURE 54. a) Drivers of the impacts experienced in Kenya in 2017-2018, and b) their score according to the survey respondents



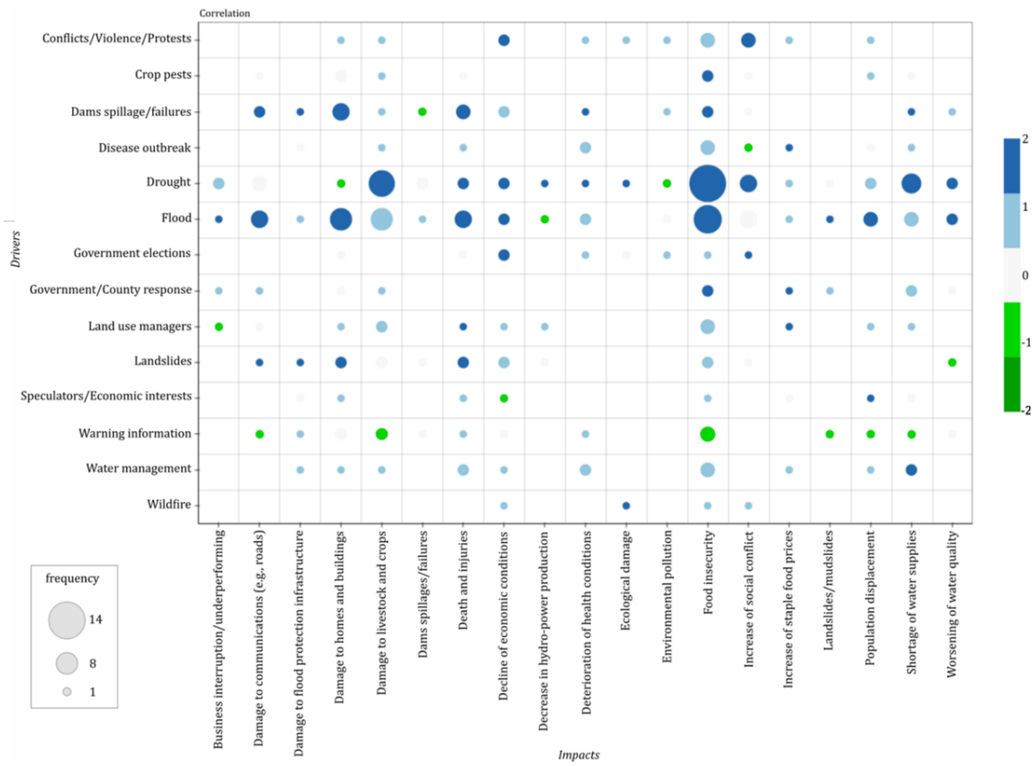
4.5.3 Interactions drivers/impacts

Consistent with the previous results, the heatmap (Figure 55) shows that drought and floods largely amplified food insecurity, along with dam spillage/failure, crop pests, and county government responses. The floods also resulted in population displacement, deterioration of water quality, deaths and injuries, business disruptions, declining economic conditions, damage to homes and buildings, damage to communications and landslides. Floods were negatively correlated to a decrease in hydropower production. This can be explained by the association of floods with heavy rains, which led to an increase water levels in the hydroelectric dams. On the other hand, the decrease of hydropower production was mainly related to drought.

Another interesting distinction that emerges between the impacts caused by drought and floods is in the social conflict, which has only been positively correlated with drought, ethnic conflicts and elections. The decline in economic conditions was mainly attributed to droughts, floods, government elections and conflicts. Another key finding is that although the warning information has been flagged to contribute to a slight reduction in most impacts, the lack or ineffectiveness of the government and county response is reported as an amplifying factor in the impacts experienced, particularly for food insecurity and increase in staple food prices.

According to the heatmap, the impacts experienced in 2017-2018 are correlated mainly to drought events, floods, landslides and dam spillages/failure. Therefore, interventions targeting these events could have broadly addressed the compounding impacts experienced in Kenya in the analyzed period.

FIGURE 55. Heatmap of the correlations between Drivers and Impacts in Kenya in 2017-2018 made by the respondents. The size of the circle represents the number of respondents that selected the analyzed correlation. Blue indicates a positive correlation, while red colors represent a negative correlation
Legend: +1 (slightly amplified), + 2 (largely amplified), -1 (slightly reduced), -2 (largely reduced)



4.6 Semi-structured interviews

The evolution of compound events in Kenya during 2017-2018 was further studied through semi-structured interviews addressing four main topics: (1) driver/impact mechanisms of the 2017-2018 humanitarian crisis; (2) DRR/DRM policies and response; (3) windows of opportunity for proactive interventions, and finally (4) early warning signs of compound risks in Kenya. In the following sessions, we summarised the respondents' answers on each topic.

4.6.1 Drivers/impacts mechanisms

All respondents indicated drought and flood events as the main drivers of food insecurity experienced in 2017-2018 in Kenya, confirming the previous survey results. In particular, according to the interviewees, the incidence of droughts and simultaneous/ consecutive floods have resulted in the escalation of numerous catastrophe events such as waterborne disease outbreaks, crop pest infestations, and conflicts. The latter has often been cited as a result of climate change/variability in Kenya. According to respondents, conflicts in Kenya are primarily driven by competition over scarce resources that easily escalate during drought and flood events. Resource competition is accentuated by past ethnic tensions and by the predominance of pastoralists especially in the arid and semi-arid regions that migrate in search of pastures and water.

"Conflicts in Kenya are usually attributed to climate change, because the incidence of floods and the long drought push pastoralists to move to other communities and steal their animals, which often results in violent conflicts."
(climate change and adaptation expert)

Three out of five respondents to whom the question was posed also mentioned the election period as one of the main aggravating factors of the impacts experienced. Accordingly, during major political events the budget available for the response is further reduced, the response is slow as the focus is on politics and violence increases, reducing accessibility to certain areas even for international organizations.

"*Elections are a terrible aggravating factor once they occur at the same time as a drought or other disasters. Because you know you're in trouble."*
(expert from the water private sector)

However, the election was not taken into account when impacts were predicted in the country, resulting in larger impacts than forecasted. According to the respondents, other underestimated events were the floods in the country, which have only recently begun to receive attention given the increasing incidence rate in the years 2018, 2019 and 2020. Especially arid and semi-arid counties are recently suffering impacts from flooding just as devastating as those experienced with drought. Given the presence of bare soils and sparse vegetation, a small increase in rainfall compared to average values can lead to widespread flooding with consequent soil erosion, damage to crops, livestock and homes, and further reduction of accessibility to communities, markets and health services. The impacts are further exacerbated by the lack of investments in flood disaster risk reduction/management (DRR/DRM) since the primary focus is on drought and by the lack of a specific authority or institutional framework for flood response.

"The areas considered arid due to the usual scarce rainfall are those that in recent years have mainly suffered floods. The government has classified these areas as arid and, therefore, the plans and activities in these areas are mainly trying to address the drought problem. But now we are in a situation where flood events are becoming the main events and the pressing issue in drylands."
(climate change and adaptation expert)

The heavy rains of 2018 not only resulted in severe flooding, but the respondents also mentioned its long-term positive effect on hydropower, crops and livestock production due to the replenishment of water sources and soil moisture. However, it has also been said that mainly central regions had benefited extensively from heavy rains as they have good infrastructure and hydroelectric dams. On the other hand, arid and semi-arid counties have been disproportionately affected by the heavy rain, with impacts that largely exceeded the benefits.

4.6.2 Coping mechanisms

Migration is one of the main coping mechanisms adopted by pastoralists when water and grazing are scarce. As pointed out in the previous section, this mechanism can increase the risk of conflicts or the exposure to flood events. According to the respondents, pastoralists are aware of the effects of their actions but feel they have no other options. The absence of alternatives pushes people to adopt the only behaviour that allows them to survive, even if this leads to reinforcing the compound mechanisms.

"Pastoralists are aware of the potential risk that they might incur if they graze their cattle in agricultural areas (e.g., causing conflicts)[7] or if they move to water source areas (e.g., increasing their exposure to floods). However, they will take the risk since they have no other options."
(economist & drought experts in pastoralist areas)

Driven by immediate needs, pastoralists may also take decisions that are not actually the most insightful in the long run, such as selling their animals during a drought period for a low price. This is because they mostly think short-term once hit by a crisis.

4.6.3 Response/DRR policies

The overlap of disaster events presents unique challenges in generating national policy responses mainly due to a lack of financial resources. According to respondents, decision-makers encounter difficulties in finding new budgets or redirecting the money that was allocated for a first event to a new event. Therefore, often, development funds are redirected to cope with a disaster, resulting in feedback loops that further exacerbate the impacts.

"They reallocate development funds to deal with disasters. And because of this reallocation, you will find many knock-on effects. For example, the government had to pay the nurses but then the money was not there, because it was used to cope with the increased incidence of cholera. So, you have the feedback that nurses start strike due to the lack of money to pay them and this leads to an increase of the mortality rate." (climate science for decision making expert)

The reallocation of development funds to disaster response interventions is detrimental especially in fragile contexts, where these funds support the livelihoods of many people.

"Our system is not robust enough to address an emergency without causing problems to areas that are in continuous need of development aid."
(expert from the water private sector)

A further problem in generating effective response policies is the poor understanding of the risks and their compound effects. Together with the lack of financial resources, this has not allowed yet the development of a multi-risk system that looks at the ripple effect. Without a system that tracks the causal chain it is difficult to effectively prioritise events and resources. A step forward in improving understanding of hazards in some areas is the development of local risk profiles that could be fed into national and county disaster management/response plans. Among the different plans, the contingency plan was the most cited by the respondents due to its importance for both single and multiple risk preparedness and response. With the support of local risk profiles, different scenarios could be developed, and the response activities could be respectively identified a priori, taking care of selecting response measures that do not increase the vulnerability and exposure of the population and economic sectors to other hazards. Identifying effective interventions is even more challenging once the risk to which the population is exposed is new (e.g., fall armyworm, Covid-19). Especially in areas exposed to multiple risks and with a fragile context, a poor understanding of how a certain response can influence exposure and vulnerability to other hazards further slows down intervention and can result in chain effects.

[7] In brackets our clarification.

"Chemicals used to fight locust infestations can be dangerous to livestock that eat the treated pasture. So it takes a long time for the government first to decide which chemical to use, second the response times, and third to provide the information to the community. When the system gathers to provide a response, you discover that it is too late, the damage has already been done and the locusts have eaten the vegetation." (climate change and adaptation expert)

Respondents also cited the importance of involving communities in the design of response interventions, as communities are more aware of the possible ripple effects that could result from a certain response. Another factor that hinders an effective response during compound events is the weak institutional framework. According to the interviewees, the roles are unclear and overlap (especially with regard to flood management), and coordination and communication between ministries and agencies can be improved.

4.6.4 Windows of opportunity for proactive interventions

Possible windows of opportunity for intervention during the humanitarian crisis of 2017-2018 and in general were discussed with respondents. Three windows of opportunity were mentioned: (1) before compound events; (2) immediately upon publication of the forecast of key events; (3) between the events and the peak of the impacts.

The most cited time windows were the second and third, even if the interviewees proposed mainly semi-structural interventions which, given the required implementation times, can be carried out mainly in the first time window. The interviewees underlined the importance of interventions during the dry seasons with the aim of reducing the impacts of potential heavy rains (e.g., floods, soil erosion) and at the same time, fully benefiting from the heavy rains (e.g., groundwater recharge, water storage for irrigation). For the case study under analysis, these interventions could have been implemented during the long drought period to prevent heavy rains from giving rise to impacts that overlapped the impacts of the drought.

In addition to the importance of enhancing water storage techniques (e.g. rainwater harvesting, dams), another semi-structured measure often cited to address compound risks was the drafting of a contingency plan at the national and local level, linked to a pre-assigned fund. Other semi-structural measures mentioned were: (1) the harmonisation of DRR and DRM policies aiming at clearly defining roles and responsibilities, coordination between different sectors/programs, (2) structural hand-over process (or also called exit strategy) of development programs to communities with the aim of reducing vulnerability to hazards recovering the programs already implemented in the areas, and finally (3) the establishment of agent networks for supporting and advising farmers and pastoralists during shocks.

As examples of suitable interventions soon after the forecast (second time window), respondents suggested the use of drought-tolerant crops and interventions aimed at reducing conflicts such as the planning of pastoralists' mobility. Finally, for the time window that goes from the events to the peak of the impacts (third time window), the interviewees proposed direct interventions to the market prices aiming at protecting both consumers and sellers. Specifically, the prices of agricultural inputs, such as medicines for animals, fertilizers and pesticides, need to be affordable during drought/flood events.

4.6.5 Early warning signs

Since respondents considered compound events in 2017-2018 primarily triggered by drought and flood events, weather/climate anomalies were considered the most important early sign of compound risks. Through climate signals, outbreaks of water-borne diseases such as malaria and crop pests infestations can be predicted. However, the interviewees also argued that this information alone would not be sufficient to predict the impacts of compound events.

"If I'm sitting in a government office and I want to predict compound events,
the accurate forecast of droughts, floods, and crop pests wouldn't be enough.
There is an important factor here, which is the people."
(expert from the water private sector)

In line with this, also socio-economic indicators were mentioned as possible early signs of compound events, such as livelihood types (to understand possible exposure and vulnerability), migration patterns/cross-border movements (especially pastoralist movements) to predict possible violence and conflicts, market trends, disease outbreaks, and access to health services.

Another important element that needs to be considered once compound events are predicted is the government agenda, including political unrest, elections/referendums, and possible new changes in government structures. These elements strongly influence the ability of the Kenyan national and county system to respond to disasters.

4.7 Summary & discussion

Drivers/impacts mechanisms

As seen in the literature (Section 4.3) and highlighted in the survey and semi-structured interviews (Subsection 4.5.3 and 4.6.1), drought, floods and government elections appear to be the trigger events of the cumulative impacts that led to the humanitarian crisis in 2017-2018 in Kenya. The long drought experienced in 2017 was not caused by a single extreme event, but was the result of successive low/moderate dry spells occurring in 2016 and early 2017. The below-normal rains during the later short rainy season (OND season) in 2016 and the long rainy season (MAM) in 2017, caused extreme impacts as they overlapped with each other and with the impacts resulting from the poor rainy season in early 2016.

Alongside the impacts of drought on agriculture, the fall armyworm infestation also played an important role in the crop impacts, since it coupled with the impacts of the concomitant drought. It was also the first time that Kenya experienced such an infestation, which brought uncertainties on the possible response actions. Besides, the new government structure undermined disaster response actions during the transition period due to unclear responsibilities and communications, and loss of experience.

Drought impacts and conflict showed to be mutually reinforcing in Kenya, giving rise to feedback loops. Scarce water and poor forage forced pastoralists to migrate to other territories, exacerbating existing ethnic tensions. The state of violence increased displacement, reduced humanitarian access and led to trade disruptions. On the top of that, the electoral campaign proved to be decisive in the escalation of the violence that occurred in 2017, exacerbating the existing ethnic tensions.

Finally, heavy rains have caused devastating impacts, especially in the drought-stricken communities. These were mainly located in arid and semi-arid regions and did not have adequate infrastructure to benefit from the abundant rainfall. Impacts were also exacerbated by coping mechanisms adopted during the drought that increased exposure and vulnerability to the floods (e.g., migration close to water sources, reduced investment in dam maintenance). At the national level, however, the benefits induced by heavy rain far outweigh the impacts suffered. The event stopped the drought cycle, replenishing water sources and hence resulting in abundant crops and pastures. This clearly shows the importance of undertaking drought response actions that do not increase the impacts of possible floods (e.g., encouraging the allocation of people in lowland areas), but also that can boost the positive impacts of above-average rainfall on drought effects.

The above mechanisms are graphically summarised in the cognitive map in Figure 56, developed according to the literature review and semi-structured interviews. The complex chain mechanisms shown in the figure were further aggravated by the fragile Kenyan context characterized by structural poverty and government budget shortfall. The constant need for development aid by certain counties and the lack of national resources resulted in extreme challenges in the generation of adequate national and county response policies. During the escalation of the events, decision-makers struggled in re-directing the money that had been allocated for a first event to a new event, or in finding new budgets. Most of the time, development funds were redirected to cope with a new disaster. This resulted in a worsening of the situation in counties chronically affected by food insecurity and in the nurses' strikes due to the late payment of their salaries. The events created positive feedback loops that further exacerbated the level of malnutrition in the arid and semi-arid regions. The national and county response was also undermined by the election period, which shifted the focus from drought impacts to politics.

By discussing the events that characterized the most recent humanitarian crisis in 2019-2020, the importance of the government agenda was once again underlined by the interviewees as a determining factor in forecasting the effectiveness of the national response to disasters. Another similarity identified in the comparison of the events that characterized 2017-2018 with those that occurred in 2019-2020 was the novelty of the armyworm infestation in 2017 and Covid-19 in 2020. Even though these events occurred on an entirely different scale, they were both new to the Kenyan population who struggled to timely identify response actions.

Early signs

The possible early signs are identified according to the drivers and driver/impact mechanisms analyzed in the previous sessions. These are weather factors, bio-physical indicators (e.g., soil moisture, NDVI) and socio-economic factors such as the rate of ethnic clashes, migration patterns, staple food prices and political events. These are summarised in Figure 57 under the name indicators/triggers, according to each identified windows of opportunity.

When these indicators are assessed, it is important to take into account their variability over space and time. In the years 2017-2018, the compound mechanisms identified show indeed high variations over time and space. Not all mechanisms developed in the same time and in the same way throughout the country due to the topographical and socio-economic variability between the north-central counties and the eastern counties. Below, we further explore the importance of these two dimensions when compound risks are being assessed through early signs.

Spatial variations

Accurate weather forecasts are seen by survey and interview respondents as an important information for timely forecast climate-related risks. In the years 2017 and 2018, the drought and subsequent flood events hit a large part of the country. Therefore, the regional rainfall forecasts already provided important early signs of the upcoming risks. However, if weather forecasts are analyzed individually, the estimate of the impacts of extreme meteorological events can be highly underestimated, especially when compound mechanisms occur. Heavy rain after the long drought had major impacts in arid and semi-arid counties, but also greatly benefited the north-central counties. This shows how the same events led to the development of two different compound mechanisms as they were also influenced by the different socio-economic characteristics and types of soil/land use between the two regions.

The national GDP seems to reflect well the humanitarian crisis that Kenya was going through in 2017, as well as the national prices of basic food products. Both provided a good picture of the country's high socio-economic vulnerability to further shocks. However, they failed to depict the impact of widespread flooding on drought-affected communities in arid and semi-arid regions in early 2018, and thus the increase in their vulnerability to future disasters.

Temporal variations

The environmental, economic and social vulnerabilities were highly dynamic in the period under review and played an important role in the development of the compound mechanisms identified. For example, the drought experienced in 2016-2017 was the result of a series of dry spells. Using the rainy season forecast in MAM 2017 alone would not have been enough to forecast the drought event without taking into account the low soil moisture resulting from the previous low rain seasons. Another example is the risk of landslides which increased when heavy rains occurred immediately after the long drought due to the aridity of the soil. Finally, another example is the growing economic vulnerability of pastoralists to flooding due to the impacts of the previous drought. Therefore, among the first signs of compound risks, we should also consider the physical and socio-economic pre-conditions that can be taken into account in the analysis in the form of vulnerability or resilience of the system to further shocks.

Windows of opportunity for interventions

Windows of opportunity to implement anticipatory actions have been identified by combining the impact calendar with the crop calendar and the releases of climate forecasts for the analyzed period (Figure 57). These were re-adapted from a Kenyan Red Cross work that primarily aimed at identifying windows of opportunity for the drought impacts in 2016-2017 (E. Mwangi et al., 2020). Using the literature review, the impact calendar was enlarged to encompass both social and economic impacts, such as population displacement, staple food prices, conflicts, deaths, and ecological damage and health conditions.

From the impact calendar, it becomes clear that the compound events in 2017 and 2018 did not affect all sectors to the same extent and at the same time. Therefore, early actions (Figure 58) could have targeted different sectors based on existing windows of opportunity. Ideally, early actions could have been directed to the agro-pastoral sector and only later, once the second dry season was forecasted, upscaled to all sectors. Early actions should also have aimed to increase benefit from the abundant forecasted rain (e.g., by enhancing simple rainwater harvesting techniques) while reducing its impacts (e.g., by providing medicine and vaccine for livestock.

FIGURE 56. **Cognitive map of the humanitarian crisis in 2017-18 in Kenya**

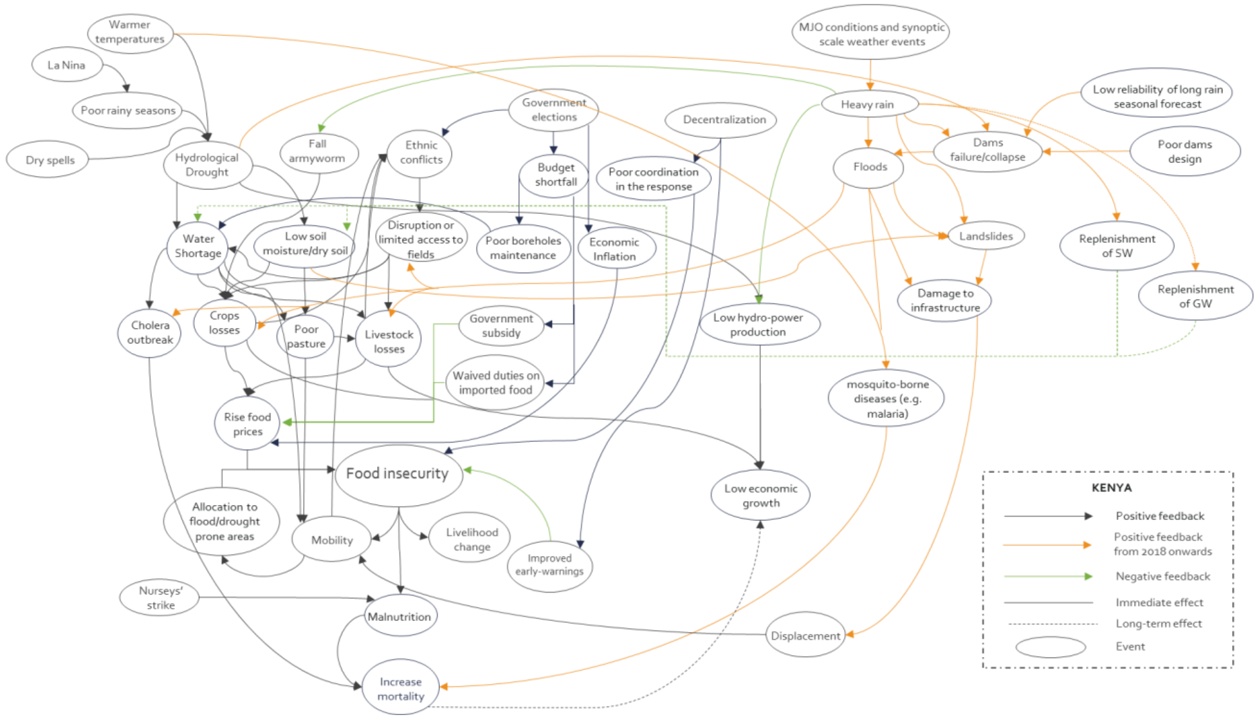


FIGURE 57. **2016/2017/2018 impact calendar with trigger indicators and possible windows of opportunity for implementing early action**

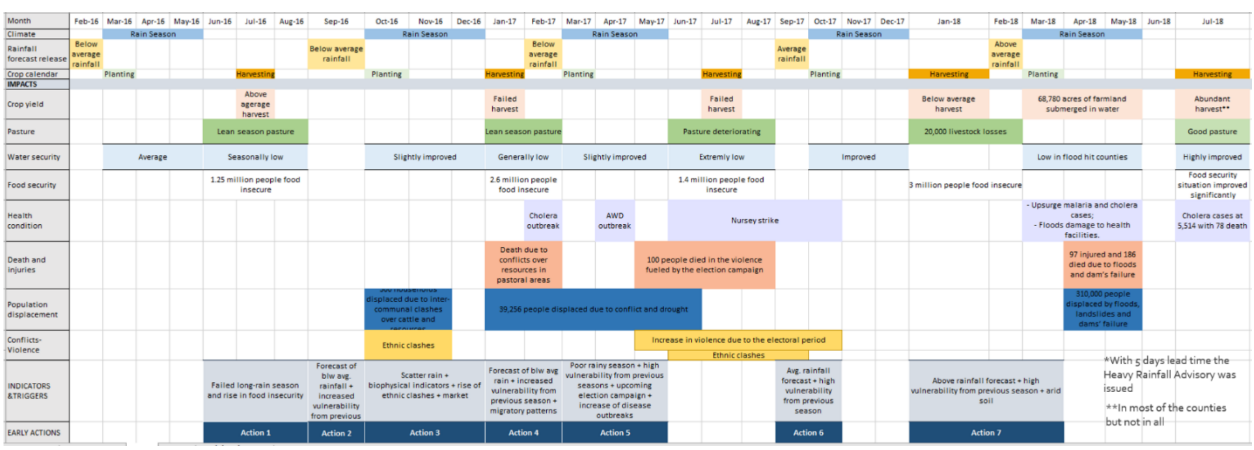
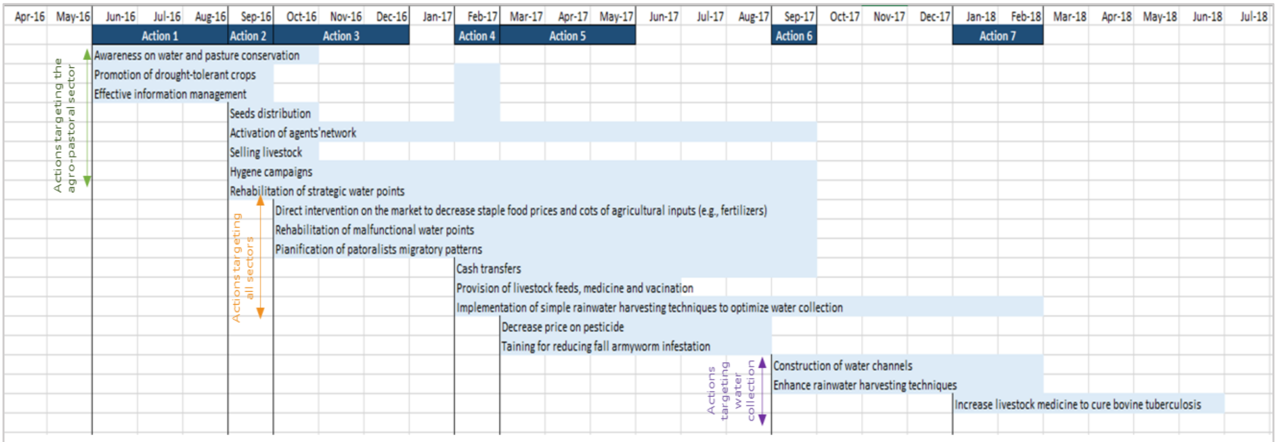


FIGURE 58. Possible early actions to implement according to the available window of opportunity. The colored cells represent the time frame in which these actions can be carried out



5. Discussion & Conclusions

From the analysis carried out on the 2017-2018 humanitarian crisis in Kenya and Ethiopia, a series of general conclusions are drawn in the following sections.

5.1 Drivers/impacts mechanisms

Main drivers and compound effects in the Ethiopian and Kenyan humanitarian crises of 2017-2018

It would be misleading to attribute the 2017-2018 humanitarian crises in Ethiopia and Kenya to the confluence of just one or two sectoral threats. These crises were the product of interactions between various physical and social factors, including consecutive dry spells, political events, changes in government structure, mobility, ethnic violence, and heavy rains. Contributing factors rapidly compounded with challenging socio-economic and institutional contexts in Ethiopian and Kenyan, characterized by political instability, structural poverty, climate-sensitive food systems, and rural communities dependent on rain-fed agro-pastoral activities. Despite the considerable impacts that ensued, specific interventions could have been prioritized in order to reduce the impacts of these compound crises threats and prevent cross-sectoral spillovers. Key takeaways from the research are presented below.

Compound mechanisms can increase or decrease risk

The compound events in 2017-2018 resulted in both positive feedback loops (aggravating the impacts) and negative feedback loops (reducing the impacts). The combination of drought, ethnic conflicts and displacement resulted in a series of mutually reinforcing mechanisms. Drought affected the migratory patterns of pastoralists, aggravating resource-based conflict and the inter-communal competition over land. This resulted in increased insecurity, which restricted access of humanitarian aid in both countries, further exacerbating the impacts of drought at local levels. In Ethiopia, politically-driven ethnic conflicts displaced entire communities in drought-prone areas and prevented aid from reaching villages now located in conflict zones. The long drought increased competition for resources and displaced drought-stricken communities, often into areas with different ethnic profiles.

A period of drought was quickly followed by heavy rain. While drought solely resulted in negative effects, the subsequent rains generated both positive and negative feedback loops. For example, meteorological drought increased soil aridity meaning that when heavy rain fell on drought-dried soil, areas were much more susceptible to landslides. Long periods of drought also influenced the operational management of dam infrastructure. When reservoirs quickly filled, stored water was suddenly released, causing much severe flooding that would not have occurred if water would have been released gradually according to flood control operational strategies. Finally, the flooding affected rural communities that were still dealing with the ramifications of drought. The quick succession of drought and flood meant that communities suffered the effects of both too little and too much rain, with insufficient time to recover from one before enduring the other.

Conversely, while the heavy rainfall in early 2018 brought flooding, it also replenished the water sources parched by two years of drought. The beneficial effect of these rainfall events was predominant in central-northern Kenya, where the presence of adequate infrastructures (e.g., dams) and sufficient vegetation-cover allowed better retention of rainwater, reducing the development of floods. In eastern Kenya and in the Somali region of Ethiopia, insufficient flood control structures and the arid soil, combined with the heavy rains, resulted in widespread flooding; in central-western Kenya, with highly variable topography, the abundant rains also brought landslides. Outside central-northern Kenya, the rain was more aggravating than beneficial in the short-term.

The example above shows that compound mechanisms can both increase and decrease the risk of food insecurity and that the type of compound effect (positive or negative) depends on the physical environment and socio-economic conditions of the affected area. Therefore, it is important to pursue early actions that boost the beneficial effects of a compound event. For example, in the humanitarian crisis in 2018, water storage systems (tanks, ponds, etc.) could have minimised the harmful impact of heavy rain (e.g., flood and soil erosion) while increasing its benefit during periods of drought. For instance, rainwater harvesting techniques were used as an adaptation strategy for drought and flood mitigation in Indonesia by UNFCCC, implementing rainwater harvesting systems in public schools. (OCHA, 2013)

Coping mechanisms for one hazard may increase vulnerability and exposure to other hazards

Several coping mechanisms adopted by the rural communities in the humanitarian crisis in 2017-2018 proved more detrimental than beneficial. For example, pastoral communities migrated in response to livelihood insecurity, but doing so only made them more vulnerable and exposed to flooding and conflict. Usually, migration is a measure adopted by rural communities when their level of food insecurity is already high and they feel they have no other solution to avoid hunger, despite being fully aware of the risk they could incur. Yet migration can in some cases raise the communities' risk to subsequent shocks. If migration is inadequately managed, it can actually exacerbate existing ethnic tensions or increase the vulnerability and exposure to other hazards.

To avoid these positive feedback loops, it is important to raise people's awareness of different coping strategies. Extension agent networks can help in this effort by supporting and advising farmers and pastoralists during shocks. These mobilized networks can equip rural communities to respond to rising food insecurity with coping strategies that will not be harmful to them in the foreseeable future. The importance of agent networks is highlighted by research from ILRI which shows the benefits of this model for Tanzanian farmers.[8] Similarly, governments and NGOs can develop pastoral migration frameworks that account for stakeholders' various interests and that set up conflict management and regulate migration routes. These frameworks can reduce the risk of ethnic tensions caused by resource competition during periods of high food insecurity. This preventive measure was cited among the best practices identified by the United Nations Peacekeeping in a study carried out in 2020, where practices to prevent, mitigate and resolve pastoralist migrations conflicts were reviewed across Africa.[9] Better knowledge of migration patterns and routes also helps governments identify infrastructural requirements, which further decreases the risk of tensions over natural resources.

National/international response interventions could create new risks

While the national and international response to droughts, floods, conflicts and displacement may lessen the harm of the crises they specifically address, they can actually cause new problems or worsen others. For example, uneven distribution of humanitarian aid, such as between farmers and pastoralists, can

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[8] Rao, E.J.O. 2019. Agent Network Model (ANM) for extension. Poster prepared for the Maziwa Zaidi Agribusiness Forum, Moshi, Tanzania, 17 October 2019. Nairobi, Kenya: ILRI

[9] Preventing, Mitigating & Resolving Transhumance-Related Conflicts in UN Peacekeeping Settings Survey of Practice, 2020 (http://dag.un.org/handle/11176/401074)

exacerbate existing inequalities or create new ones. Furthermore, risk reduction measures that address hazards individually can aggravate vulnerability to other disasters. Some examples are the reallocation of people to flood- or drought-prone areas (increasing exposure to floods and droughts) or the construction of dams (increasing the hazard of dam collapse).

Response measures should address multiple risks in an integrated manner and not individually. To this end, information on particular risks must feed into larger decision-making processes that take the wider scope of risks into account and that consciously avoid response mechanisms' negative, short-sighted consequences. Examples on how country risk profiles can be used to inform disaster risk management are provided by United Nation Disaster Risk Reduction in a guidance document.[10]

Compound effects vary over time and space

In early 2018, heavy rains brought significant flooding in a very short time frame, worsening food insecurity. However, in the longer term, the rains replenished water sources dry from the long drought, reducing food insecurity. This sequence occurred mainly in central Kenya, and less so in the arid and semi-arid regions of Kenya and Ethiopia. These latter areas lacked the infrastructure (e.g. dams) and sufficient vegetation-cover that would have reduced flooding and landslides, and allowed the areas to instead benefit from the heavy rainfall.

The example above shows how the cascading impacts of certain compound mechanisms vary over time: an event can have negative effects in the short-term, while being positive in the longer term, and vice versa. But the scenario also shows how compound events can differ widely within the same national territory when the environmental and socio-economic contexts differ: while an event may be good in one area, it may cause harm in another if that other area is not prepared to withstand or benefit from it. It is therefore important, when analysing compound risks, to (1) increase the spatial resolution of the analysis and (2) consider the temporal dynamism of vulnerability.

Compound events present a unique challenge in generating national response policy to disasters

The occurrence of simultaneous and consecutive events presents unique challenges in generating national policy response, in part because of financial resource constraints. Decision-makers struggle to redirect money allocated towards the first event's response to the seconds, and the money spent on the first event means there is less funding available for the second. In cases where resources are redirected, the original intended use often still requires funding; while the new allocation is also important, it withdraws necessary resources from the prior crisis response.

It is therefore important that disaster response funds are allocated in advance and that their amounts reflect the analyses based on multi-risk scenarios developed in national and regional contingency plans. The funds need to be linked to early warnings that activate the financial mechanisms in a timely manner. One example is the ex-ante financing instrument developed by the Red Cross as part of the Forecast-Based Financing system. The instrument automatically allocates funding once a forecast reaches a predetermined level of danger. This system, however, is still under development, especially for slow-onset hazards like droughts, and it analyses the hazards individually. Further studies are needed for upscaling it to a multi-risks warning system.

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[10] Guidance Note on Using the Probabilistic Country Risk Profiles for Disaster Risk Management, CIMA and UNDRR, 2020 (https://www.undrr.org/publication/guidance-note-using-probabilistic-country-risk-profiles-disaster-risk-management)

5.2 Early warning systems

To monitor compound risks, dynamic vulnerability needs to be taken into account

When monitoring compound risks, one must consider how vulnerability varies with context. Vulnerability can differ significantly when multiple shocks occur in succession, or concurrently. For example, dry spells in 2016 and 2017 led to a long period of drought in both Ethiopia and Kenya because the soil was already very dry. The effect of the meteorological event was much more devastating than would be anticipated in an analysis of similar precipitation levels that did not take pre-existing conditions into account. Similarly, the flood event in 2018, as discussed above, was far more destructive because of the preceding drought. An analysis that assessed the heavy rains in isolation would not anticipate the same level of flooding and landslides.

Early-warning signs for compound risks in Ethiopia and Kenya

Although there are some differences in the main drivers of Ethiopia's and Kenya's 2017-2018 humanitarian crises, and their socio-economic and environmental conditions, the above analysis shows similar compound mechanisms developed in both countries. Therefore, the early warning signs of the compound events in the two countries differed only slightly. For both Ethiopia and Kenya, forecasting extreme weather events is particularly important when monitoring compound risk, especially because both countries' economies and livelihoods heavily depend on rain-fed agro-pastoral activities. Climate shocks can easily compound with the fragile contextual conditions present in both countries, triggering mechanisms that further aggravate the weather-driven effects. Climate indicators can also provide information on the likelihood of crop pest infestation or water-borne diseases.

However, weather forecasts alone are not sufficient to monitor compound risks; other biophysical and socio-economic indicators must also be observed when available. Indicators such as market trends, variation in staple food prices, increase in rate of clashes/violence, and increase in seeking financial resources can all provide information on upcoming socio-economic shocks. Biophysical indicators (such as NDVI, soil moisture) can help in monitoring the temporal variability of natural system, which can highly vary once consecutive or simultaneous shocks occur. Socio-economic indicators allow us to monitor the vulnerability of the human system over time. These can be categorized as semi-static indicators (such as infrastructure types and demographic information), which need to be updated only annually or semi-annually, and dynamic indicators, which need to be monitored continually. Dynamic indicators include migration patterns and cross-border movements. Beyond signalling the crisis events that may have propelled the relocating, these indicators also provide information on the changing vulnerability and exposure to risks, as settlement patterns are reconfigured. For example, the rapid increase of IDPs in 2017 due to drought and conflicts in Ethiopia quickly escalated the country's vulnerability and exposure to floods, as entire communities now lived in precarious shelters and overcrowded areas.

It is also important to monitor government transitions and political events. In both the examined countries, the capacity to effectively respond to possible shocks was influenced by political structures and developments. Political events appear to have a significant impact on the timeliness and effectiveness of government interventions during a crisis, with the potential to exacerbate impacts and lead to further compounding impacts (e.g., ethnic violence).

Importance of the spatial and temporal variations

The indicators listed above need to be monitored over time and with finer spatial resolution. The spatial variation of compound mechanisms discussed above ('Compound mechanisms vary over time and space') highlighted the importance of capturing the spatial socio-economic and topographic differences within the national territory. This is extremely relevant for Ethiopia given the high topographic and climatic spatial variability, but also for Kenya where differences in soil type, land use and infrastructure led to different drought–rain effects.

5.3 Windows of opportunity and early actions

Compound events do not affect all sectors at the same time and with the same magnitude

In 2017-2018, compound events in Ethiopia and Kenya did not affect all sectors to the same extent and at the same time. Therefore, early actions could have targeted different sectors based on the possible windows of opportunity. Looking at Kenya, the first failure of the rainy season in late 2016 had only a small impact on crop and livestock production. Therefore, once the weather forecast was issued, early actions could have prioritized structural and long-term measures (e.g., increase awareness). A second failure of the rainy season resulted in impacts on yields and pasture. In this case, early actions could have been aimed at pastoralists and farmers. By the third failure of the rainy season, agricultural and industrial sectors were impacted and the level of water insecurity peaked. This required interventions to all sectors especially in the context of the upcoming elections. At this point, the response should have focused on short-term, less-structural measures, such as decreasing staple food prices and agricultural inputs as well as rehabilitating existing boreholes.

Possible windows of opportunity for interventions during the development of compound risks

As shown by the findings from this analysis, compound events are convoluted with multiple drivers, spillovers and impacts. While designing dedicated response activities is a challenge, it is possible to identify three main windows of opportunity that can guide effective risk management activities.

i. Prior to the onset of a compound crisis:

This time window provides opportunities to address structural issues and implement long-term risk reduction measures. Such activities relate to efforts to reduce future vulnerability and exposure of key hazards. This includes measures to tackle underlying causes of vulnerability such as poverty reduction strategies, social protection systems of resilience-building activities. The window is also a valuable opportunity to promote crisis preparedness measures at national and local levels. Supporting such measures can not only reduce the risk of a given hazard resulting in a disaster event, doing so also significantly reduces compound risk as a result of knock-impacts that can ensure from the initial trigger event.

ii. Immediately after a hazard is forecasted:

Forecasts and real-time early warning systems provide valuable windows to support preparedness and response activities. The ability to provide accurate forecasts (and the length of advertised warnings) will differ depending on the type of hazard. In the case of climate variability, seasonal forecasts can provide meaningful warnings regarding conditions of above or below average rainfall to national and local decision makers up to 3-month in advance. Weather forecasts can also provide information about the likelihood of extreme weather events, with actionable accuracy up to 10 days and beyond. While these timeframes do not typically allow risk prevention, they can support decision makers in promoting preparedness and response activities days and months in advance of trigger events.

iii. **Shortly after the start of one or more trigger events:**

Under this window, options are severely limited as the initial trigger event(s) has already started. However, responding immediately after an early hazard (one that has the potential to develop into a compounding event) can help to significantly reduce the risk of spill overs cascading across sectors – factors that often lead to complex crises given the exponential nature of their development.

Structural and short-term interventions are discussed in the following sub-section.

5.4 Policy implications

The following subsections propose structural and operational measures to prevent and mitigate compound disasters. These proposals target government agencies, regional institutions and development partners working at different spatial scales. The proposed measures need to be addressed together to ensure their effectiveness.

Structural Measures (long-term)

Strategic planning & coordination

- *Improve coordination among national actors operating in different sectors and at different governance levels as well as coordination between government institutions and development partners:*

Effective coordination and engagement among different sectors and jurisdiction levels allows for more comprehensive understanding of the cascading effects triggered by compound events. Compound events do not affect all the sectors at the same time and with the same magnitude, but create a very dynamic situation where hazards, vulnerability and exposure vary considerably. Therefore, cross-sectoral coordination makes it possible to identify which sectors are initially most affected, and to target interventions accordingly, thereby avoiding the generation of ripple effects that would further exacerbate and escalate the impact at larger scales. Coordination should occur among and between national government agencies, regional institutions, private organizations and development partners.

- *Enhance the development of national and regional contingency plans based on multi-risks analyses*

National and regional contingency plans need to be prepared ahead of a possible crisis and need to be based on site-specific multi-risk scenarios. This allows identifying early actions for each opportunity window that do not create new risks or exacerbate exposure and vulnerability and that reduce the chance of developing compound risks.

- *Enhance development interventions that can decrease the impact once compound risks occur*

Climatic and socio-economic events easily compound with the contextual condition such as structural poverty, weak institutional capacity, and poor infrastructure, developing positive feedback loops that further increase the impact. Hence, it is important to support development interventions that enhance negative (self-regulating) feedback loops once compound risks happen (e.g., rainwater harvesting techniques to increase mechanisms that increase the benefit of Drought-to-Heavy Rain events).

- *Action plans for other disasters can be suitable to address new and unexpected hazards if impacts are similar*

Governments struggle to formulate response actions when a new and unexpected event hits the country. In such cases, the limited information on the new risk further slows down response mechanisms. Here, available action plans related to disasters whose impacts are similar to that experienced with the new event can be adopted (e.g., the use of action plan for drought to tackle food insecurity caused by Covid-19). Similarly, development partners could activate response mechanisms to new unforeseen disasters by relying on previous humanitarian plans that address similar impacts.

- *Promote livelihood diversification*

Climate shocks can trigger compounding impacts given the strong dependency of the rural communities' livelihoods in Ethiopia and Kenya to rain-fed agro-pastoral activities. The promotion of livelihood diversification would decrease national vulnerability to compound risks.

Financial preparedness

- *Link national and regional preparedness and response plans to pre-arranged financing strategies and plans*

Linking national and regional plans to pre-arranged financing strategies and plans is an important measure for tackling single or compound risks and avoiding knock-on effects. Through this measure, funds that had been allocated for a first disaster event do not need to be redirected to a new pressing disaster. At the same time, an adequate financial preparedness based on multi-risk analyses avoids the use of development fund to address the humanitarian needs that resulted from a rising crisis. In fragile counties and regions, such as Turkana in Kenya and Somali in Ethiopia, this measure would allow development support interventions to continue during an emergency.

Risk monitoring & EWS

- *Include spatial and temporal variations in the analysis of compound risks*

Compound mechanisms are dependent on the socio-economic context of the area under analysis. This can significantly vary over the national area and hence it is important to increase the spatial resolution of indicators that describe sectors' exposure and vulnerability to different hazards. Additionally, the risks tend to change quickly during compound events, so it is important to track indicators with frequency and to understand how hazards, exposure and vulnerability change and interact across time. By monitoring some biophysical and socio-economic indicators is it possible to take this into account.

- *Link early warning forecast to financial mechanisms*

Establishing triggers that link specific early warnings with appropriate financial mechanisms accelerates crisis response time. Compound events soon develop knock-on effects that further exacerbate and multiply the impacts. Therefore, response needs to be activated as soon as warnings are issued. Automating the response as much as possible, through EWS and forecast-based triggers, can minimize lag time.

Operational interventions

Several operational interventions can be adopted to mitigate the effect of compound risks. These can be divided into long-term and short-term actions, according to the time windows in which they can be implemented. The interventions mentioned in this section are not exhaustive and refer mainly to compound mechanisms that develop during cascading drought-flood events.

For example, long-term interventions to compound weather events include enhancing water- and food-storage. Doing so would make the most of heavy rain events during extreme wet-to-dry cascading events. Other possible interventions are the improvement of pastoralist/farmer trainings and the establishment of agent networks (which can support communities in better managing crops and livestock and help mitigate conflicts). In all of these interventions, care should be taken to avoid creating new risks or exacerbating exposure and vulnerability.

Short-term interventions can be implemented during compound crises to avoid the development of knock-on effects. Examples of such interventions include decreasing market prices for both staple foods and agricultural inputs (livestock medicines, fertilizers, pesticides), the rehabilitation of strategic wells, and cash transfers.

References

[1] M. Leonard *et al.*, "A compound event framework for understanding extreme impacts," *Wiley Interdiscip.*

Rev. Clim. Chang., vol. 5, no. 1, pp. 113–128, 2014.

[2] J. Zscheischler *et al.*, "Future climate risk from compound events," *Nat. Clim. Chang.*, vol. 8, no. 6, pp. 469–477, 2018.

[3] M. C. de Ruiter, A. Couasnon, M. J. C. van den Homberg, J. E. Daniell, J. C. Gill, and P. J. Ward, "Why We Can No Longer Ignore Consecutive Disasters," *Earth's Futur.*, vol. 8, no. 3, 2020.

[4] United Nations Office for Disaster Risk Reduction, "Global Assessment Report on Disaster Risk Reduction 2019 (GAR19)," *Int. Strat. Disaster Reduct.*, pp. 1–311, 2019.

[5] IPCC, *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*. 2012.

[6] D. A. Kenea, G. Teshome, and F. Yemane, "Institutional Development in Ethiopia: Challanges and Policy Options," vol. 88, no. 7, pp. 69–88, 2020.

[7] M. Adem, E. Tadele, and H. Mossie, "Income diversification and food security situation in Ethiopia: A review study," *Cogent Food Agric.*, vol. 4, no. 1, pp. 1–17, 2018.

[8] J. Abbink, "Ethnicity and Conflict Generation in Ethiopia: Some Problems and Prospects of Ethno-Regional Federalism," 2006.

[9] M. T. Tayea, E. Dyer, K. J. Charles, and L. C. Hirons, "Potential predictability of the Ethiopian summer rains: Understanding local variations and their implications for water management decisions," 2021.

[10] B. Doty, E. Grajeda, P. Phillips, and A. Shrestha, "Vulnerability to Climate Change: An Assessment of East and Central Africa," no. August, 2011.

[11] T. Shitarek, "Ethiopia Country Report Ethiopia," no. May, pp. 1–34, 2012.

[12] Y. Liou, "Spatio – temporal Assessment of Drought in Ethiopia and the Impact of Recent Intense Droughts," pp. 1–19, 2019.

[13] E. Viste, D. Korecha, and A. Sorteberg, "Recent drought and precipitation tendencies in Ethiopia," pp. 535–551, 2012.

[14] Z. B. Weldegebriel and B. E. Amphune, "Livelihood resilience in the face of recurring floods: an empirical evidence from Northwest Ethiopia," vol. 2014, pp. 1–19, 2017.

[15] International Federation of Red Cross and Red Crescent Societies, "Emergency Plan of Action (EPoA) Ethiopia: Floods," no. September, pp. 1–10, 2017.

[16] M. Yishak, "Climate-fragility risk brief: Ethiopia," 2019.

[17] OCHA, "Ethiopia: Drought - 2015-2021," 2021. [Online]. Available: https://reliefweb.int/disaster/dr-2015-000109-eth. [Accessed: 03-May-2021].

[18] FAO, "Ethiopia: Drought response plan and priorities in 2017," 2017.

[19] FEWS NET, "ETHIOPIA Food Security Outlook: Jume 2018 to January 2019," 2018.

[20] FEWS NET, "East Africa Food Security Outlook: October 2017 to May 2018," no. May, 2017.

[21] OCHA, "Ethiopia: Areas affected by 2017 IOD induced drought," 2017.

[22] K. Lewis, "Understanding climate as a driver of food insecurity in Ethiopia," *Clim. Change*, vol. 144, no. 2, pp. 317–328, 2017.

[23] G. A. Mera, "Drought and its impacts in Ethiopia," *Weather Clim. Extrem.*, vol. 22, no. November 2017, pp. 24–35, 2018.

[24] Emergency Response Coordination Centre (ERCC), "Horn of Africa: Floods," p. 2018, 2018.

[25] OCHA, "Ethiopia: Floods and Landslides - Apr 2018," 2018. [Online]. Available: https://reliefweb.int/disaster/ff-2018-000042-eth. [Accessed: 04-May-2021].

[26] OCHA, "Ethiopia – Flooding, Flash Update 2," vol. 2018, no. July, pp. 2–3, 2018.

[27] World Food Program, “WFP Ethiopia: Emergency Situation Report #11,” pp. 1–2, 2018.

[28] World Health Organization, “Weekly bulletin on outbreaks and other emergencies,” 2018.

[29] OCHA, “Humanitarian Bulletin: Ethiopia,” no. 54, pp. 1–4, 2018.

[30] GardaWorld, “Ethiopia: Landslide kills 23 people in Oromia region May 26,” 2018. [Online]. Available: https://www.garda.com/crisis24/news-alerts/122781/ethiopia-landslide-kills-23-people-in-oromia-region-may-26. [Accessed: 04-May-2021].

[31] OCHA, “Ethiopia – Floods: Flash Update #1,” no. May, pp. 1–2, 2018.

[32] OCHA, “Ethiopia – Flooding: Flash Update 1,” no. September, pp. 1–2, 2017.

[33] OCHA, “Ethiopia – Flooding Flash Update 3,” no. July, pp. 2–3, 2018.

[34] OCHA, “Humanitarian Response Plan,” no. January, pp. 1–12, 2019.

[35] Inter-Agency Humanitarian Evaluation Steering Group, “Inter-Agency Humanitarian Evaluation of the Drought Response in Ethiopia,” no. May, pp. 1–56, 2019.

[36] FAO, “Ethiopia: Situation Report - November 2016,” no. November 2016, pp. 2016–2017, 2016.

[37] Ethiopia Humanitarian Fund, “Ethiopia Humanitarian Fund - Annual Report,” 2017.

[38] UNICEF, “Humanitarian situation report,” no. December 2014, pp. 1–3, 2017.

[39] OCHA, “Humanitarian Bulletin: Ethiopia - issue 36 | 04-17 September 2017,” no. 36, pp. 1–4, 2017.

[40] ECHO, “Horn of Africa | Food Insecurity and Drought | January 2018 – DG ECHO Daily Map | 08/02/2018,” 2018.

[41] FEWS NET, “East Africa Alert: August 13, 2018,” no. September, pp. 1–2, 2018.

[42] Earth Observatory NASA, “Dramatic Flooding in Eastern Africa,” 2018. [Online]. Available: https://earthobservatory.nasa.gov/images/92130/dramatic-flooding-in-eastern-africa. [Accessed: 04-May-2021].

[43] F. Assefa, “Status of Fall Armyworm (Spodoptera frugiperda), Biology and Control Measures on Maize Crop in Ethiopia: A Review,” *Int. J. Entomol. Res.*, vol. 6, no. 2, pp. 75–85, 2018.

[44] FAO, “Fall armyworm continues to spread in Ethiopia’s maize fields,” 2017. [Online]. Available: http://www.fao.org/ethiopia/news/detail-events/en/c/1028088/. [Accessed: 04-May-2021].

[45] ACAPS, “Food insecurity: Ethiopia, Nigeria, Somalia, South Sudan, and Yemen,” vol. 1, 2018.

[46] ACAPS, “Fall Armyworms infestation in Sidama zone, SNNP,” no. July, pp. 1–8, 2017.

[47] B. A. Taye, “Ethnic federalism and conflict in Ethiopia,” 2017. [Online]. Available: https://www.accord.org.za/ajcr-issues/ethnic-federalism-conflict-ethiopia/. [Accessed: 04-May-2021].

[48] International Crisis Group, “Ethiopia: Ethnic Federalism and its Discontents,” *Afr. Rep.*, no. September, 2009.

[49] BBC News, “What is behind Ethiopia’s wave of protests?,” 2016. [Online]. Available: https://www.bbc.com/news/world-africa-36940906.

[50] R. Kishi, “10 Hidden Conflicts in Africa: #5 Demonstrations in Ethiopia,” 2018. [Online]. Available: https://acleddata.com/2018/02/16/10-hidden-conflicts-in-africa-5-demonstrations-in-ethiopia/. [Accessed: 04-May-2021].

[51] P. Wight, “Threats to Ethiopia’s Fragile Democratic Transition,” 2020. [Online]. Available: https://www.accord.org.za/conflict-trends/threats-to-ethiopias-fragile-democratic-transition/.

[52] BBC News, “Ethiopia declares national state of emergency,” 2018. [Online]. Available: https://www.bbc.com/news/world-africa-43091248. [Accessed: 04-May-2021].

[53] ACLED, “Ethiopia – November 2017 Update,” 2017. [Online]. Available: https://acleddata.com/2017/12/27/ethiopia-november-2017-update/. [Accessed: 04-May-2021].

[54] S. Solomon, “What’s Driving Clashes Between Ethiopia’s Somali, Oromia Regions?,” 2017. [Online]. Available: https://www.voanews.com/africa/whats-driving-clashes-between-ethiopias-somali-oromia-regions. [Accessed: 04-May-2021].

[55] BBC News, “What is behind clashes in Ethiopia’s Oromia and Somali regions?,” 2017. [Online]. Available: https://www.bbc.com/news/world-africa-41278618. [Accessed: 05-May-2021].

[56] T. Hagmann and M. M. Abdi, “Inter-ethnic violence in Ethiopia’s Somali Regional State, 2017 - 2018,” no. August 2018, pp. 1–7, 2020.

[57] VOA, “Ethiopia: 55,000 People Displaced Amid Ethnic Clashes,” 2017. [Online]. Available: https://www.voanews.com/africa/ethiopia-55000-people-displaced-amid-ethnic-clashes. [Accessed: 04-May-2021].

[58] DW, “Ethnic violence in Ethiopia leaves deep wounds,” 2017. [Online]. Available: https://www.dw.com/en/ethnic-violence-in-ethiopia-leaves-deep-wounds/a-41654395. [Accessed: 04-May-2021].

[59] M. Yarnell, “The Crisis Below the Headlines: Conflict Displacement in Ethiopia,” no. November, 2018.

[60] Reuters, “Violence in southern Ethiopia forces more than 800,000 to flee,” 2018. [Online]. Available: https://news.trust.org/item/20180704103356-r3kbj/. [Accessed: 04-May-2021].

[61] All Answers Ltd., “Emerging Conflicts and Quest for Sustainable Peace Building in Southern Ethiopia,” 2018. [Online]. Available: https://ukdiss.com/examples/peace-building-in-southern-ethiopia.php?vref=1. [Accessed: 04-May-2021].

[62] IDMC, “Internal displacement in 2018,” *IDMC (Internal Displac. Monit. center)*, no. August, p. 10, 2018.

[63] OCHA, “Ethiopia: West Guji – Gedeo Conflict Displacement - Update June 2018,” no. June, pp. 1–4, 2018.

[64] UNHCR, “Damage and Loss Assessment (DaLA) of Gedeo Zone,” 2019.

[65] OXFAM, “Oxfam Horn of Africa: 2017 Drought Response,” 2017.

[66] World Bank, “Moving Away from Humanitarian Appeals to Managing Droughts in Ethiopia,” 2017. [Online]. Available: https://www.worldbank.org/en/news/feature/2017/05/02/moving-away-from-humanitarian-appeals-to-managing-droughts-in-ethiopia. [Accessed: 04-May-2021].

[67] UNHCR, “Ethiopia: status of refugees,” 2018. [Online]. Available: https://www.unhcr.org/en-us/ethiopia.htm. [Accessed: 04-May-2021].

[68] Humanitarian Information Unit, “Ethiopia: Displacement and Food Security,” p. 2018, 2018.

[69] UNICEF, “Ethiopia Situation (25 November 2017),” 2017. [Online]. Available: https://reliefweb.int/report/ethiopia/ethiopia-situation-25-november-2017. [Accessed: 04-May-2021].

[70] J. C. Gill and B. D. Malamud, “Reviewing and visualizing the interactions of natural hazards,” *Rev. Geophys.*, vol. 52, no. 4, pp. 680–722, 2014.

[71] World Health Organization, “Weekly bulletin on outbreaks and other emergencies: Week 47 - 18-24 November 2017,” *Angew. Chemie Int. Ed.*, vol. 6, no. 11, pp. 951–952, 2017.

[72] T. P. Ofcansky and L. Berry, “Ethiopia: A Country Study.,” 1991.

[73] T. Abate *et al.*, “Factors that transformed maize productivity in Ethiopia,” *Food Secur.*, vol. 7, no. 5, pp. 965–981, 2015.

[74] WFP, VAM, and CSA, “Comprehensive Food Security and Vulnerability Assessment,” pp. 1–212, 2019.

[75] OCHA, “Ethiopia: Conflict Displacement - Situation Report,” no. December 2017, 2018.

[76] WFP, “Monthly Market Watch Report: March 2018,” no. April, pp. 1–2, 2018.

[77] FAO, “GIEWS Country Brief: Ethiopia,” 2017.

[78] VAM Food Security Analysis - WFP, “Price Forecasts & Alerts,” 2021. [Online]. Available: https://dataviz.vam.wfp.org/economic_explorer/price-forecasts-alerts?iso3=ETH. [Accessed: 04-May-2021].

[79] J. Zscheischler *et al.*, “A typology of compound weather and climate events,” *Nat. Rev. Earth Environ.*, vol. 1, no. 7, pp. 333–347, 2020.

[80] S. Yusuf, “What is driving Ethiopia’s ethnic conflicts?,” *Inst. Secur. Stud.*, no. November, 2019.

[81] The World Bank, “THE INESCAPABLE MANUFACTURING- SERVICES NEXUS: Exploring the potential,” pp. 19–38, 2019.

[82] A. Teshome and A. Lupi, “Determinants of Agricultural Gross Domestic Product in Ethiopia,” vol. 4, no. 2, pp. 12–20, 2018.

[83] VAM Food Security Analysis - WFP, “Economic Explore,” 2021. [Online]. Available: https://dataviz.vam.wfp.org/economic_explorer/macro-economics/inflation?iso3=ETH. [Accessed: 04-May-2021].

[84] IMF News, “Ethiopia: Remarkable Progress Over More Than a Decade,” 2018. [Online]. Available: https://www.imf.org/en/News/Articles/2018/12/04/na120418-ethiopia-remarkable-progress.

[85] Trading Economics, “Ethiopia Government Debt to GDP,” 2021. [Online]. Available: https://tradingeconomics.com/ethiopia/government-debt-to-gdp. [Accessed: 04-May-2021].

[86] Export Gov, “Ethiopia - Market Overview,” 2019. [Online]. Available: https://www.export.gov/apex/article2?id=Ethiopia-Market-Overview. [Accessed: 04-May-2021].

[87] International Federation of Red Cross and Red Crescent Societies, “Emergency Plan of Action Final Report - Ethiopia: Drought,” vol. 2016, no. Im, 2017.

[88] FEWS NET, “Ethiopia: Food Security Outlook - October 2018 to May 2019,” no. May, 2019.

[89] UNICEF, “Humanitarian Action for Children - Ethiopia,” *UNICEF for every child*, pp. 1–5, 2018.

[90] IOM, “IOM Displacement Tracking Matrix (DTM) dataset,” 2021. [Online]. Available: https://displacement.iom.int/ethiopia. [Accessed: 04-May-2021].

[91] IDMC, “Global Report on Internal Displacement,” *Intern. Displac. Monit. Cent.*, no. 5, p. 16, 2019.

[92] OCHA, “Ethiopia: Humanitarian Dashboard (April 2018),” vol. 30, no. 29, pp. 1–8, 2018.

[93] M. T. Maru, “Causes, Dynamics, and Consequences of Internal Displacement in Ethiopia,” no. May, p. 42, 2017.

[94] OCHA, “Ethiopia : Oromia – Somali Conflict-Induced Displacement,” no. 4, pp. 1–6, 2018.

[95] UNICEF, “Humanitarian situation report - January 2018,” pp. 1–3, 2018.

[96] I. Hajžmanová, “Drought-stricken communities hit by destructive floods in the Horn of Africa,” 2018. [Online]. Available: https://www.internal-displacement.org/expert-opinion/drought-stricken-communities-hit-by-destructive-floods-in-the-horn-of-africa. [Accessed: 04-May-2021].

[97] G. Yigzaw and E. Abitew, “Causes and Impacts of internal displacement in Ethiopia,” *African J. Soc. Work*, vol. 9, no. 2, pp. 32–41, 2019.

[98] Medicins Sans Frontieres, “Thousands hit by outbreak of acute watery diarrhoea during worst drought for decades,” 2017. [Online]. Available: https://www.msf.org/ethiopia-thousands-hit-outbreak-acute-watery-diarrhoea-during-worst-drought-decades. [Accessed: 04-May-2021].

[99] WHO, “WHO responds to new acute watery diarrhea outbreak rumour in a remote zone in Somali region of

Ethiopia," 2017. [Online]. Available: https://www.afro.who.int/news/who-responds-new-acute-watery-diarrhea-outbreak-rumour-remote-zone-somali-region-ethiopia. [Accessed: 04-May-2021].

[100] WHO, "Ethiopia WHO Annual Report," 2017.

[101] OCHA, "Weekly Humanitarian Bulletin: Ethiopia (May 2017)," no. May, pp. 1–3, 2017.

[102] World Meteorological Organization, "Drought set to worsen in parts of Greater Horn of Africa," 2017. [Online]. Available: https://public.wmo.int/en/media/news/drought-set-worsen-parts-of-greater-horn-of-africa. [Accessed: 04-May-2021].

[103] FEWS NET, "Ethiopia Food Security Outlook Update December 2016," no. December 2016, 2017.

[104] FEWS NET, "Ethiopia Food Security Outlook February to September 2017," no. September, 2017.

[105] FEWS NET, "Food insecurity intensifies despite late Gu and Belg season rainfall," 2017. [Online]. Available: https://fews.net/east-africa/ethiopia/key-message-update/may-2017. [Accessed: 04-May-2021].

[106] J. Jeffrey, "Why can't booming Ethiopia handle this year's drought?," 2017. [Online]. Available: https://www.thenewhumanitarian.org/analysis/2017/10/19/why-can-t-booming-ethiopia-handle-year-s-drought. [Accessed: 04-May-2021].

[107] Federal Democratic Republic of Ethiopia [FDRE], "Landslide incident in Oromia region, 29 May 2018 June," no. 3, pp. 1–7, 2018.

[108] E. Mwangi, M. Arango, and H. S. Abdillahi, "Anticipatory Risk Management: Defining windows of opportunity based on impact calendar," 2020.

[109] Kenya Human Rights Commission, *Ethnicity and Politicization in Kenya*. 2018.

[110] S. Alobo Loison, "Household livelihood diversification and gender: Panel evidence from rural Kenya," *J. Rural Stud.*, vol. 69, no. February 2017, pp. 156–172, 2019.

[111] B. Rohwerder, "Conflict Analysis of Kenya," no. May, pp. 1–33, 2015.

[112] Roz Price - Institute of Development Studies, "Climate change, vulnerability to violent extremism and conflict in Kenya," 2019.

[113] A. Halakhe, "'R2P in Practice': Ethnic Violence, Elections and Atrocity Prevention in Kenya," *Glob. Cent. Responsib. to Prot.*, vol. 3, no. 4, pp. 5–23, 2013.

[114] ACE, "Consequences of electoral violence in Kenya," 2013. [Online]. Available: https://aceproject.org/ace-en/topics/ev/Electoral violence/consequences-of-electoral-violence/mobile_browsing/onePag. [Accessed: 05-May-2021].

[115] R. Porhel, "The economic consequences of the political crisis," *Gen. Elections Kenya, 2007*, no. July, pp. 225–250, 2009.

[116] Ministerie van landbouw natuur en voedselkwaliteit, "Impact of Drought in Kenya and Tanzania," 2021. [Online]. Available: https://www.agroberichtenbuitenland.nl/landeninformatie/kenia/achtergrond/studies--factsheets/impact-of-drought-in-kenya-and-tanzania. [Accessed: 05-May-2021].

[117] A. Opere, *Floods in Kenya*, 1st ed., vol. 16, no. 1965. Elsevier B.V., 2013.

[118] B. Ayugi *et al.*, "Evaluation of meteorological drought and flood scenarios over Kenya, East Africa," *Atmosphere (Basel).*, vol. 11, no. 3, 2020.

[119] J. M. Huho and R. C. Kosonei, "Understanding Extreme Climatic Events for Economic Development in Kenya," *IOSR J. Environ. Sci. Toxicol. Food Technol.*, vol. 8, no. 2, pp. 14–24, 2014.

[120] J.-E. Parry, D. Echeverria, J. Dekens, and J. Maitime, "Climate Risks, Vulnerability and Governance in Kenya: A review," *UNDP*, p. 83, 2012.

[121] D. E. Mateche, “The Cycle of Drought in Kenya a Looming Humanitarian Crisis,” 2011. [Online]. Available: https://issafrica.org/iss-today/the-cycle-of-drought-in-kenya-a-looming-humanitarian-crisis. [Accessed: 05-May-2021].

[122] V. Ongoma, T. Guirong, B. Ogwang, and J. Ngarukiyimana, “Diagnosis of Seasonal Rainfall Variability over East Africa: A Case Study of 2010-2011 Drought over Kenya,” *Pakistan J. Meteorol.*, vol. 11, no. 22, pp. 13–21, 2015.

[123] J. M. Huho and E. M. Mugalavai, “The Effects of Droughts on Food Security in Kenya,” *Int. J. Clim. Chang. Impacts Responses*, vol. 2, no. 2, pp. 61–72, 2010.

[124] P. J. Ward *et al.*, “The need to integrate flood and drought disaster risk reduction strategies,” *Water Secur.*, vol. 11, no. 2020, 2020.

[125] C. Raymond *et al.*, “Understanding and managing connected extreme events,” *Nat. Clim. Chang.*, vol. 10, no. 7, pp. 611–621, 2020.

[126] A. Rateb and E. Hermas, “The 2018 long rainy season in Kenya: Hydrological changes and correlated land subsidence,” *Remote Sens.*, vol. 12, no. 9, 2020.

[127] Daily Nation, “Kenya: The other effects of the floods,” 2019. [Online]. Available: https://www.preventionweb.net/news/view/69506. [Accessed: 05-May-2021].

[128] Statista, “Food insecurity: share of citizens without access to money to buy food in Kenya from 2010 to 2019,” 2019. [Online]. Available: https://www.statista.com/statistics/1107617/food-insecurity-kenya/#statisticContainer. [Accessed: 05-May-2021].

[129] OCHA, “Kenya: Drought - 2014-2020,” 2021. [Online]. Available: https://reliefweb.int/disaster/dr-2014-000131-ken. [Accessed: 05-May-2021].

[130] UNICEF, “Kenya Floods Response Update May 2018,” 2018.

[131] P. Uhe *et al.*, “Attributing drivers of the 2016 Kenyan drought,” *Int. J. Climatol.*, vol. 38, no. December 2017, pp. e554–e568, 2018.

[132] P. Uhe *et al.*, “The Drought in Kenya, 2016 - 2017,” *Drought Kenya, 2016 - 2017. Clim. Dev. Knowl. Netw. World Weather Attrib. Initiat.*, no. April, pp. 1–8, 2017.

[133] International Federation of Red Cross and Red Crescent Societies, “Emergency appeal operation update Kenya: Drought,” no. July 2011, pp. 1–11, 2016.

[134] FAO Kenya, “Drought in Kenya declared a national disaster,” 2017. [Online]. Available: http://www.fao.org/kenya/news/detail-events/en/c/470567/. [Accessed: 05-May-2021].

[135] D. MacLeod, “Seasonal forecasts of the East African long rains: insight from atmospheric relaxation experiments,” *Clim. Dyn.*, vol. 53, no. 7–8, pp. 4505–4520, 2019.

[136] L. Weingärtner, C. Jaime, M. Todd, S. Levine, S. Mcdowell, and D. Macleod, “Reducing flood impacts through forecast-based action,” 2019.

[137] International Federation of Red Cross and Red Crescent Societies, “Emergency Plan of Action Operation Update Kenya: Floods,” vol. 1, no. 1, pp. 1–11, 2018.

[138] FEWS NET, “Kenya food security outlook: June 2017 to January 2018,” *Kenya Food Secur. Outlook*, no. June 2017, 2018.

[139] M. Kilavi *et al.*, “Extreme rainfall and flooding over Central Kenya Including Nairobi City during the long-rains season 2018: Causes, predictability, and potential for early warning and actions,” *Atmosphere (Basel).*, vol. 9, no. 12, 2018.

[140] ACAPS, “La Niña events impacts Eastern and Southern Africa,” 2016. [Online]. Available: https://reliefweb.int/report/malawi/la-ni-events-impacts-eastern-and-southern-africa. [Accessed: 05-May-2021].

[141] FloodList, “Deadly Flash Floods Set to Worsen Poverty and Hunger in Kenya, Experts Say,” 2017. [Online]. Available: http://floodlist.com/africa/floods-worsen-poverty-kenya. [Accessed: 05-May-2021].

[142] D. Macleod *et al.*, “Are Kenya Meteorological Department heavy rainfall advisories useful for forecast-based early action and early preparedness for flooding?,” *Nat. Hazards Earth Syst. Sci.*, vol. 21, no. 1, pp. 261–277, 2021.

[143] OCHA, “Horn of Africa: Humanitarian Impacts of Drought – Issue 4 (May 2017),” vol. 1, no. 1, pp. 23–25, 2017.

[144] FloodList, “Kenya – Deadly Floods in Central and Northern Areas,” 2017. [Online]. Available: http://floodlist.com/africa/kenya-floods-november-2017. [Accessed: 05-May-2021].

[145] OCHA, “Kenya: Floods - Mar 2018,” 2018. [Online]. Available: https://reliefweb.int/disaster/ff-2018-000030-ken. [Accessed: 05-May-2021].

[146] KNBS, “Quarterly Gross Domestic Product Report First Quarter 2017,” 2017. [Online]. Available: https://www.knbs.or.ke/?wpdmpro=quarterly-gross-domestic-product-report-first-quarter-2017. [Accessed: 05-May-2021].

[147] KNBS, “Quarterly Gross Domestic Product Report Second Quarter 2017,” 2017. [Online]. Available: https://www.knbs.or.ke/?wpdmpro=quarterly-gross-domestic-product-report-second-quarter-2017. [Accessed: 05-May-2021].

[148] KNBS, “Quarterly Gross Domestic Product Report Third Quarter 2017,” 2017. [Online]. Available: https://www.knbs.or.ke/?wpdmpro=quarterly-gross-domestic-product-report-third-quarter-2017. [Accessed: 05-May-2021].

[149] H. De Groote, S. C. Kimenju, B. Munyua, S. Palmas, M. Kassie, and A. Bruce, “Spread and impact of fall armyworm (Spodoptera frugiperda J.E. Smith) in maize production areas of Kenya,” *Agric. Ecosyst. Environ.*, vol. 292, no. December 2019, p. 106804, 2020.

[150] OCHA, “East Africa: Armyworm Infestation - Mar 2017,” 2017. [Online]. Available: https://reliefweb.int/disaster/2017-000041-ken?country%3D22=&page=5. [Accessed: 05-May-2021].

[151] FAO, “Fall Army Worm situation in Kenya,” pp. 2–35, 2017.

[152] The Carter Center, “Kenya 2017 General and Presidential Elections Report,” pp. 1–172, 2018.

[153] E. Gadjanova, “Kenya’s 2017 election and its aftermath,” 2017. [Online]. Available: https://www.mpg.de/11436923/elections-kenya. [Accessed: 05-May-2021].

[154] International Federation of Red Cross and Red Crescent Societies, “Emergency Plan of Action operation update: Kenya Elections Preparedness & Response,” no. October, 2017.

[155] N. Cheeseman, “The Kenyan Elections of 2007: An Introduction,” 2008.

[156] DW, “In Kenya, politics split on ethnic divide,” 2017. [Online]. Available: https://www.dw.com/en/in-kenya-politics-split-on-ethnic-divide/a-37442394. [Accessed: 05-May-2021].

[157] OCHA, “Kenya: Drought Response Situation Report No.2 | May 2017,” no. 2, pp. 1–15, 2017.

[158] J. Craig, “Drought Blamed for Conflict in Kenya From Illegal Grazing,” 2017. [Online]. Available: https://www.voanews.com/africa/drought-blamed-conflict-kenya-illegal-grazing. [Accessed: 05-May-2021].

[159] International Federation of Red Cross and Red Crescent Societies, “Operation Update Kenya: Floods,” 2019.

[160] A. M. Linke, F. D. W. Witmer, J. O’Loughlin, J. T. McCabe, and J. Tir, “The consequences of relocating in response to drought: Human mobility and conflict in contemporary Kenya,” *Environ. Res. Lett.*, vol. 13, no. 9, 2018.

[161] A. S. and L. Lumbasi and Trinity, “the Impact of Decentralization in Kenya,” p. 20, 2016.

[162] F. Grunewald, V. Leon, and S. Levine, “Comprehensive Review of 2016-17 ECHO Horn of Africa Drought Response,” p. 84, 2019.

[163] International Federation of Red Cross and Red Crescent Societies, “Emergency plan of action operation update - Kenya: Drought,” no. 1, 2016.

[164] International Federation of Red Cross and Red Crescent Societies, “Emergency appeal operation update - Kenya: Drought,” no. July 2011, pp. 1–11, 2017.

[165] International Federation of Red Cross and Red Crescent Societies, “Revised Emergency Plan of Action (EPoA) - Kenya: Drought,” no. March, 2017.

[166] Ministry of Agriculture Livestock and Fisheries, “Kenya Maize Production by Counties,” 2018. [Online]. Available: http://kilimodata.developlocal.org/dataset/kenya-maize-production-by-counties. [Accessed: 05-May-2021].

[167] The National Treasury, “Pre and Post Election Economic and Fiscal Reports,” 2018.

[168] ACAPS, “Widespread and localised electoral violence,” vol. 2018, p. 2018, 2018.

[169] C. W. Mwangi, “Food security, drought, and politics: Kenya’s maize crisis before and after elections,” 2020.

[170] World Bank Group, “Kenya Economic Update: Poised to bounce back?,” *Kenya Econ. Updat.*, no. 16, 2017.

[171] FAO, “Kenya extends maize subsidy program,” 2017. [Online]. Available: http://www.fao.org/giews/food-prices/food-policies/detail/en/c/1039242/. [Accessed: 06-Jan-2021].

[172] CEIC Data, “Kenya Real GDP Growth,” 2020. [Online]. Available: https://www.ceicdata.com/en/indicator/kenya/real-gdp-growth. [Accessed: 05-May-2021].

[173] M. Driop *et al.*, “Disaster Risk Management Development Policy Fnancing with a Catastrophe Deferred Drawdown option,” p. 56, 2018.

[174] WHO Regional Office for Africa, “Weekly Bulletin on Outbreaks and Other Emergencies,” no. August, pp. 1–20, 2017.

[175] OXFAM, “Horn of Africa: Flood and Drought Response,” no. December 2017, 2018.

[176] World Health Organization, “Cholera – Kenya,” 2017. [Online]. Available: https://www.who.int/csr/don/11-december-2017-cholera-kenya/en/. [Accessed: 05-May-2021].

[177] N. Turman-Bryant, C. Nagel, L. Stover, C. Muragijimana, and E. A. Thomas, “Improved drought resilience through continuous water service monitoring and specialized institutions-A longitudinal analysis of water service delivery across motorized boreholes in Northern Kenya,” *Sustain.*, vol. 11, no. 11, 2019.

[178] International Federation of Red Cross and Red Crescent Societies, “Emergency appeal revision - Kenya: Flood,” no. February 2015, pp. 1–13, 2018.

[179] International Federation of Red Cross and Red Crescent Societies, “Emergency appeal Kenya: Floods,” 2018.

[180] A. Kamau *et al.*, “Malaria infection, disease and mortality among children and adults on the coast of Kenya,” *Malar. J.*, vol. 19, no. 1, pp. 1–12, 2020.

[181] J. Njuguna, “Impact of nurses’ strike in Kenya on number of fully immunized infants in 18 county referral hospitals,” *J. Health Care Poor Underserved*, vol. 29, no. 4, pp. 1281–1287, 2018.

[182] ACLED, “Kenya – June 2017 Update,” 2017. [Online]. Available: https://acleddata.com/2017/07/17/kenya-june-2017-update/. [Accessed: 05-May-2021].

[183] NDMA, “Sector Plan for Drought Risk Management and Ending Drought Emergencies,” 2018.

[184] ACLED, “Kenya – November 2017 Update,” 2017. [Online]. Available: https://acleddata.com/2017/12/27/kenya-november-2017-update/. [Accessed: 05-May-2021].

[185] Inter, “Emergency Plan of Action (EPoA) - Kenya: Election Preparedness,” no. August, pp. 1–10, 2017.

[186] D. K. Mwangi, “Fall armyworm Technical Brief from Kenya (May 2018),” no. March, pp. 1–7, 2018.

[187] OCHA, “Ethiopia: Administrative Map (as of 27 Mar 2013),” 2013. [Online]. Available: https://reliefweb.int/map/ethiopia/ethiopia-administrative-map-27-mar-2013. [Accessed: 05-May-2021].

[188] The World Bank, “Ethiopia data,” 2021. [Online]. Available: https://data.worldbank.org/country/ET. [Accessed: 05-May-2021].

[189] A. Majbauddin *et al.*, “The influence of income and livelihood diversification on health-related quality of life in rural Ethiopia,” *Int. J. Environ. Res. Public Health*, vol. 17, no. 8, pp. 1–12, 2020.

[190] Statista, “Ethiopia: Share of economic sectors in the gross domestic product (GDP) from 2009 to 2019,” 2020. [Online]. Available: https://www.statista.com/statistics/455149/share-of-economic-sectors-in-the-gdp-in-ethiopia/. [Accessed: 05-May-2021].

[191] Federal Democratic Republic of Ethiopia, “National Policy and Strategy on Disaster Risk,” no. March, 2009.

[192] A. Alemayehu, M. Maru, W. Bewket, and M. Assen, “Spatiotemporal variability and trends in rainfall and temperature in Alwero watershed, western Ethiopia,” *Environ. Syst. Res.*, vol. 9, no. 1, 2020.

[193] Met Office, “Seasonal Weather Assessment for Ethiopia during March - July 2016,” no. July, p. 3, 2016.

[194] E. Viste, D. Korecha, and A. Sorteberg, “Recent drought and precipitation tendencies in Ethiopia,” *Theor. Appl. Climatol.*, vol. 112, no. 3–4, pp. 535–551, 2012.

[195] Joint Government and Humanitarian Partners’ Document, “Humanitarian and Disaster Resilience Plan,” 2018.

[196] USAID, “El Niño in Ethiopia: Uncertainities, impacts and decision-making,” *Agric. Knowledge, Learn. Doc. Policy Proj.*, no. September, p. 2, 2015.

[197] S. Philip *et al.*, “Attribution analysis of the Ethiopian drought of 2015,” *J. Clim.*, vol. 31, no. 6, pp. 2465–2486, 2018.

[198] OCHA, “Ethiopia: learning from the impact of past la Nina events,” no. August, 2016.

[199] FEWS NET, “Ethiopia Livelihood,” 2018. [Online]. Available: https://fews.net/content/ethiopia-livelihood-zones-2018. [Accessed: 05-May-2021].

[200] Worldometer, “Demographics Kenya,” 2020. [Online]. Available: https://www.worldometers.info/demographics/kenya-demographics/. [Accessed: 05-May-2021].

[201] T. S. Jayne and M. Muyanga, “Land constraints in Kenya’s densely populated rural areas: Implications for food policy and institutional reform,” *Food Secur.*, vol. 4, no. 3, pp. 399–421, 2012.

[202] The World Bank, “Rural Population in Kenya,” 2021. [Online]. Available: https://data.worldbank.org/indicator/SP.RUR.TOTL.ZS?locations=KE. [Accessed: 05-May-2021].

[203] The World Bank, “Kenya: Overview,” 2021. [Online]. Available: https://www.worldbank.org/en/country/kenya/overview. [Accessed: 05-May-2021].

[204] Statista, “Kenya: Share of economic sectors in the gross domestic product (GDP) from 2009 to 2019,” 2020. [Online]. Available: https://www.statista.com/statistics/451143/share-of-economic-sectors-in-the-gdp-in-kenya/. [Accessed: 05-May-2021].

[205] USAID, “Agriculture and Food Security: Kenya,” 2021. [Online]. Available: https://www.usaid.gov/kenya/agriculture-and-food-security. [Accessed: 05-May-2021].

[206] UNDP, “Kenya Climate Smart Agriculture Implementation Framework,” 2018.

[207] Santander - Trade Markets, “Kenyan economic outline,” 2020. [Online]. Available: https://santandertrade.com/en/portal/analyze-markets/kenya/economic-outline?url_de_la_page=%2Fen%2Fportal%2Fanalyze-markets%2Fkenya%2Feconomic-

outline&&actualiser_id_banque=oui&id_banque=0&memoriser_choix=memoriser https://www.statista.com/statistics/451143/share-of-economic-sectors-in-the-gdp-in-kenya/. [Accessed: 05-May-2021].

[208] P. C. Wankuru, “For the first time, the relative economic size of Kenya’s counties is clear,” 2019. [Online]. Available: https://blogs.worldbank.org/africacan/for-the-first-time-the-relative-economic-size-of-kenyas-counties-is-clear. [Accessed: 05-May-2021].

[209] National Disaster Management Unit (NDMU), “Kenya National Emergency Response Plan & Standard Operating Procedures (SOPs),” 2014.

[210] E. Mbogo, F. Inganga, and J. M. Maina, “Drought conditions and management strategies in Kenya,” pp. 1–10, 2012.

[211] Develpment Initiatives, “Assessment of Kenya’s preparedness to disasters caused by natural hazards,” no. January, 2017.

[212] M. Gichaba, E. K. Kipseba, and M. Masibo, “Overview of Landslide Occurrences in Kenya. Causes, Mitigation, and Challenges,” 2013.

[213] S. Zhou, S. Zhou, and X. Tan, “Nationwide susceptibility mapping of landslides in Kenya using the fuzzy analytic hierarchy process model,” *Land*, vol. 9, no. 12, pp. 1–22, 2020.

[214] A. K. Kiptum, “Seasonality, causes, impacts and frequency of floods in Kenya,” 2019.

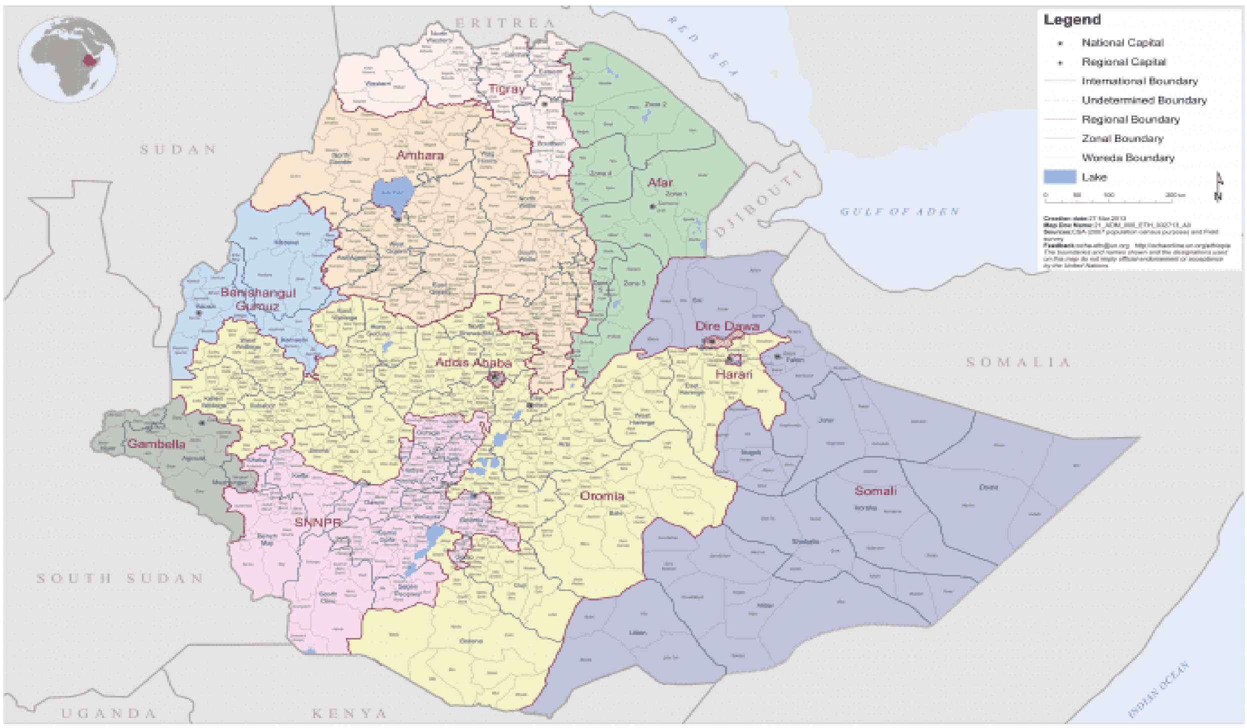
[215] IUCN, “Kenya National Climate Change Framework Policy,” 2016.

[216] T. M. Mutua and S. N. Runguma, “Climatology & Weather Forecasting Rainfall Variability and Extreme

Annex A: Ethiopia country profile

Ethiopia is located in the Horn of Africa and shares its borders with Eritrea, Djibouti, Somalia, Sudan, South Sudan and Kenya (Figure 59). As of 2020, the country has a population of around 114 million people distributed heterogeneously within an area of 1,127,127 square kilometres, with Addis Ababa, Amhara, Oromia and SNNPR the most densely populated regions.

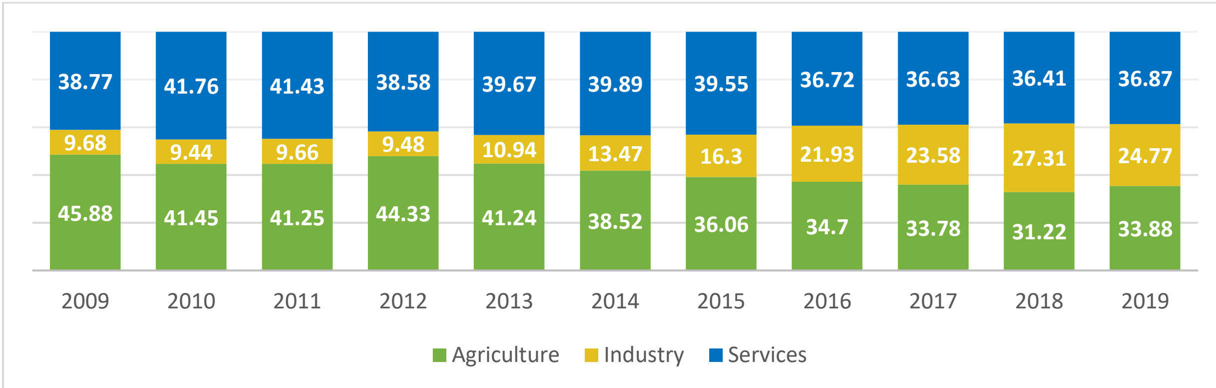
FIGURE 59. Ethiopia administrative map (OCHA, 2013)



Main economic sectors

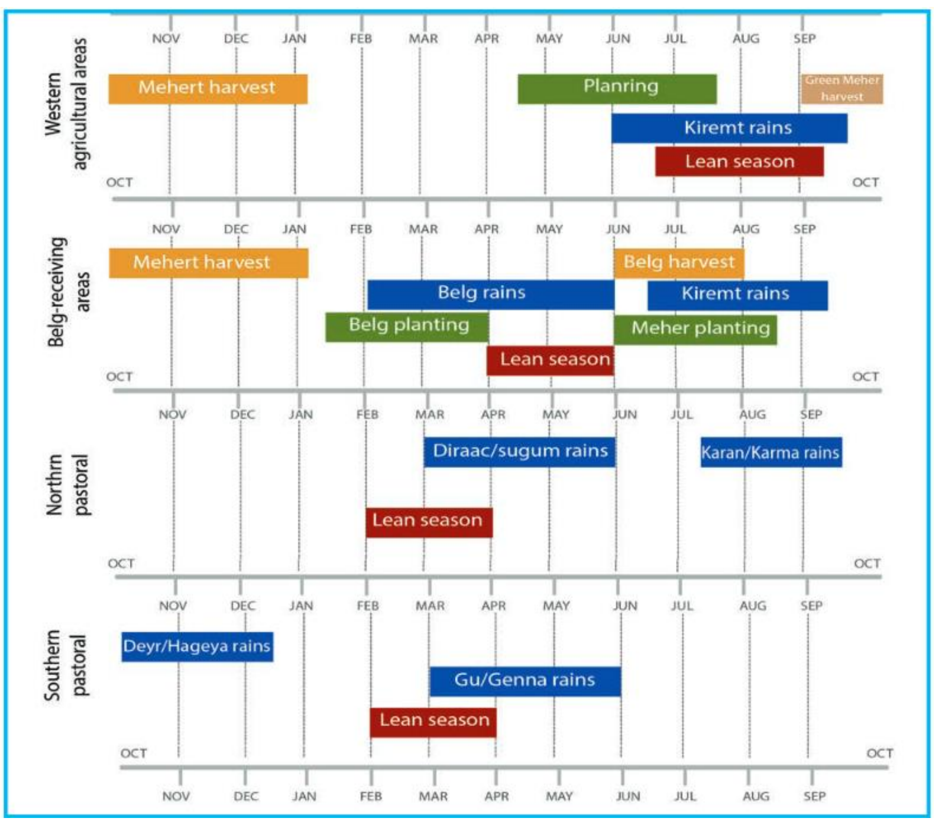
Historically, agriculture has been the country's most important economic sector. However, since 2014 it has been surpassed by the service sector, which made up an estimated 36.9% of Ethiopia's GDP in 2019 (Figure 60). Agriculture still accounted for 34% of GDP, while industry accounts for 25% (The World Bank, 2021a). Even though the service sector is larger than agriculture as a source of GDP, the agricultural sector continues to employ a larger portion of the labour force, estimated at 66% in 2018 (Yishak, 2019). Around 80% of Ethiopians live in rural areas and are mainly dependent on agriculture for their livelihoods (Majbauddin et al., 2020). Among them, 89% are cultivators, while pastoralists account for 6% and agro-pastoralists for 5% of the agricultural sector (Yishak, 2019).

FIGURE 60. **Share of economic sectors in GDP from 2009 to 2019 in Ethiopia (Statista, 2020a)**



Most of Ethiopia's food production comes from the west, centre and north of the country, which receive seasonal rains during the Kiremt and Belg rain seasons. The two main harvests periods occur during the Meher and Belg seasons (Figure 61). Major cultivated crops in Ethiopia includes a variety of grains, oil seeds and coffee. Single season crops such as wheat, teff and barley grow over the Kiremt season and are harvested during Meher. Long-cycle crops, such as maize, millet, and sorghum, grow over both the Belg and Meher seasons (April–September/October) and account for nearly 50% of the total crop production.

FIGURE 61. **Seasonal calendar in Ethiopia (WFP et al., 2019)**



Main hazards

According to the National Policy and Strategy on Disaster Risk Management (2009) (Federal Democratic Republic of Ethiopia, 2009), the main hazards identified in Ethiopia are drought, flood, human and livestock diseases, crop pests, seismic and volcanic activities. Historically, drought is the country's leading hazard, with flood as second major hazard in terms of people affected and loss of lives and livelihoods.

Rain seasons

The inter-annual spatio-temporal variability of rainfall in Ethiopia is partially explained by its complex topography (varying from 130 to 4550 masl) (Viste et al., 2012a) and latitude span (varying from 3 to 15 oN and 33 oE to 48 oE) (Alemayehu, Maru, Bewket, & Assen, 2020) (Figure 62), which results in different climatic regions in the country. Western and central regions experiences two main rainy seasons: the Belg (from February to May) and the Kiremt (June to mid-September) (Figure 63). Rainy seasons in the north-central regions fall in the same periods but are shorter (March to April and July to mid-September). The eastern regions present instead two rainy seasons named Gu (April to June) and Deyr (October to December) (Met Office, 2016). The majority of rainfall, 50-80%, arrives during the Kiremt season (Yishak, 2019), when about 85–95% of the Ethiopian food crop is produced (Viste, Korecha, & Sorteberg, 2012b).

FIGURE 62. Average annual rainfall (on the left) and topography (on the right) of Ethiopia (EMD)

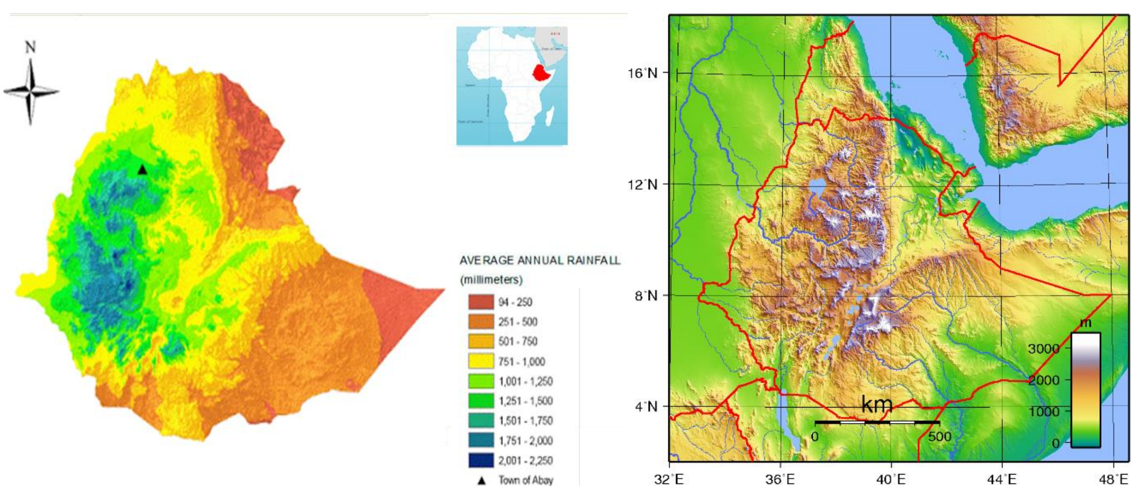
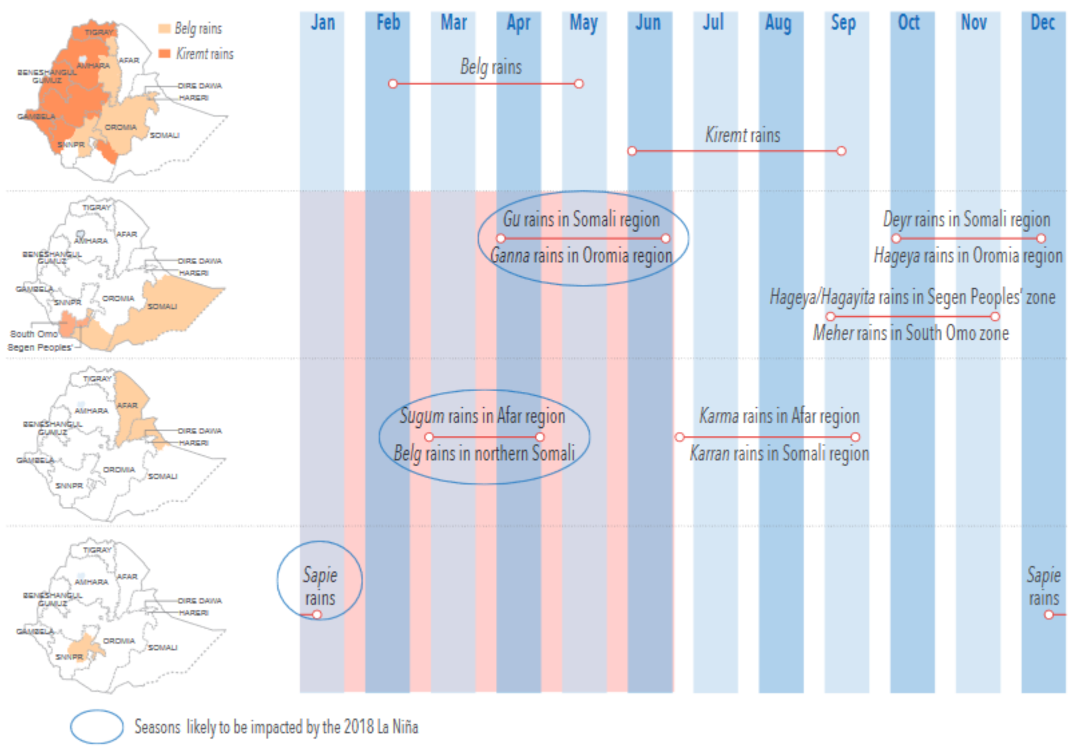


FIGURE 63. **Temporal and spatial distribution of rainy seasons in Ethiopia (Joint Government and Humanitarian Partners' Document, 2018)**



Climate phenomena that affect rainfall variability

Variations in the seasonal precipitation cycle are generally linked to fluctuations in atmospheric and ocean circulations resulted from climate phenomena such as El Niño/La Niña Southern Oscillation (ENSO) conditions over Tropical Pacific Ocean, and the Indian Ocean Dipole (IOD) (USAID, 2015). Typically, across southern regions of the country, El Niño increases the probability of above average rainfall during the Belg (Feb-May) in northern-central Ethiopia and during the Gu (Apr-Jun) in eastern Ethiopia. During the Kiremt (Jun-Sep), below-average rainfall is more probable in El Niño years mainly affecting northern and central Ethiopia (Philip et al., 2018). Contrary, La Niña episodes are associated with above-normal rainfall during the Kiremt season affecting western and central regions, and below-normal rainfall during the Deyr and Gu seasons effecting mainly the eastern regions (OCHA, 2016). Hydrological droughts in Ethiopia usually develops when rainfall drops below normal by almost 30 to 50%.

Oromia and Somali livelihood zones

FIGURE 64. Oromia livelihood zones (FEWS NET, 2018c)

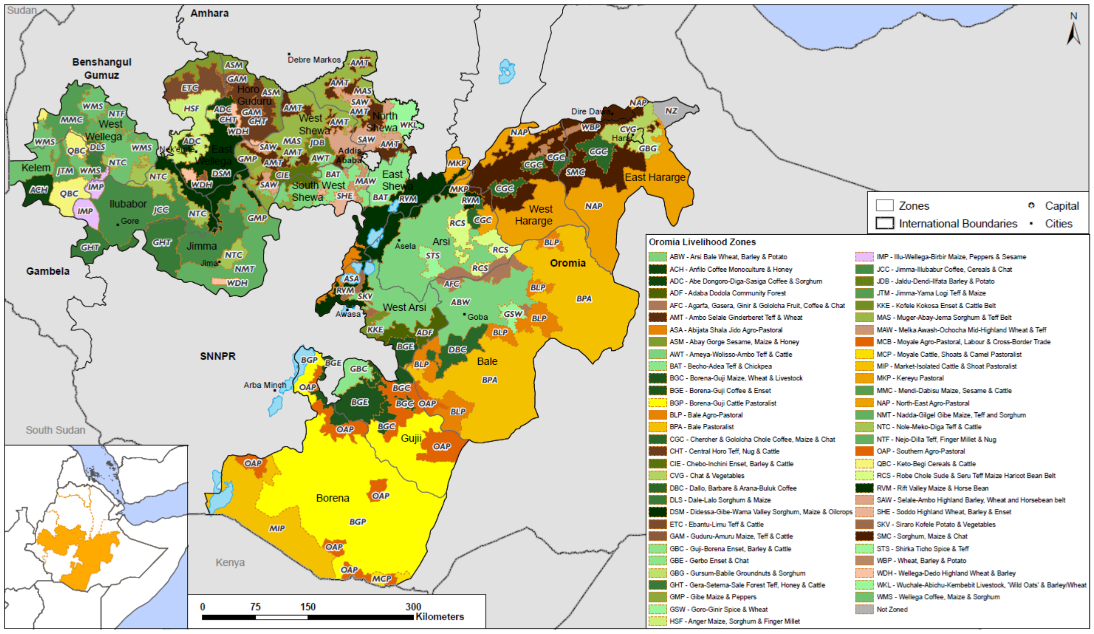
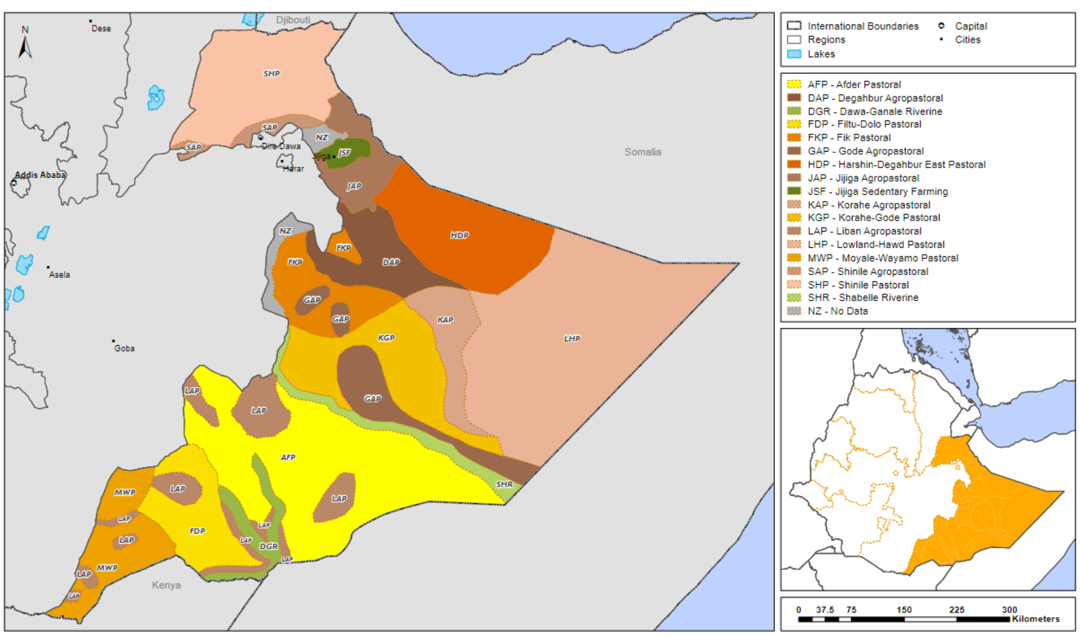


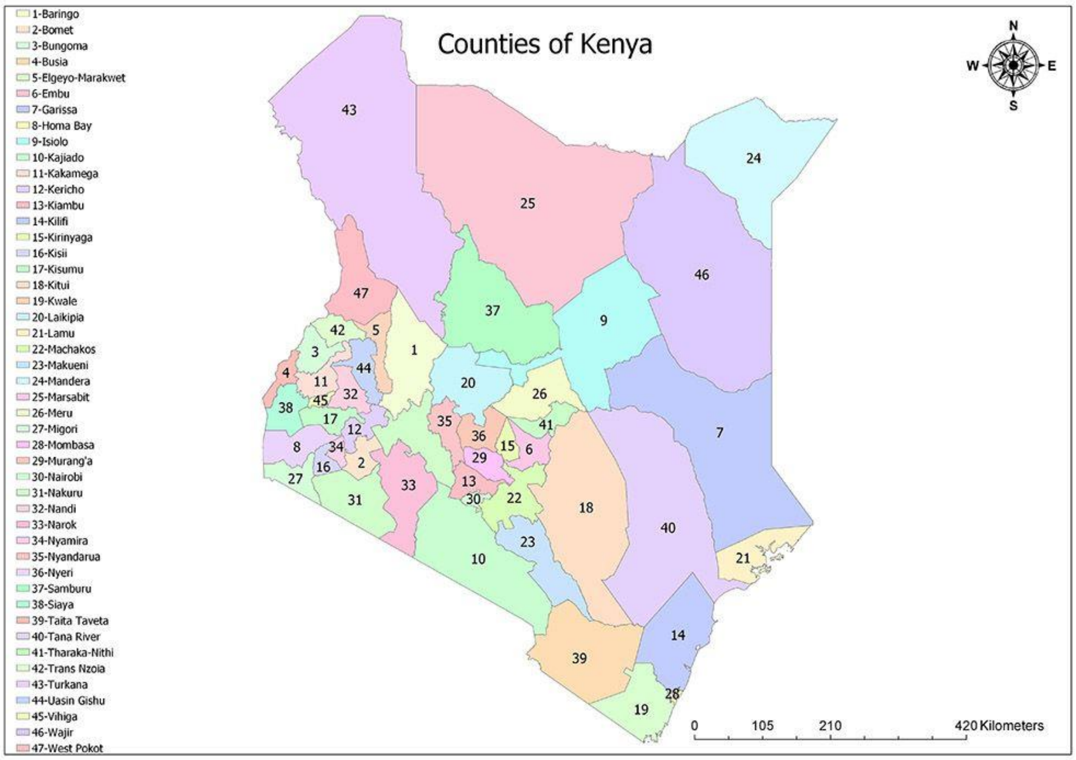
FIGURE 65. Somali livelihood zones (FEWS NET, 2018c)



Annex B: Kenya country profile

Situated in eastern Africa, Kenya lies between Ethiopia, Somalia, South Sudan, Tanzania, and Uganda. As of 2020, the country has a population of around 53 million people (Worldometer, 2020) unevenly distributed over 582,650 square kilometres of land, with the highest population density in the urban areas located in the central and north-western areas (Jayne & Muyanga, 2012). However, the majority of the population (70%) lives in rural areas (The World Bank, 2021b).

FIGURE 66. Kenya administrative map

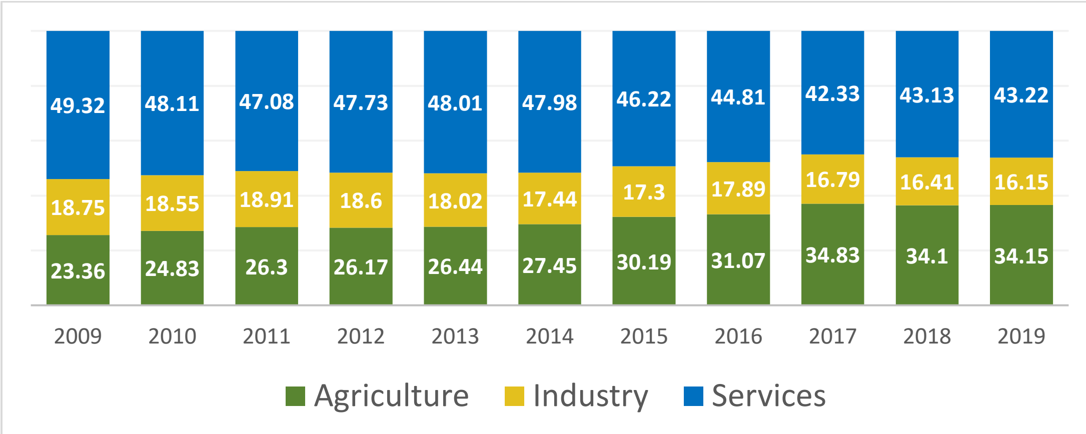


Main economic sectors

In 2019, Kenya's economic growth averaged 5.7%, placing Kenya as one of the fastest growing economies in sub-Saharan Africa (The World Bank, 2021). Agriculture has always been a relevant sector for the Kenyan economy, contributing to approximately 30% of Kenya's Gross Domestic Product (GDP) in 2019 (Figure 67) (Statista, 2020b). The agriculture sector employs more than 40 percent of the total population and 70% of the rural population (USAID, 2021). About 98% of Kenya's agricultural activities are rain-fed and highly susceptible to climate change and climate variability (UNDP, 2018).

Major industries include forestry and fishing. Service is the largest economic sector, followed by agriculture, mining, energy, tourism and manufacturing (Santander – Trade Markets, 2020).

FIGURE 67. Share of economic sectors in GDP from 2009 to 2019 in Kenya (Statista, 2020b)



The counties in the central western part of Kenya are the main contributors to the national GDP. From 2013-2017, the urban counties of Nairobi, Nakuru and Mombasa contribute in average respectively 21.7%, 6.1%, 4.7% to the national GDP, indicating large disparities in the size of GDP across the counties (Wankuru, 2019).

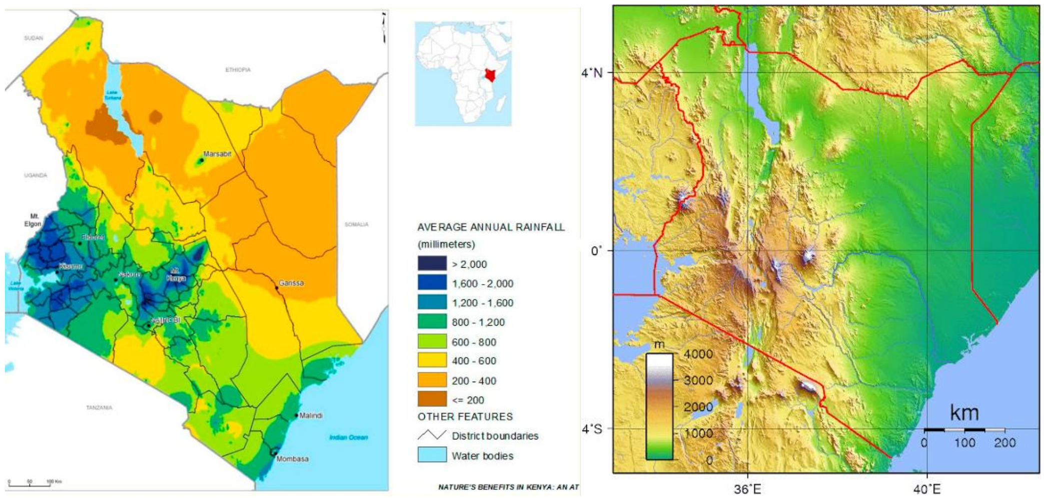
Main hazards

According to the National Emergency Plan (2014) (National Disaster Management Unit (NDMU), 2014), the main hazards in Kenya are drought, floods, wild fires, diseases and epidemics (Mbogo, Inganga, & Maina, 2012). Drought is the most prevalent natural hazard affecting mainly the arid and semi-arid lands in Kenya (eastern area). These areas cover about 89% of the total land mass and are home to about 36% of the population (Development Initiatives, 2017). These lands are mainly flat, while the main hills are located in western Kenya where significant landslides occur (Gichaba, Kipseba, & Masibo, 2013; Zhou, Zhou, & Tan, 2020). Floods occur seasonally and mainly along the flood plains of Lake Victoria and the Tana river.

Rain seasons

Most parts of Kenya experiences two rain seasons: a long rain season between March and May, and a short rain season between October and December (Kiptum, 2019). According to a study carried out by the Ministry of Environment and Natural Resources in 2016, rainfall patterns show increased irregularity and variability with neutral to slightly decreasing trends in annual rainfall over most areas (IUCN, 2016). Decreasing rainfall trends have been observed mainly during the long rainfall seasons. Rainfall is also not equally distributed geographically. Western parts of Kenya receive more rainfall than other parts showing an annual average of 1,000 mm compared to the 400 mm in eastern Kenya (Figure 68).

FIGURE 68. Average annual rainfall (on the left) and topography (on the right) of Kenya (KMD)



Climate phenomena that affect rainfall variability

Interannual rainfall variations in Kenya are tightly linked to climate phenomena such as El Niño/La Niña Southern Oscillation (ENSO) conditions over Tropical Pacific Ocean, and the Indian Ocean Dipole (IOD) (Mutua & Runguma, 2012). It is not yet clear how these climate phenomena play a role in rainfall variability and trends (Anyah & Semazzi, 2006; Liebmann et al., 2014). In general, El Niño conditions lead to wet conditions, while La Niña conditions lead to opposite effects (dry conditions), especially in north-western and eastern Kenya.

Crop calendar and livelihood

FIGURE 69. Kenyan crop calendar (FEWS NET 2020)

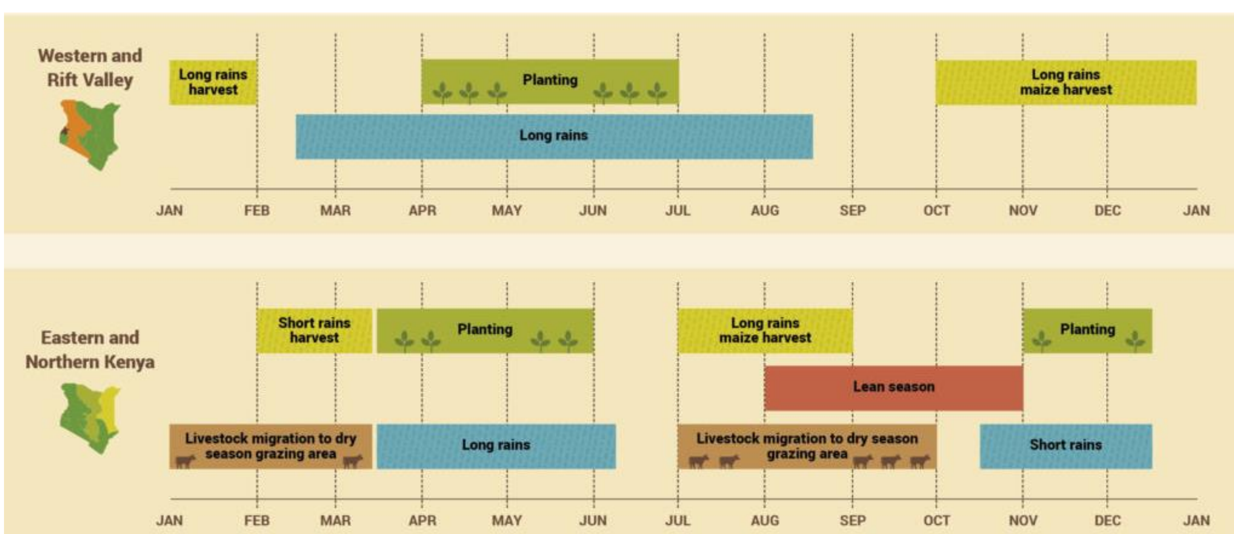
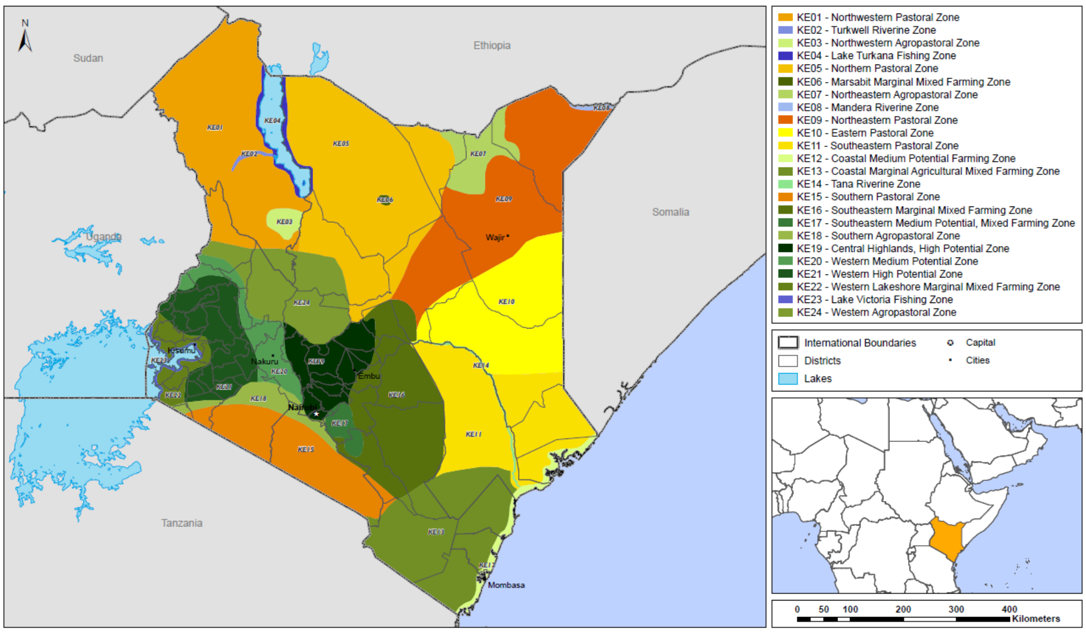


FIGURE 70. **Kenyan livelihoods (FEWS NET, 2011)**



Updated: March 14, 2011