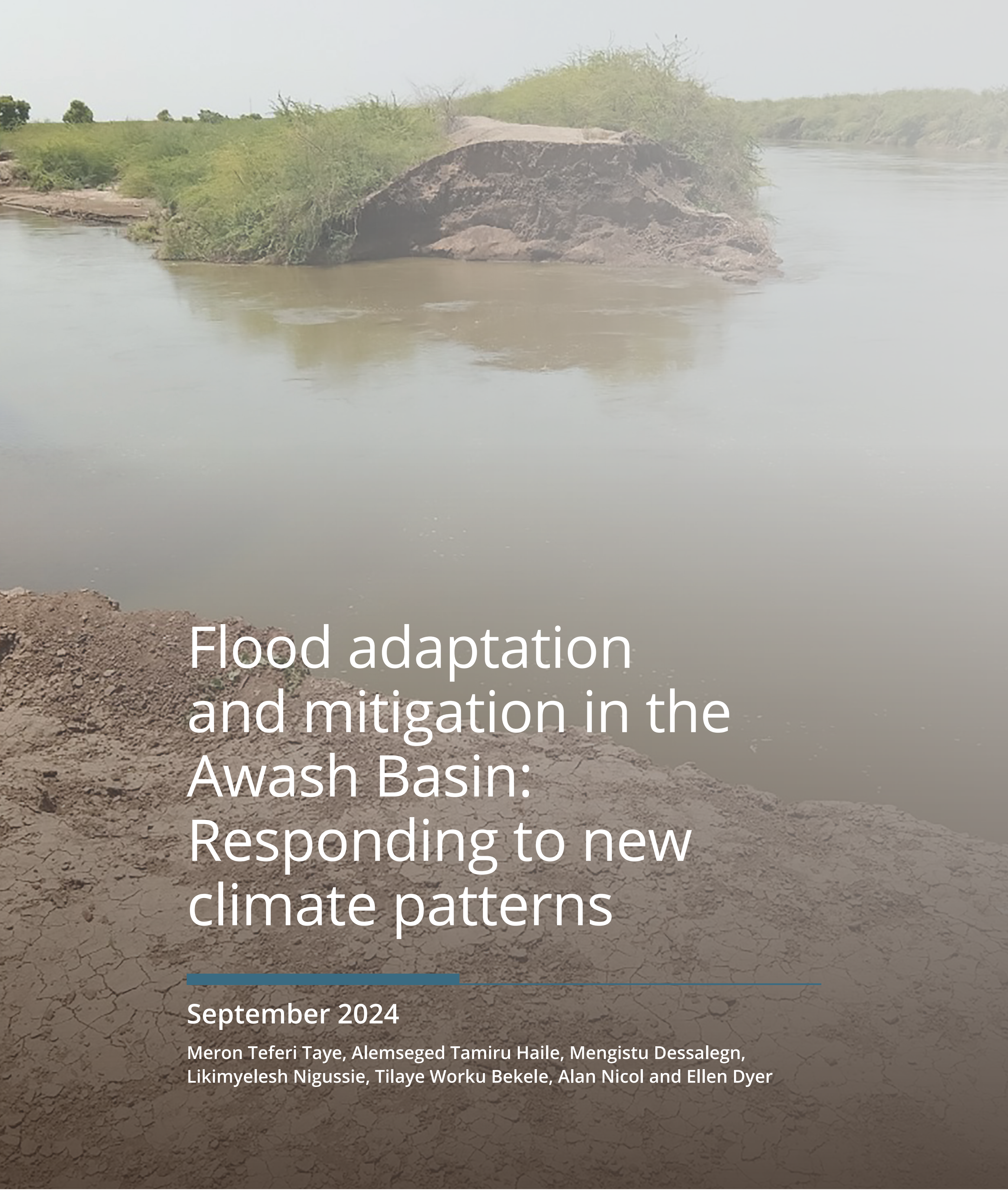

Flood adaptation and mitigation in the Awash Basin: Responding to new climate patterns

September 2024

Meron Teferi Taye, Alemseged Tamiru Haile, Mengistu Dessalegn, Likimyelesh Nigussie, Tilaye Worku Bekele, Alan Nicol and Ellen Dyer

International Water Management Institute

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Project

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Collaborators

International Water Management Institute (IWMI)

Donor

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Contents

Acronyms and abbreviations

Atl	Atlantic region
CHIRPS	Climate Hazards Group Infrared Precipitation with Stations
CN	Curve Number
CWD	Consecutive Wet Days
DMI	Dipole Mode Index
EMI	Ethiopian Meteorological Institute
ESA-CCI-SM	European Space Agency's Soil Moisture Climate Change Initiative project
GCPs	Ground Control Points
GEE	Google Earth Engine
HadISST	Hadley Centre Sea Ice and Sea Surface Temperature
IOD	Indian Ocean Dipole
LULC	Land Use Land Cover
N34	Niño 3.4 region
OCHA	United Nations Office for the Coordination of Humanitarian Affairs
ONI	Oceanic Niño Index
SNNPRs	South Nation Nationalities Peoples' Regional states
SIO	South-west Indian Ocean region
SST	Sea Surface Temperature
WIO	West Indian Ocean region

Summary

The Awash Basin in Ethiopia experiences frequent flooding, sometimes with devastating consequences. Climate change is now creating new flood regimes in different parts of the basin and reshaping the interaction of flooding with rapidly changing communities. This is causing heightened risk, particularly for the most vulnerable communities across the basin, and requires new forms of management and response.

This study explores the physical changes in rainfall and landscapes leading to major flood events and examines the interaction of physical phenomena with societal and economic dynamics across the basin's upper, middle, and lower reaches. The study's multi-dimensional perspective includes analysis of hydroclimatic variables at the basin level including global drivers, flood characterization in selected catchments, and understanding of affected communities at sub-catchment levels. Selected catchments cover urban parts of the Awash, as well as agricultural, pastoral, and agro-pastoral areas. The major focus of the work was the recent extreme wet season in 2020 and associated flooding during which an estimated, 144,000 were displaced and 60,000 hectares were inundated. This was the most serious flood event in the basin since 1996.

The core questions of the study are as follows:

1. What kind of rainfall was responsible for flooding in the summer of 2020 and what were the large-scale drivers?
2. What aspects of the 2020 flood characteristics were different from previous floods and what is the interaction between land use and land cover with flooding?
3. What are the non-climatic drivers of flooding and what are the impacts of flooding on different communities and their coping mechanisms?

The study results show that rainfall extremes during the summer of 2020 occurred in unexpected parts of the basin. Compared to the 1981-2010 baseline the lower part of the basin had a rainfall anomaly of more than 75%. Moreover, antecedent rainfall conditions from April to June contributed to soil saturation before the exceptional rainfall, as the months before July were wetter than the base period on average by 62%. Soil moisture conditions overall were wetter than average from 10 to 40% during these antecedent months which, combined with higher rainfall in the lower basin, and timing was a major cause of flooding in 2020.

To describe in more detail, the western part of the lower basin received higher rainfall than normal in previous wet years, and earlier in the season (early July). Then, in the latter part of the season (August), the upper basin received high rainfall that increased upstream river discharge and contributed to massive flooding in the lower basin. This characterizes the 2020 flood by early onset and delayed recession. The most severe impact of flooding was observed in the lower Awash basin with consequences such as roads near Dubti town being washed away and abandoning of irrigated farms.

The major cause of flood impact was both the severity of the hydrological extreme combined with anthropomorphic factors. For instance, the Awash River broke from its normal course during the 2020 extreme rainfall period in part due to farmers having diverted water to their farms creating new flood channels. Longer-term sedimentation as a result of highland erosion having raised the riverbed (and therefore flooding level) over time, heightened risks for surrounding farmers. Structures such as dikes that are constructed to prevent floods are also of insufficient quality to handle increasingly extreme rainfall events, and upstream urbanization and deforestation in combination with weak collective action are additional exacerbating factors.

More holistic approaches to solving the devastating impact of climate extremes in the Awash Basin will need to begin with a better understanding of the multi-causality and -dimensionality of water-related risks, implementing more adaptive management approaches within more effective monitoring of human-physical systems interactions, and strengthening coordination within and across sectors.

Introduction

Climate change has increased the frequency and magnitude of extreme events worldwide (Jeong et al., 2022). In the East Africa region, in the past decade, several severe extreme cases have occurred with dire implications for the most vulnerable people (Taye and Dyer 2024). Consecutive multi-season droughts in the Horn of Africa related to the triple-dip La Niña event (2020-2022) impacted bimodal rainfall regions such as Kenya (Anderson et al., 2023). In contrast, large rainfall caused flooding in different parts of East Africa at different times. For instance, the 2020 floods during the July to September season caused distraction in Sudan (Alfieri et al., 2024) and the Awash basin in Ethiopia. Between July to September 2020, flooding in the Awash Basin caused the displacement of 144,000 persons and over 5 billion Birr in damages within Afar Regional State alone (ENA, 2020). Climate change is intensifying extreme rainfall conditions and causing floods in unexpected locations and seasons.

The type and range of flooding in the Awash Basin varies widely reflecting the basin's complex geography. Major causes are heavy rainfall, the overflow of the Awash River, flash floods from tributary streams, and water release from dams. Urban locations that experience flash flooding and river spillage include the capital, Addis Ababa. Areas of the upper Awash Basin including the Awash Bello floodplain are regularly flooded (Tola and Shetty, 2024). In Middle Awash, there are large, mechanized irrigation systems such as Metehera and Wonji, and areas in Melka Werer, that have experienced devastating flooding in the past. Tadesse and Frohle, (2014) simulated the year 1996 flood when the Awash River dike was breached at Wonji, using a 2-dimensional hydrodynamic flood model – Telemac2D. This flood event was a historic dike breach and destroyed the sugar plantation and offices of Wonji Shoa Sugar Factory.

Certain areas of the lower Awash Basin become inundated more frequently. The districts that are commonly associated with floods are Amibara, Dulecha, Assaita, Afambo, Dubti, Gewane and Buremudaitu. In addition to flooding of the main Awash River, other areas experience flash flooding including Dire Dawa and Logiya towns (Adane et al., 2022). Historical wet years that resulted in flooding events in different parts of the Awash Basin include 1996, 1999, 2003, 2006, 2016, and 2020 (Woldegebrael et al., 2022). Most prior information on flooding is available from UN emergency unit reports (Ahrens, 1996; Guinand 1999; OCHA 2020a). Limited scientific literature is available, most of which focuses on the upper Awash Basin upstream of the Koka Dam. This part of the basin is not affected by large water infrastructure and the availability of river flow data at Hombole station attracts hydrological studies. The rest of the basin remains data-scarce which hampers scientific assessments on extreme cases.

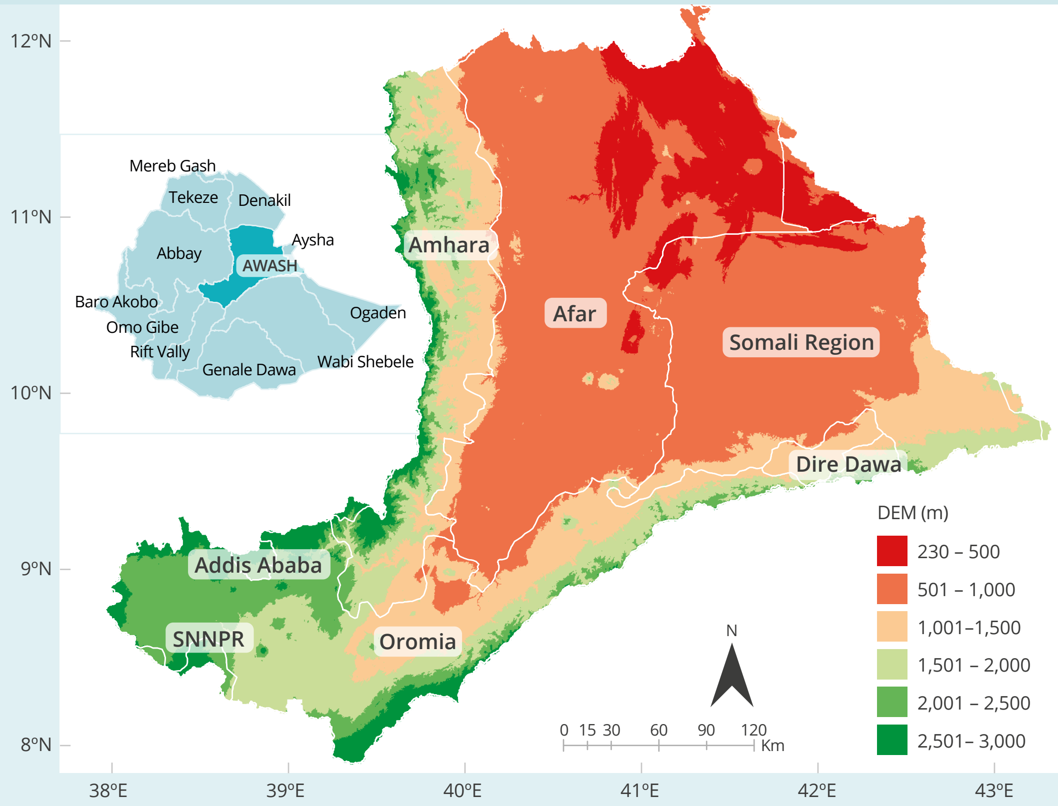
Given the gap in research, interdisciplinary studies can enable a more holistic understanding of extreme events in the Awash Basin. This study examined the characteristics of extreme rainfall and associated drivers of flooding, examining the experience of the 2020 floods from a climatic and non-climatic perspective. Recent wet extremes and flooding were compared with previous flood occurrences and rainfall characteristics. Examining the experiences of different water users in the sub-basins due to these extremes can help plan future management adaptation and/or measures to mitigate flood impacts in different parts of the basin.

Photo by Genet Alazar on Unsplash

Study area

The Awash River Basin in Ethiopia is located between 7°53'N and 12°N latitude and 37°57'E and 43°25'E longitude. The river source emerges in the central highlands of Ethiopia near Ginchi town approximately 3,000m asl (above sea level) and flows northeast through the northern section of the Rift Valley to eventually discharge into the saline Lake Abbe on the Ethiopia-Djibouti border at 250m asl, after traveling a distance of about some 1,200km (Bekele et al., 2019). In total, the whole basin area of about 116,424 km^2 is divided into 21 sub-catchments by the Ministry of Water and Energy. Administratively, the basin includes five regional states: Afar, Amhara, Oromia, South Nation Nationalities People's Regional States (SNNPRs), Somali Regional State, and two administrative cities namely Addis Ababa and Dire Dawa (Figure 1).

Figure 1: Location of the Awash Basin in Ethiopian river basins and elevation map of Awash basin.



Rainfall is bimodal in the upper and western parts of the basin with a main rainfall season from June to September locally known as *Kiremt* and a second rainfall season from March through May, locally known as *Belg* (Figure 2). The annual rainfall ranges between 100 mm in the lowlands to 1200 mm in the highlands. Mean temperature over the basin averages from 19°C to 23°C with May and June being the hottest months (Taye et al., 2018). The upper part of the basin is cooler with temperatures in the range of 15°C to 24°C. The middle and lower parts of the basin are characterized by hot temperatures in the range of 25°C to 32°C. Maximum temperatures range from 17.5°C to 37.5°C while minimum temperatures range from 5°C to 25°C (Figure 3).

Figure 2: Annual total rainfall in the Awash basin (a) and monthly rainfall averaged over Awash basin (b) for the period 1981-2021. Data source: CHIRPS

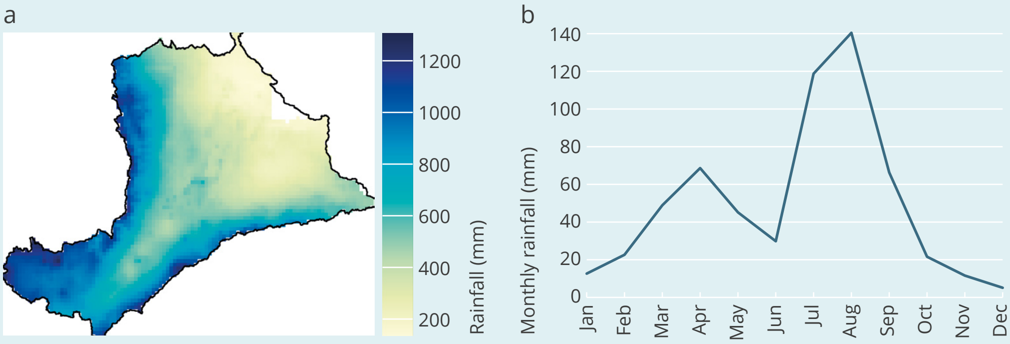
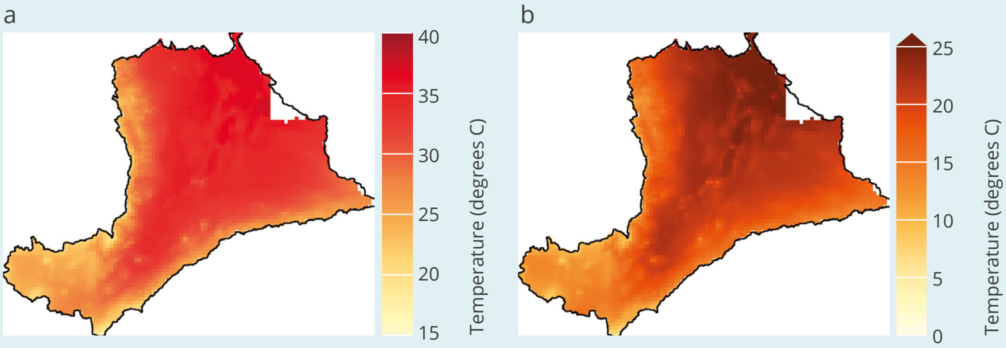


Figure 3: Annual average maximum (a) and minimum (b) temperature for the period 1981-2016. Data source: CHIRPTs



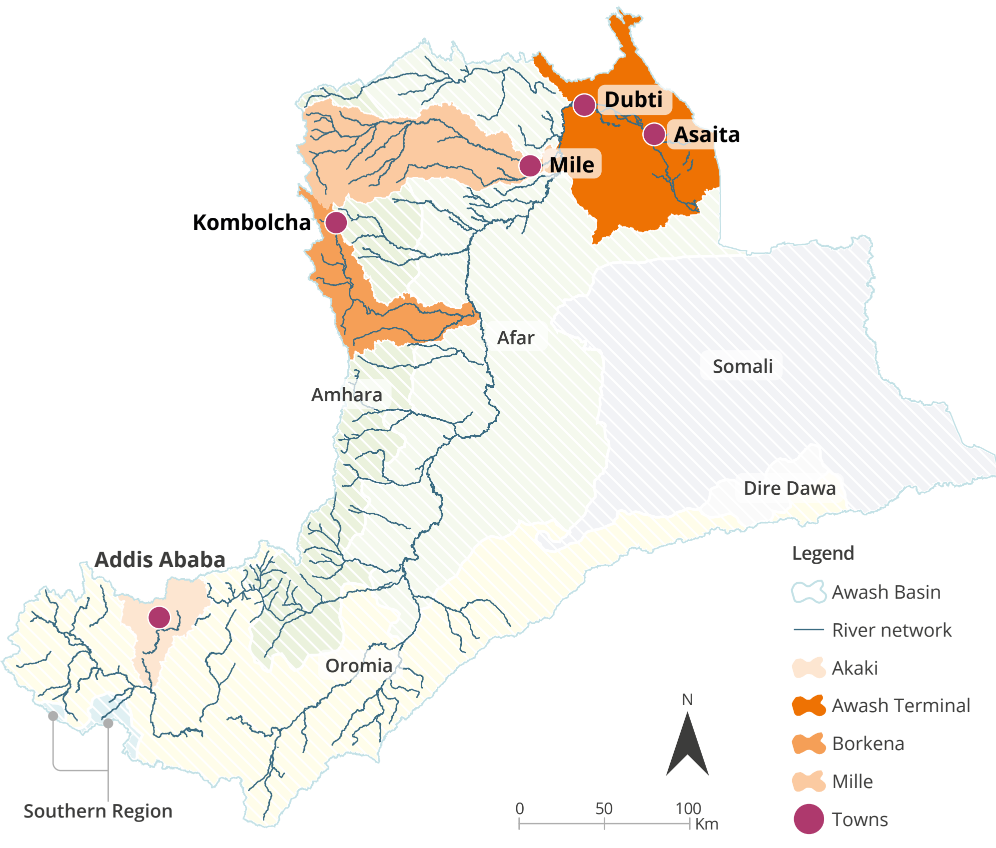
There are three dominant livelihood systems in the Awash Basin: in the mid-highland and highland mixed crop-livestock farming systems are common covering one-third of the basin's area, whereas in the lowland areas agro-pastoralism and pastoralism systems dominate. Over half the basin area is dominated by pastoralism covering most of the Afar and Somali portions of the basin. Total population has doubled in the last 30 years, with a 2020 estimate of some 16.6 million in the basin[1] while the national population is about 115 million.

1 WorldPop Hub

Average population density is some 155 people/km^2 in 2020 with considerable variation between regions. The population density of Addis Ababa and the Afar region as a whole was 6,695 and 28 people/km^2 in 2020[2], respectively showing the difference between the capital city in the upstream and the rural areas in the lowlands, downstream of the basin.

To analyse the experiences of different water users in the Awash Basin in 2020 and for mapping flood extent, four sub-basins were selected – the sub-basins of Akaki, Borkena, Mille and Awash Terminal. This broadly represents the upper, middle, and lower parts of the basin, the characteristics for which are given in Figure 4, below.

Figure 4: Selected sub-basins for flood mapping and communities perspective study.



2 WorldPop Hub

Methodology

The study combined hydroclimatic variables analysis, flood characterization and mapping, land use land cover mapping, and a perspective study on communities.

Hydroclimatic variables analysis

The hydroclimatic analysis focused on analyzing three variables, namely, gridded rainfall, sea surface temperature, and soil moisture to characterize the rainfall and other drivers of the 2020 wet extremes. Gridded precipitation data was downloaded from Climate Hazards Group Infrared Precipitation with Stations v2.0 (CHIRPS). CHIRPS is a blend of satellite-based rainfall estimates and gauge data available at a 0.05 X 0.05 resolution from 1981 to the present (Funk et al., 2015). This data is used to conduct spatial analysis of rainfall on different extreme rainfall indicators. The selected indicators are maximum daily precipitation, 5 days total precipitation (pentad rainfall), 10 days total precipitation (dekad rainfall), number of heavy and very heavy rainfall days, and consecutive wet days (CWD) above a threshold. These indicators were calculated for the peak rainfall months of July and August. The 2020 rainfall during July and August was compared with the period 1981-2010, which is referred to as the baseline period in this study. The anomaly changes were calculated as percentage changes.

One of the methods the Ethiopian Meteorological Institute (EMI) uses to forecast rainfall and flooding conditions for Ethiopia is the analogue year method. Analogue years used for forecasting the 2020 Kiremt rainfall were 1996, 2001, and 2008 (information obtained during stakeholder consultation). Analyses of rainfall averages for these years were compared to that of 2020 to understand how extreme the 2020 event was compared to the analogue years used in flood forecasting. Additionally, historical wet years that resulted in flooding events in different parts of the Awash Basin – e.g. 1996, 2006, 2008, and 2016 – were considered for further assessment. The average of these years was compared with that of the rainfall in 2020 to understand the spatial differences and magnitude changes in the case of the 2020 floods.

To understand the potential large-scale drivers of heavy rainfall, analysis was conducted using global sea surface temperature data (SST). SST data was sourced from the Hadley Centre Sea Ice and Sea Surface Temperature data set (HadISST; Rayner et al., 2003). The monthly and seasonal SSTs of 2020 were compared with the baseline period, 1981-2010, to obtain the SST anomalies for 2020. Four SST regions were selected to represent the Western Indian Ocean, Southern Indian Ocean, Atlantic Ocean, and Niño 3.4 indices to compare the monthly 2020 SST anomalies with the baseline period.

The regions were selected based on Taye et al., (2021) and Dyer et al., (2022), which showed influence on East African rainfall patterns.

In addition to the peak rainfall months of July and August, to understand the impact of antecedent conditions, soil moisture and rainfall during April-June was also analyzed. For soil moisture, the European Space Agency's (ESA) Soil Moisture Climate Change Initiative (CCI) project – (ESA-CCI-SM) data – was used (Dorigo et al., 2017). Similar to earlier variables cited, the anomaly of 2020 was compared to the baseline period.

Table 1: Global SST regions used in this study with their longitude and latitude bounds

No.	Region representing	Code	Lat-Lon region
1.	West Indian Ocean region	WIO	0°-25° N & 45°-70° E
2.	South-west Indian Ocean region	SIO	35°-50° S & 40°-70° E
3.	Atlantic region	Atl	0°-15° N & 10°-60° W
4.	Niño 3.4 region	N34	5°S-5°N & 120-170° W

Remote sensing image analysis

Remote sensing image analysis was used to characterize the flood inundation in the summer of 2020 and the period 2017-2022. This was useful for identifying the flood characteristics (extent, duration, depth, and propagation time) that were responsible for the extensive flood damage in 2020. It also identified which aspects of flooding in the summer 2020 were different from floods in previous seasons. The focus sites for this analysis were Borkena, which is situated in the north-western part of the Awash Basin, and Dubti town and surroundings, which is situated in the northeastern part of the Awash Basin. A combination of data sources was used for these analyses including satellite images, global datasets, and Ground Control Points (GCPs). Satellite images were processed in the Google Earth Engine (GEE).

The flood detection method constituted three major steps. First, GCPs were collected from the Borkena and Dubti sites through a field survey. A data collection protocol guided the collection of reference data for training remote sensing-based flood detection algorithms. Next, three flood detection algorithms using Sentinel-1 images were identified and refined for these locations. This was followed by comparing the algorithms' performance to map the 2020 floods in Borkena and Dubti. The reference flood extent map for comparison was prepared using the GCPs collected through a field survey. The characterization of the 2020 flood in terms of the extent and frequency of flood inundation was evaluated and compared against those characteristics for the period 2017-2022 excluding the year 2020. To analyse the contribution of changes in land use and land cover to flood risks and impacts the Curve Number (CN) map of the Awash basin was generated from LULC and soil maps for the period 2017-2022 to relate to the runoff generation situation of the catchment.

Communities' perspective analysis

Combining climate and hydrology analysis with social science approaches helped bring community perspectives into the research. This included how flood extent and duration differed from previous events, how communities were impacted, the gender dimensions of these impacts, and the short to long-term consequences of these impacts. To examine these factors surveys were undertaken in communities in the upper, middle, and lower parts of the basin. These surveys examined key livelihoods, institutional and gender factors, the implications of institutional and political-economic dynamics, and how these factors have helped shape major flood responses by government and society in recent years.

In the Akaki sub-basin sites in Upper Awash, two sites were chosen – Akaki Woreda 3 which is included in the Addis Ababa city government Administration, and Akaki Woreda-Hechu which is included within the Oromia special zone of the Oromia regional government. The first site is within an urban setting, while the other is rural. However, both localities were identified as highly flood-prone areas within the Akaki basin. In the Middle Awash, the study was conducted in the flood-prone areas of the North Wello zone, which is included in the Amhara regional government. Specifically, the study was conducted in the Habru district and two research sites within the district, namely Mehal Amba and Wurgessa. In the Lower Awash, research was conducted within the Afar region, specifically in flood-prone areas of Asayita, including two sites in Mamule and Siseledemo kebeles.

Results

Rainfall anomalies

Unusual rainfall in terms of location, magnitude, and timing was the major cause of flooding in 2020. Figure 5 shows these anomalies for July and August of 2020 for each dekad in these months. High rainfall in the lower basin and western escarpment early in the rainy season was unusual. In the baseline period the 1st dekad of July on average receives 18 mm of rainfall. However, in 2020 for the same 1st dekad of July on average total rainfall of about 40 mm was observed. This translates to a rainfall anomaly of more than 75% observed for 2020 compared to the long-term average (1981-2010) for the lower basin. The lower part of the basin received very high rainfall during the 1st dekad of July 2020 and 3rd dekad of August 2020. These results align with the report by OCHA published on 15 August 2020 that stated the occurrence of flooding in 11 woredas in the Afar region since the end of July 2020 from the backflow of the Tendaho dam and overflow of the Awash River. The UN office reported a displacement of 144000 people from Afar region by September 2020.

Compared to previous wet years with severe flooding, the 2020 rainfall anomaly (by volume) was more than 50% higher than the average of previous wet years, as demonstrated in Figure 6. The 1st dekad of July and 1st dekad of August experienced more than 50% more rainfall in the west and lower part of the basin. In the 2nd dekad of August, the upper part of the basin experienced more than 50% more rainfall and during the 3rd dekad of August both the upper and eastern parts of the lower basin experienced high rainfall anomalies. This shows the 2020 rainfall season was exceptionally wet due to two factors. First, the western part of the lower basin received higher rainfall than in previous wet years; and secondly, in the latter part of the season, the upper basin received high rainfall that increased the amount of water in upstream tributaries.

Figure 5: July and August 2020 dekad rainfall anomaly compared to the 1981-2010 average rainfall total of the respective dekads

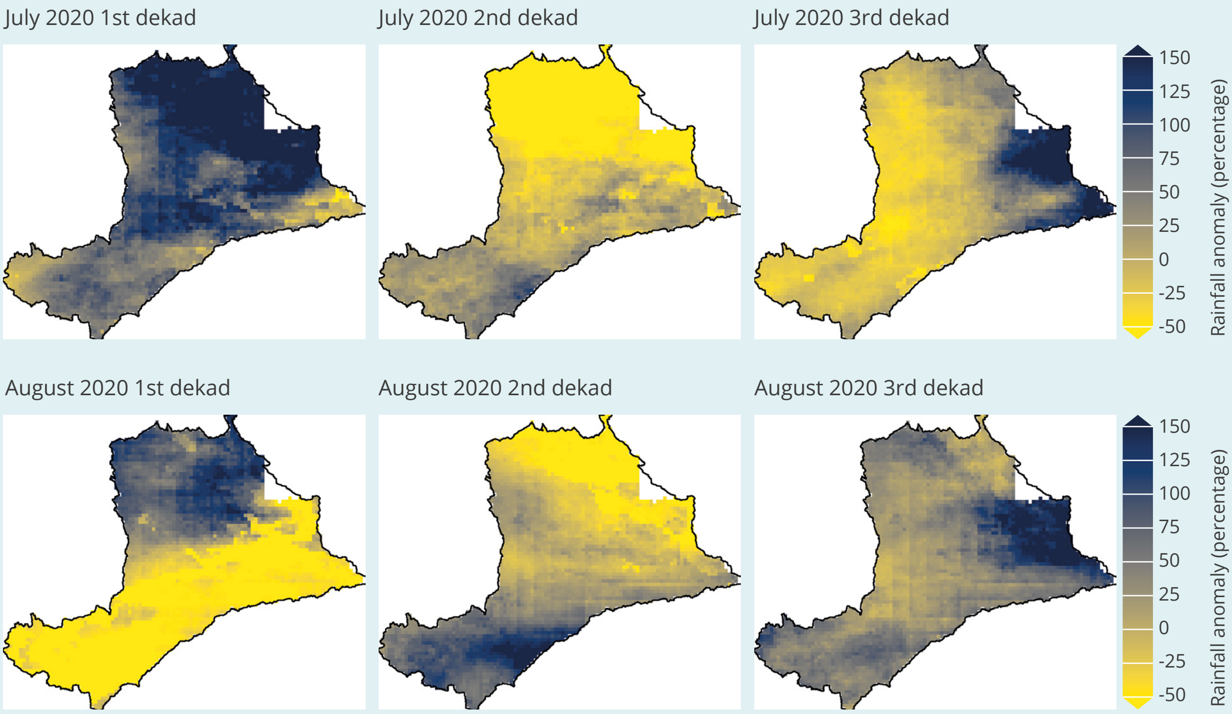
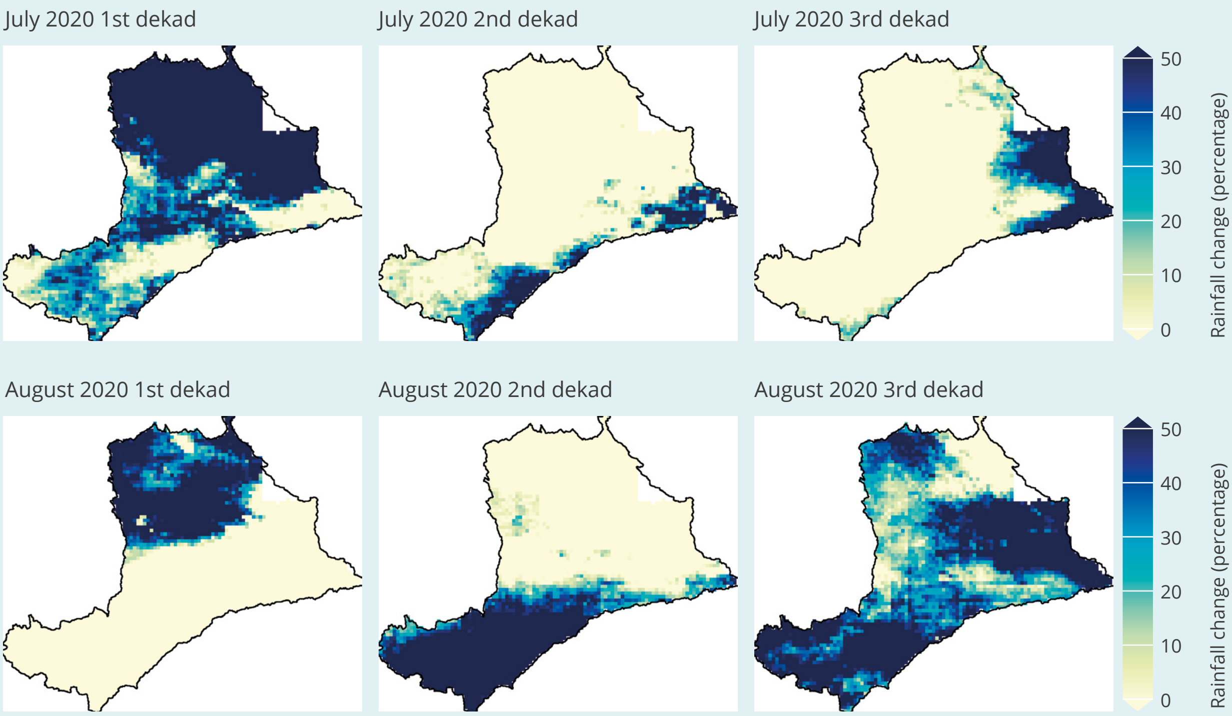


Figure 6: July and August 2020 dekad rainfall anomaly compared to previous wet years average rainfall total of the respective dekads



Number of heavy rainfall days

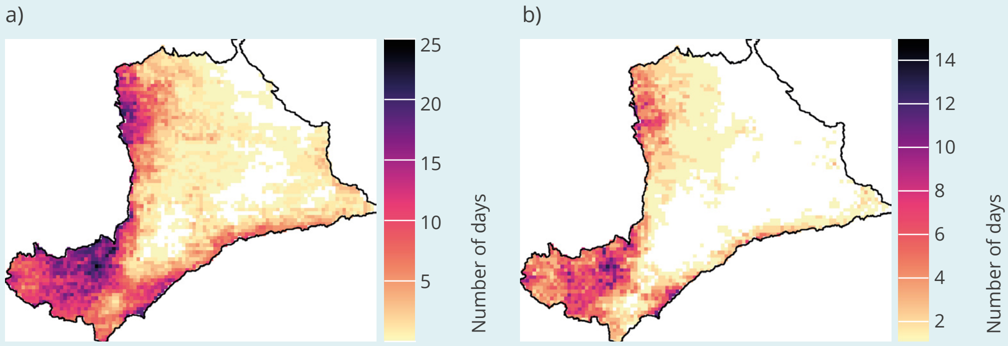
The number of heavy and very heavy rainfall days were counted above the threshold of the 95th percentile during the base year 1981-2010 and the July- August rainfall period. This threshold was set for the lower and upper basins separately as given in Table 2.

The number of heavy rainfall days during the July-August season in 2020 was more than the long-term period by up to 25 days in parts of the Lower Awash western escarpment (Figure 7). The number of very heavy rainfall days was higher by about 10 days in some locations (Figure 7). These results show that in the lower part of the basin both on the escarpment and in the lowlands, there was unprecedented heavy rainfall which contributed to the high floods that occurred in the lower part of the basin during 2020.

Table 2: Heavy and very heavy rainfall days of the long-term 1981-2010 period during July and August to be used as threshold values to compare to 2020 days

Selected regions	Heavy rainfall (95th percentile) (mm/day)
Lower basin (10-12 N & 40-41E)	10.2
Upper basin (8-9 N & 38-40 E)	17.0

Figure 7: Number of heavy rainfall (a) and very heavy rainfall days (b) in the lower basin in 2020 more than the 1981-2010 reference in July-August



Antecedent rainfall

Antecedent rainfall conditions in the April-June (Belg) season in 2020 were wetter than average by about 62% in terms of the magnitude of total rainfall. The number of heavy rainfall days was also more than the baseline period by 10-15 days in most parts of the Lower Awash western escarpment. April and June were the wettest months in the Belg season of year 2020 (Figure 8). This shows the potential for the basin to have exhibited high soil moisture conditions before the heavy rains in July-August.

As per the Joint Government – Humanitarian Partners Response Plan published in May 2020, heavy and prolonged rains during the months of April and May 2020 led to flooding and landslide incidents in different parts of the country. In the Afar region around 18,600 people were affected (OCHA, 2020b).

The soil moisture results confirm the antecedent conditions were wetter than the long-term average. Figure 9 shows soil moisture anomalies for the months of April to June. Most parts of the Awash Basin were from 10 to 40% wetter than average in these antecedent months.

Figure 8: April to June 2020 monthly rainfall anomaly compared to the 1981-2010 average rainfall total of the respective months

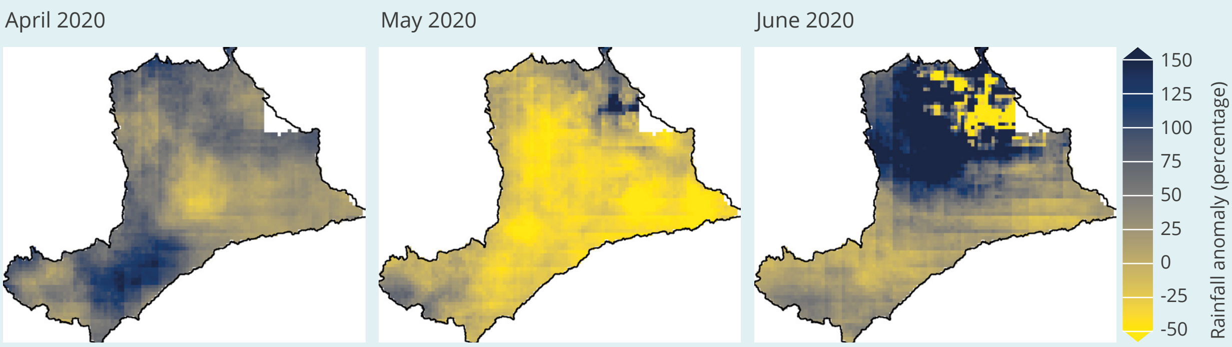
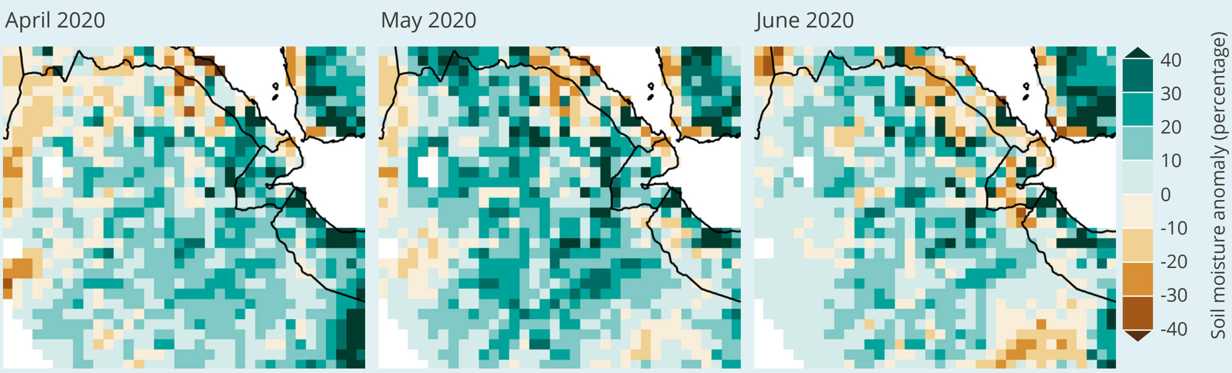


Figure 9: Soil moisture anomaly of 2020 compared to the 1981-2010 average for April to June



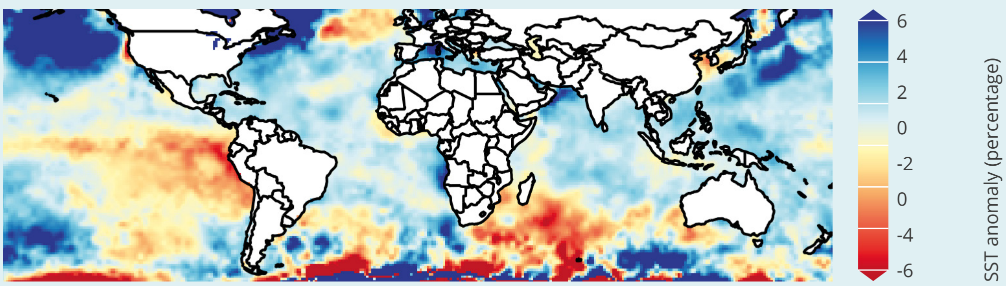
Large-scale atmospheric drivers

The atmospheric drivers of the 2020 July-August extreme rainfall events are a combination of climate factors. The occurrence of a weak La Niña and positive Western Indian Ocean likely contributed to the intense rains. The Oceanic Niño Index (ONI) index for July to September had a value of -0.6,[3] which is in the category of a weak La Niña. Figure 10 shows generally the Pacific Ocean region was cooler than the baseline period during the July-August period. Starting from this season there were unusually consecutive La Niña years from 2020–2022.

Figure 11 illustrates the March to August 2020 Sea Surface Temperature anomaly of four indices compared to the base period 1981-2010. Indian Ocean related indices, the WIO was positive compared to the baseline period for the months from April to August and the SIO was negative, which suggests a potential influence of these changes in the Indian Ocean on heavy rainfall in East Africa. Given that Sudan experienced devastating flooding in August 2020, Elagib et al., (2021) suggests the cause of increased rainfall intensity can be both large-scale changes in the atmospheric circulation and more local factors enhancing the convection intensity. Hence, the need to better understand mesoscale convective systems across the region and improve the forecasting skill of the influence of ENSO, IOD, and Atlantic Meridional Oscillation (AMO), which reportedly influence the magnitude of rainfall over the Ethiopian highlands (Elagib et al., 2021).

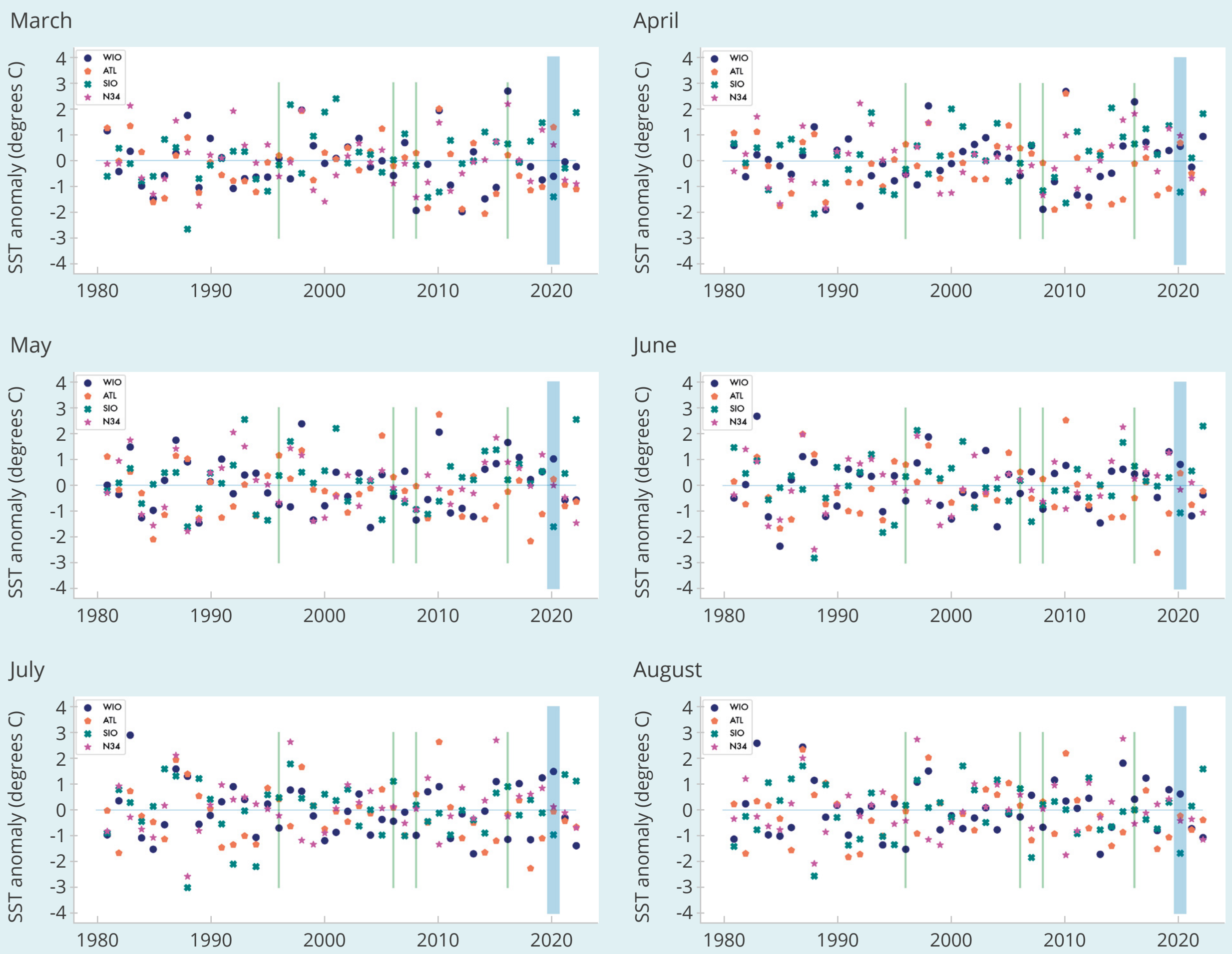
Rather than relying on standalone drivers to predict severity, a better understanding of how multiple compounding drivers can interact and lead to more extreme impacts in a changing climate is necessary for future adaptation and resilience purposes (Taye and Dyer, 2024). This should extend more than the climatic drivers and include other aspects of physical infrastructure, land use change, and socio-economic factors.

Figure 10: July to August 2020 Sea Surface Temperature anomaly compared to the base period 1981-2010



3 National Weather Service Climate Prediction Center – cold and warm episodes by season.

Figure 11: March to August 2020 Sea Surface Temperature anomaly of four indices compared to the base period 1981-2010



River flow analysis

In order to understand how the rainfall anomalies translated into floods, river flow data is necessary. Although there are several stations installed in the Awash basin only a handful of stations have long-term data. The data obtained from the Ministry of Water and Energy for these river flow stations ended in 2014. Therefore, it was not possible to do an analysis comparing the 2020 flow with rainfall anomalies and that of previous wet years' river flows.

The time series of the annual maximum flow of the Awash River at Hombole, Melka Kunture, and Wonji are available for a common period of 1969-2014 (Figure 12). A maximum annual flow of 803 m^3/s at the Homoble site with about a return period of 50 years is observed, while the corresponding figure at Melka Kunture is 555 m^3/s and that of Wonji is 304 m^3/s. How these values were exceeded in the case of the 2020 exceptional wet season remains unclear due to the lack of observed river flow data since 2015.

Figure 12: Annual maximum flow of Awash River at Hombole, Melka Kunture and Wonji river gauging sites

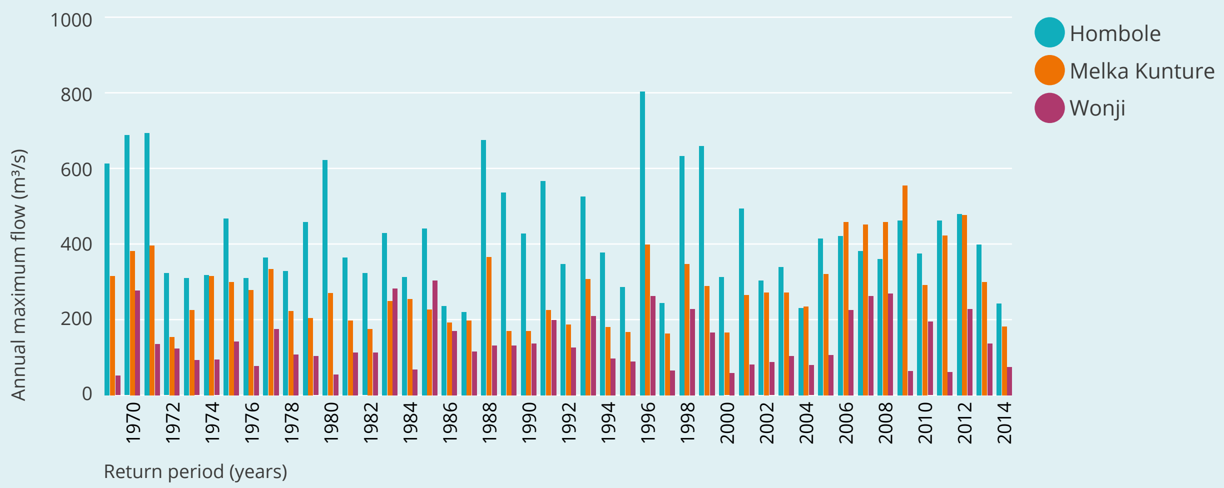


Figure 13: The return period of annual maximum flow of Awash River at Hombole, Melka Kunture and Wonji river gauging sites

Flood mapping

The 2020 flood was characterized by early onset, delayed recession, and a greater extent than in past flood events. Remote sensing analysis using images of 10-m resolution and 6 to 12 days revisit time showed a flood extent that reached 159.22 km^2 in 2020 (Figure 14) amounting to a 26% increase as compared to the flood extent in 2017-2019.

Such was its extent and power that it washed away roads near Dubti town (Figure 15) that caused flooding and abandoning of an irrigated area. Community consultations and ground truthing of the remote sensing analysis highlighted that floods from the Logyia tributary were damaging to lowland areas of the basin more than the main Awash River (Haile et al., 2024). This is because of unpredictable and high magnitude flood generated by a combination of unusually extreme rainfall combined with steep topography and degraded land cover.

Figure 14: Flood extent in Dubti town based on remote sensing analysis. Red boxes show sites which were flooded in 2020 but used to be dry before in similar seasons, and CR refers to parallel access road and canal.

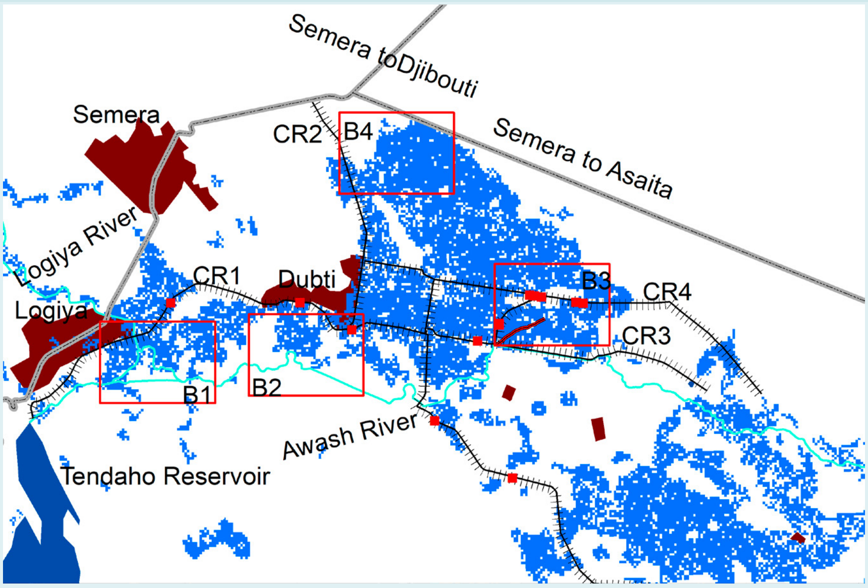
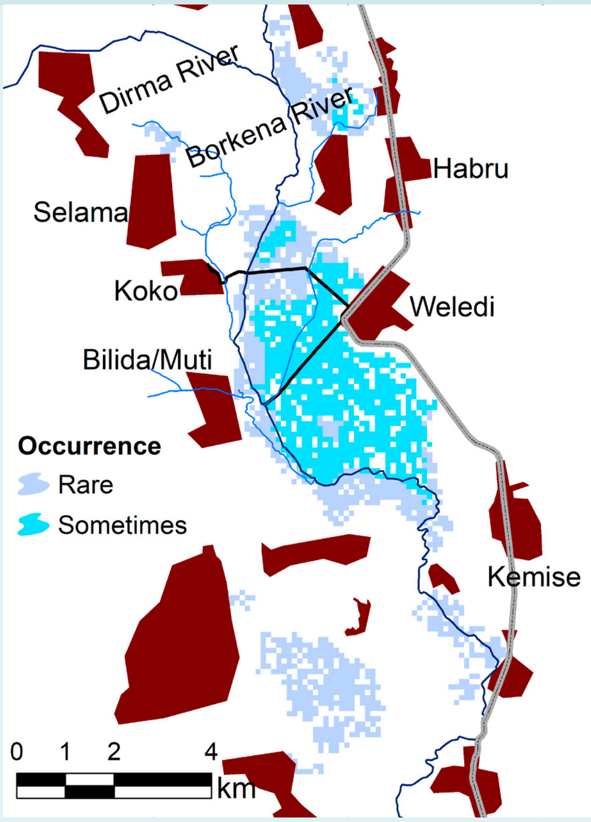


Figure 15: Road washed away in Dubti town due to the 2020 floods, which resulted in abandoning of irrigated land.

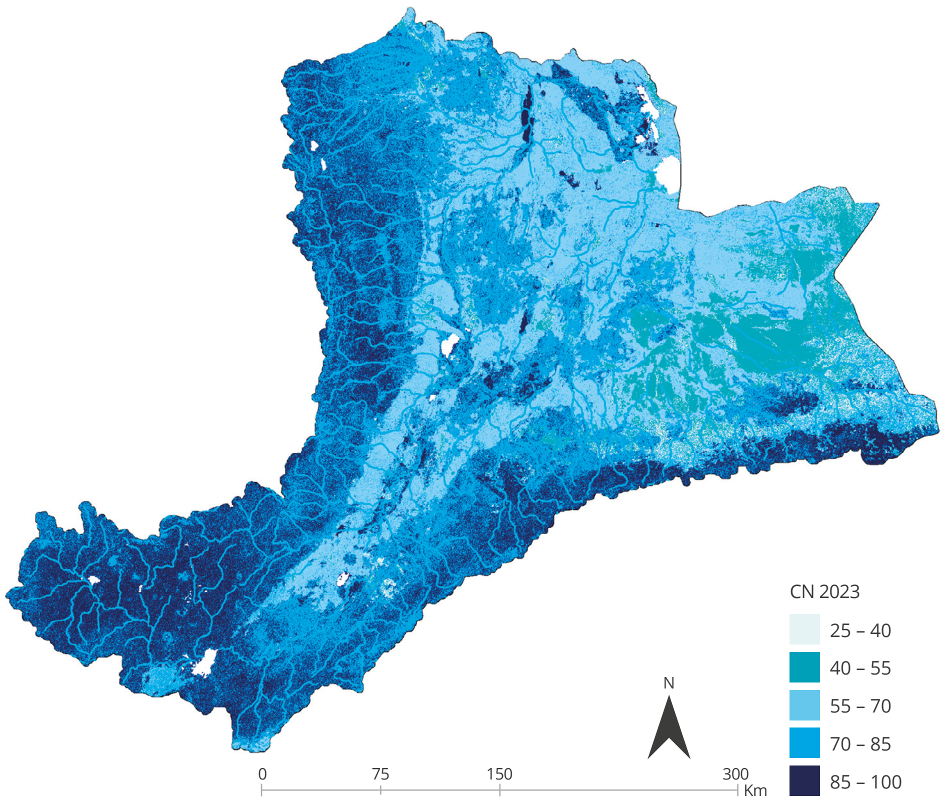
In the Borkena site, Figure 16 shows that the middle part of Borkena sub-basin (situated between Koko, Weledi and Bilida/Muti villages) was inundated up to 40 percent of the time (i.e. sometimes) in the 2020 flood season. However, other flooded parts of the site were inundated only less than 10 percent of the time (i.e. rarely). The flooded areas, which were inundated rarely, are found at upstream and downstream sites with most of them along the western floodplain of the river. The flood affected mostly agricultural lands with minor threats to settlements in this location.

Figure 16: Flood extent in Borkena town based on remote sensing analysis (Brown polygons indicate settlements)



The remote sensing analysis also highlighted the impact of land use change on exacerbating floods and vice versa for the entire Awash Basin. This caused an increase in curve number (runoff generation potential) values that signify the basin's susceptibility to easily produce runoff even from smaller rainfall events (Figure 17). The upstream parts of the Awash basin are characterized by steep topography, settlements, and possible land degradation. As a result, large curve number values are observed indicating a large runoff generation potential over most of its parts (Figure 12). In such types of basins, flood producing runoff is expected not only from extreme rainfall amounts but also from moderate rainfall amounts. Hence, ongoing efforts of tree plantation in the basin can have a positive impact on reducing runoff generation potential and consequently flooding in the basin.

Figure 17: Curve number of Awash Basin for recent period



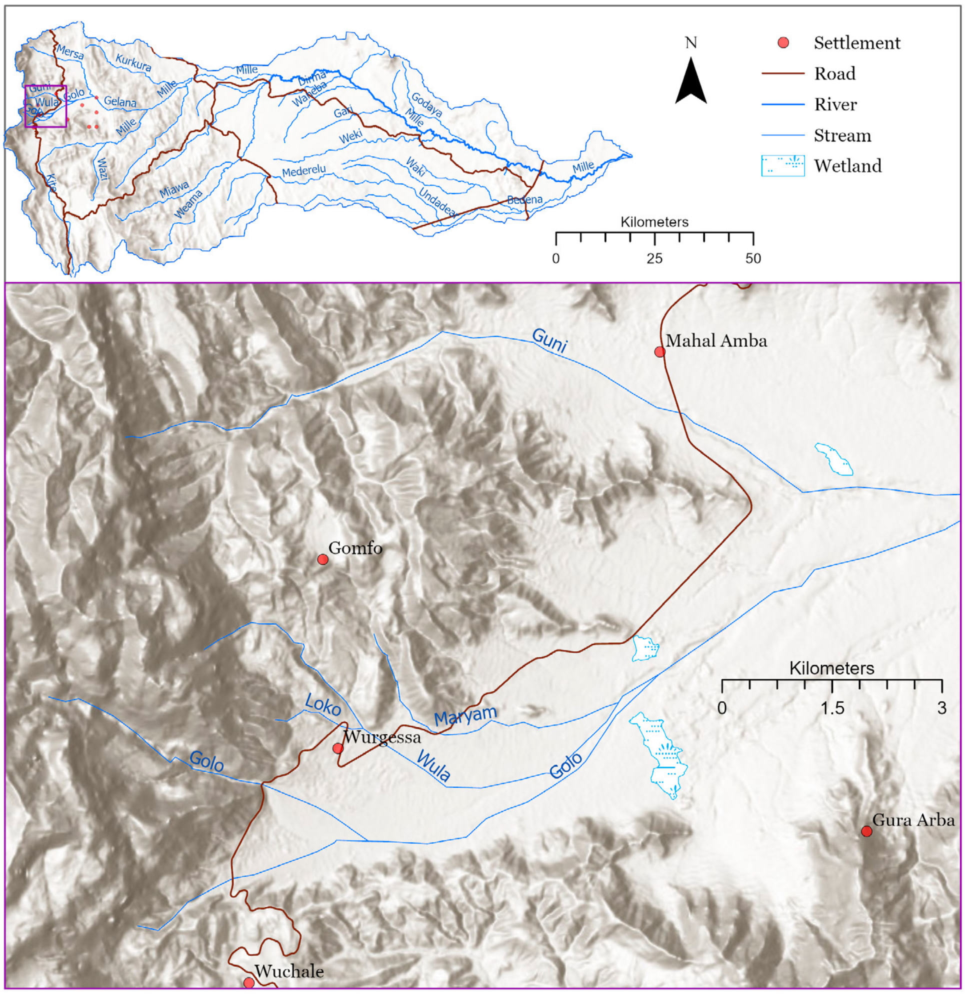
Communities' perspective

Physical context

In the middle Awash Basin of North Wello at Mehal Amba and Wurgessa flooding has occurred several times in the past, in particular from the Guni and Wula rivers (Figure 18). Some key informants consulted indicated that the Guni and Wula Rivers pose a constant, localized flood risk, with severe floods occurring in recent years including 2020.

In describing the chronology of flooding events, local informants indicated that the Guni River started silting up from 2016 onwards. During fieldwork, a respondent from Ade Gulfeta recalled that "Before 2016, the river was deep. But now, you can cross over it from any side. Now we lost the river. The river land and adjacent farmlands have become the same level." During fieldwork, respondents in Wurgessa recalled that the 2020 flood was not just high, but that the timing of the first incident was extreme, with flood waters arriving late in the evening and destroying bridges, offices and trading shops after hours of heavy rain.

Figure 18: Location map of Guni and Wula rivers



In the Upper Awash Akaki sub-basin, flooding is a common occurrence during the rainy season. Key informants reported that there had been recurrent flooding since 2015, albeit with variation in intensity. According to informants, there was high flooding before the turn of the Ethiopian millennium (2000 Eth Cal/2012), but the intensity decreased in the following decade (from 2008 to 2018). This was largely attributed to the establishment of new drainage infrastructure.

In the Lower Awash Basin flooding in Asayita has a long history associated with the main channel of the Awash River eventually feeding into an endoreic delta at this point. Field work participants revealed that past events had occurred largely during the rainy season, every 2-3 years, and with fairly predictable impacts. However, in the past 5-6 years respondents indicated that flood frequency had increased, including during both Kiremt and Belg seasons. In Afar, the floods of 2020 and 2022 were particularly devastating and during the Kiremt season of 2020, in particular, floodwaters inundated large areas for an extended period.

During previous floods in Afar, affected communities would have time to move their livestock and households to safer areas. However, in 2020 flooding was so extreme – and fast – that the process of evacuation was impeded, leaving many livestock stranded and people having to be airlifted out. Social-distancing measures to stem the Covid-19 pandemic at the time also complicated flood responses, preventing community members from assisting each other in person during the emergency. The breakdown in mutual support left many isolated and contributed to more serious social impacts.

Socio-economic context

Land and water-based interventions in study sites in the middle Awash Basin, in Mehal Amba and Wurgessa woredas within North Wello Zone, also contributed to more severe flood impacts. In particular, the extraction of building stone by large vehicles from riverbeds over a 10-year period changed the composition and size of river channels, according to key community informants, altering the direction and depth of tributaries and ultimately exacerbating flood impacts (Figure 19).

Figure 19: Stone extraction in the north Wello Zone.

Respondents in Hechu, a rural part of the Akaki Basin, indicated that discharge from the Abasamuel hydroelectric dam had also contributed to the intensity of flooding. According to rural Akaki residents, this is because the water flow is blocked by the dam and water backs up in the reservoir. During heavy rain, the amount of 'reversed water' increases, flooding nearby farmland.

In the Lower Awash Basin in Afar, key informants revealed that the Tendaho Dam, which is associated with a sugar cane plantation and factory, was one of the key factors contributing to flooding. Water released from the dam mixed with the Awash River and inundated nearby villages and farmland. Respondents also associated the 2020 flooding with the over-filling of the dam and subsequent release of water. The flood wall which was built to protect the sugar cane plantation and sugar factory exacerbated flooding in the area. Key informant interviews and focus group discussions conducted in Assaiyta indicated that the wall had obstructed the natural flood path and led to inundated of villages and farmland instead.

Generally, poor management of existing infrastructure systems in combination with more extreme climate situations increase the impact of flooding.

Urbanization

In the Middle and Upper Awash where urbanization is greatest, built environments both contribute to flood events and exacerbate their impacts on people. In Wurgessa, North Wello, respondents indicated that in the last 10 years urbanization had been increasing, particularly following the distribution of land for house building and the expansion of larger settlements. Local respondents in Wurgessa indicated that the building of houses affected river flows, with areas prone to flooding increasingly being built upon, added to which new settlements were constructed with their own inadequate drainage. Expansion of towns also increased the demand for construction materials, adding to the extraction of resources from river channels. Similar urban impacts were reported in the Akaki basin as well with the added problem of more paved surfaces reducing rainfall infiltration and contributing to rapid runoff.

In the Lower Awash Basin, urbanization is less significant as a cause although respondents in Asayita town noted that localized flooding had been exacerbated by poor waste management and disposal causing drainage channels to become filled with waste.

Weak collective action

Weak collective action has been a significant problem in Middle Awash Basin study sites. This has hastened the degradation of forests which, in turn, has led to more soil erosion, contributing to additional runoff and siltation of gullies and channels. Hitherto, forested areas had been protected and looked after by hired guards through sponsored payment. This protection ended five years ago leading to rapid loss of tree cover for woody biomass fuel, with the added challenge of people driving livestock into these areas for grazing.

The problem of collective action to protect upland forested areas has been exacerbated by socio-ecological divides between upland residents and those living at lower elevations. Clearance upstream ultimately affects lower elevations; however responsible authorities are non-contiguous between upland and lowland areas. Other collective action challenges include in the Akaki study sites. During heavy rainfall, the problem of flooding in Akaki is exacerbated by poor drainage facilities. Respondents in Akaki indicated that most residents do not regularly help clear drainage infrastructure around their houses.

In the Afar site of the Awash Basin, there has been a lack of proper clearing of the river channel, leading to silt and debris accumulation as well as vegetation growth within water channels. In addition, the growth of fig, date, and acacia trees in the river over time blocks flows and exacerbates flooding. Invasive species, including *Prosopis juliflora* have also exacerbated the problem by narrowing the river channel through riverbank colonisation.

The overall conclusion is that collective action at a community level to maintain the Awash River basin landscape has declined over the years. This is due, in part, to the lack of a responsible body to organize and coordinate actions. Key informants in Asayita explained that in the past, a river body would organize the community to clear the riverbanks regularly. As a result, the river was not blocked by bushes, fallen trees, and sediment. However, there has been a lack of community coordination to manage river protection and clearing activities.

Institutions

Regional level

During the 2020 flood, the Afar Region Water Office played a crucial role in issuing public safety guidance to minimize flood damage through media channels. However, remote populations had only limited access to these advisories. Local government in Asayita also worked closely with charitable organizations on emergency responses including evacuation, providing temporary shelter and relief supplies for those displaced, as well as livelihood assistance from livestock relief to support recovery. During past flood disasters, the local government worked closely with NGOs to provide temporary shelter for displaced individuals and livestock. Some organizations also distributed urgent food supplies after the 2020 floods.

At communal level

At a community level, both men and women raised funds and worked together to plant wooden poles and fill gaps with soil, Kesha (grain sacks), and other resources. These barriers helped protect vulnerable areas. Community-based support systems also enabled agropastoralists – both men and women – to support one another during and after flood events and to collaborate in prevention and coping efforts. Close networks of friends, family, and neighbours helped to distribute supplies, share resources such as labour and finance, and collaborate in prevention, coping strategies, and recovery efforts.

To support efforts in rebuilding livelihoods, men were allowed to use fields that had not been flood-affected, helping them preserve their livelihoods. Male and female agro-pastoral families that had lost small stock were also provided with goats to help them replace lost livestock. At a household level, meals and rations were provided to those who could not access food due to crop or property damage. Loans were also provided to enable men and women to cover basic needs.

Impacts

In the different sites of the Awash Basin, the 2020 flood affected people's livelihood activities in different ways. These impacts, among other things, include loss of farmland, crop losses, disruption of agriculture, and economic activities. Flooding also affected properties, assets, infrastructure, investment, and mobility. We discuss these impacts below and identify in the concluding section critical gender-specific factors involved.

Impacts on livelihoods and livelihood activities

In the Middle Awash Basin, flooding significantly affected people's livelihood activities. Loss of farmland is the largest single impact of flooding on livelihoods. Respondents in Habru, North Wollo, indicated that although the 2020 flooding had a major visible impact on farmland, progressive farmland erosion had begun during preceding flood events. "My farmland was constantly being degraded by the flood. In 2020, the rain was very heavy. The flood that occurred during this time completely took away my farmland. I lost 2 timad[4] of land." One farmer reported. Another stated, "I have 1 timad of land in the flooded area. I used to cultivate onions and tomatoes using irrigation. I would harvest two times per year. From the sale of my produce, I would get 30,000 birr to 40,000 birr per harvest. Now I have lost all this, as I lost my farm plot."

Farmers who lost land to flooding also had administrative problems to tackle. Although the land was no longer functional, it still appeared in the government's land registration documentation and, therefore, they were required to pay land use tax on it. A key informant in Wurgessa indicated that many farmers who had lost land returned their land certificates to avoid having to pay taxes.

The potential risk of future flooding has now made farmland in flood-prone areas unattractive for investment. This is a problem particularly felt by female-headed households who engage in sharecropping and may lack essential resources such as labour and plough animals to work their own land. As a result, sharecroppers may not be interested in sharecropping with them. A 32-year-old female farmer in Mehal Amba affected in this way stated "I have been widowed since my husband passed away. I was sharecropping my small land with another [male] farmer. The 2020 flood-affected parts of my farmland. Then after, my farmland remained uncultivated. No farmer wanted to sharecrop this risk-prone farmland."

4 1 timad is 0.25 ha.

In the Upper Awash Basin, the 2020 flooding adversely impacted both urban and rural livelihoods and livelihood activities, including agriculture, trading, and other economic activities. In urban Akaki vegetable and grass production along the Akaki River was seriously affected. The damage to production affected not only the producers but also traders who bought goods to sell in the market. In rural parts of the Akaki Basin, flooding in the Kiremt season impacted cereal crops like maize, teff, and wheat, while the Belg floods affected irrigated vegetables and wheat cultivation. In the Afar site, the 2020 floods inundated farmlands and washed away planted crops, including pepper, onions, tomatoes, maize, and cotton, as well as standing crops such as mango. Besides destroying planted crops, floods also made farmland unusable. In Asayita recurring floods have left many hectares of land in the area fallow and uncultivated since 2020, with inundated farmland preventing farming over successive years.

Floods also significantly affected livestock in keyways. Many goats, cattle, and camels die because of the floods, with the problem compounded by floods restricting access to grazing for those animals that initially survived. Focus group participants in Asayita indicated that livestock could not easily move to areas where grazing resources would be available while, at the same time, key grasslands were completely flooded. Livestock grazing became especially difficult with feed also becoming scarce. Contaminated flood waters then compounded the problem and led to the further death of many livestock. Knock-on effects for consumers included the loss of products such as milk, cheese, and meat.

In Habru, north Wello, the impact of the floods included households desperately selling their livestock due to loss of land holdings and access to grazing, a particular challenge for cattle owners. Physical destruction of settlements in urban Akaki affected the operation of social and cultural institutions such as *iddirs*. Respondents in Akaki explained that because of the flooding problems, it was difficult to organize social gatherings and maintain the activities of *iddirs*.[5]

Impacts on infrastructure, investment and mobility

In the Middle Awash study sites in North Wollo, the major impact of flooding on public infrastructure relates to water supply facilities. Respondents in Wurgessa and Mehal Amba indicated that during the 2020 flood water pipelines were damaged multiple times and residents were unable to access tap water until the pipelines had been repaired at the end of the flood season. In Upper Awash, flooding affected public infrastructure in the Akaki sub-basin, including damage to power lines directly affecting socio-economic activities. Damage to road infrastructure further interrupted the movement of people and goods. In the Afar study sites, a major impact was on water supply, particularly as flooding in Asayita town had contaminated groundwater wells, prevented borehole drilling in new areas and affected access to piped water, especially in Asayita town.

5 An informal social insurance arrangement at community level.

In the Middle Awash study areas flooding significantly affected personal mobility. Based on data from Habru, north Wello, disruption included impacts on market activities and trade in goods and services, including the sale and purchase of grain (teff), vegetables (tomato), and livestock (camel, sheep, goat, chicken). Particular problems for livestock trading occurred in the Lower Awash with interruptions to livestock trading leaving Afar pastoralists with no access to income in some cases.

Vulnerability to flood and differential vulnerability contexts

Vulnerability to flooding in urban Akaki is closely linked to socio-economic status. Many of those living in the most flood-affected areas are already relatively poor. There are also people living in old government-subsidized kebele houses with poor drainage systems and weak design. In rural areas, flooding differentially impacted the livelihoods of people who depend on agriculture. People who are settled around the riverside and farmers with land located in or adjacent to flooding routes are highly vulnerable to the impacts of flooding. Relatively “poor” farmers, who lack access to farmland in other non-flood-prone farm areas work on farm plots around the riverside. Most of the rural lands next to the river were formerly communal lands for grazing livestock. They are marginal areas that involve cultivation risks.

There are also variations depending on the seasons. In the rural surroundings of Akaki, the flooding that occurred during the Belg season largely affected the livelihoods of youth. This is because youth are involved in irrigated horticulture along the river during the Belg season. Key informants in Hechu indicated that youth engaged in irrigation-based vegetable production by borrowing money to run agricultural activities. When these activities were jeopardized by flooding, they lost not only production goods but also their ability to pay off debts.

Gender-specific issues

The 2020 floods disproportionately affected women, disrupting livelihoods, increasing domestic responsibilities, and limiting access to basic facilities like health and education. These gender-specific vulnerabilities are important in understanding how best to respond to extreme flood events in the future.

Disproportionate impact on women’s livelihood and income: The livelihood activities of rural women and men are significantly influenced by flooding, with agricultural land and livestock being the primary assets. The loss of these assets during recurring flood events severely impacts rural women in flood-prone areas. Specifically, women reliant on single livelihoods and having a limited asset base were most impacted as they lacked a means of income to support their families. For example, female household heads in resource-poor agropastoral communities who grew crops often lacked the funds to hire labourers. A 58-year-old woman from a resource-poor household in Siselendemu Kebele described her situation as follows: "I had planted cotton, but the flood in 2020 destroyed it due to a shortage of labour on my part. Meanwhile, my neighbour, a man, had also planted cotton, but he had money and hired daily labourers to collect his cotton and save it from the floodwaters.”

Additionally, the flood caused significant financial losses for women who earned income from selling dairy products, handicrafts, and products from perennial crops such as palm tree products, mangoes, papayas and coffee. In Asayita and Habru woredas, perennial crops that once thrived perished due to years of inundation, which affected the main source of income that women typically control. A 45-year-old resource-poor woman from Mamula Kebele, described the challenges she faced due to the 2020 floods while making mats from palm trees: "… Our primary source of income relied on farming. However, we were unable to farm because the land remained waterlogged for an extended period. I used to weave palm mats and sell them. However, cutting palm trees was challenging because they were partially submerged in water. The floods had severely impacted our livelihoods and ways of life." These gendered impacts can hinder women's post-flood coping capacity, leading to increased poverty and vulnerability, and exacerbating pre-existing gender inequalities.

Increased workload for women: Division of labour can undergo significant shifts due to flooding, resulting in expanded (unpaid) family care and additional roles for flood prevention and recovery, limiting women's capacity to rebuild their livelihoods. At a community level, apart from specific groups such as pregnant and nursing women, the elderly, and individuals with disabilities, both men and women participate in activities aimed at mitigating floods. These activities include tasks such as cleaning canals, excavating ditches, maintaining drainage systems, constructing stone and soil barriers, establishing check dams, and planting vegetation like trees or grass in residential areas, surrounding regions, and agricultural land. Moreover, women in Habru woreda contributed by providing food to workers engaged in various flood prevention initiatives.

At household level, women at the study sites are solely responsible for all domestic tasks, such as cleaning, cooking, caring for elderly, young children, and sick household members, fetching water and firewood, while also actively participating in income-generating activities such as farming and weaving mats (for women in Asayita, in particular). The 2020 floods caused damage to infrastructure such as water and power systems as well as health centres exacerbating women's domestic responsibilities in several ways.

The damage to infrastructure such as water, road and power systems due to the 2020 floods increase workloads for women. In rural Habru and Asayita woredas where there is heavy reliance on groundwater and a lack of alternative sources nearby, when floods damaged these sources impacts on women included having to travel longer distances while carrying jerrycans. Damage to roads made it challenging to use transportation including bajaj (three-wheelers) or animals such as donkeys to carry jerry cans, forcing women to carry them on their backs. In Habru, women faced these challenges until the rainy season concluded, lasting almost three months. Power outages also placed a significant burden on women in urban areas of Habru and Asayita compelling them to either manually grind cereals at home or travel long distances to access grinding mills.

The 2020 floods also significantly impacted women’s caregiving responsibilities, particularly in agro-pastoral communities. Here women faced increased risks during floods, often caring for children, the elderly, and the disabled. Women living in slums and flood-prone areas also had to pack their belongings for easy relocation before or during a flood. This workload made it difficult for them to prepare for floods, evacuate promptly and participate in income-generating activities. The floods also contributed to disease outbreaks such as respiratory tract infections, flu, headaches, diarrhoea, and malaria. Women were left to care for sick household members, making them feel powerless and vulnerable. After the floods, women had to clean up garbage from their homes, compounds, local areas, and farmlands, and dry flooded houses using smoke or ash. A 45-year-old woman from Akaki living in a high-impact area, describes the situation: “Floods usually bring garbage, which has a negative impact on our health. So, we wash and clean our compound two or three times a day. Otherwise, all the dirt coming from upstream is staying in our compound and verandas”. Agro-pastoral women in Asayita had to construct and repair damaged shelters when their houses were destroyed or swept away by the 2020 floods. These additional responsibilities made it even more challenging for women to engage in income-generating activities.

Among women, the increase in workload significantly affects young women in agro-pastoral communities as floods often lead to reduced time for schooling or essential skills training for employment. While all young people in agro-pastoral communities experience disruptions in their learning, female youth face additional challenges. Burdened with domestic responsibilities, they miss opportunities to establish social connections and acquire the qualifications needed to access better employment and achieve financial independence later in life.

Limited access to infrastructures: Disruption of access to health services predominantly affected women (and men) with non-communicable diseases, pregnant women, and infants, whereas disruption of education services, especially in Asayita, impacts future incomes of young men and women.

Limited access to information among women: The study reveals that there is a lack of comprehensive understanding of factors causing flooding, and limited access to information on early warning and flood risk management among women. Reasons for the differential access to information and knowledge includes unequal distribution of labour and power in household and across the public sphere. One of the female participants in the focus group discussions (FGD) expressed the reason why she has a limited understanding about floods: "We are always around fire at home and have no education or information to tell you more about the reasons for flood risks." Female spouses in all kebeles reported limited participation in communal flood meetings due to domestic workloads and assumptions that men are meant for the public sphere, often receiving vital information that they might miss on flood risk management. In Akaki, for example, the local government provided compensation to male and female farmers who had land certificates and whose crops were damaged during the 2020 floods. Some women (and men) reported they had limited access to information regarding the compensation. A 60-year-old woman from a resource-poor household in at-risk communities expressed her situation as follows: "I am the female head of the household, and I had no information about the compensation to report to the relevant authorities regarding my losses during that time. Those who reported received some support, while I ended up empty-handed and got nothing.".

Limited participation of women in decision-making processes: There is scope for more collaborative decision-making processes at both the household and communal levels by actively involving men, women, and youth. However, traditional gender roles, power dynamics, and age-based hierarchies create barriers to the full participation of women and youth in decision-making processes at both community and household levels. Across the study kebeles, except in Akaki, men primarily lead flood prevention efforts, coordination, participation, and decision-making at communal and household levels. Although household members engage in discussions to share perspectives and ideas before reaching a consensus on the best course of action, final decisions were ultimately made by male spouses or the heads of the household. The participation of women and youth in decision-making processes at the household level is limited by prevailing patriarchal culture, traditional gender roles, power- and age-based dynamics. A young woman from Akaki explained her limited participation in decision-making processes: "My father is the sole decision-maker when it comes to managing floods. I and the other family members do what he orders us to do, such as filling the bag with soil and placing it around the house." The participation of young people in decision-making processes at the household level is often limited, as parents typically make decisions on their behalf.

Coping mechanisms and responses

People in the different sites of the Awash Basin employed several mechanisms to cope with and respond to the impacts of flooding. Household-level responses differed according to location, although there were commonalities including building flood barriers, resorting to alternative fragmented plots, increased sharecropping, wage labour provision, cash cropping, selling livestock, and, ultimately, migration.

Building flood barriers

In response to flooding in their areas, residents in Akaki attempted to make flood barriers by using stones and sacks filled with sand. They also cleaned drainage channels. However, local respondents indicated that there had been a lack of sustainable response, as flooding in the area as beyond the capacity of the community. This was particularly the case during the 2020 flooding when barriers constructed by local communities could not hold back the flood. It was so powerful that it continued overflowing.

There are also similar experiences in Afar. Households in Asayita living in flood-prone and flood-affected areas construct barriers using palm date trees. In doing so, they try to block or divert flood waters from entering their homes. They reinforce such structures by using sandbags to raise the ground level and build stone bunds around farmland to protect croplands from inundation. However, in the face of extreme flooding events, their attempts to defend their homes and farmlands against flooding are largely ineffective.

Resort to alternative fragmented plot and sharecropping

Another coping mechanism involves increasing reliance on alternative plots. This is practiced in the middle Awash areas in Habru, north Wello. The political economy of land distribution in these study areas is characterized by scattered distribution of farmland. This means that lands worked by a farmer may be located in different. Farmers who lost farmlands to flooding reported that they resorted to full reliance on remaining plots located in areas not part of flooded areas. For example, a farmer interviewed in Mehal Amba area stated "I have 2 timad farmland in Guni area and I have another 1 timad farmland in Golaw. I lost the 2 timad land in Guni due to flooding. I am now working on the 1 timad land I have in Golaw where there is no flood." Although such farmers have tried to cope with the impact of flooding by resorting to alternative plots, these alternative plots are often too small to fulfil their households' needs.

In the Middle Awash sites, increased sharecropping activity has been another coping mechanism after the 2020 floods. Farmers who lost their farm plots resorted to sharecropping activities to make up for their production losses. It should be noted that farmers whose farmland has been destroyed by flooding engage in sharecropping with farmers who have land in non-flood-prone areas. This means that farming activities have been concentrated in non-flood-prone areas and can create greater competition for land. Competition and conflict can result among farmers who want to engage in sharecropping arrangements with farmers located in non-flood-prone areas.

Wage labour and selling livestock

Wage labour is another coping mechanism practiced in different research areas within the Awash Basin, but in particular in the Akaki and North Wello sites. In the upper Awash in Akaki, residents whose livelihood activities were affected due to flooding tried to support their households by working as daily labourers in factories. Similarly, in the middle Awash sites in north Wello, people who lost their farmland because of flooding engaged in daily wage labour activities. Wage labour activities in north Wello largely relate to farming and construction activities.

Interviews conducted with people in the Middle and Upper Awash reveal that selling livestock is also a coping strategy in times of flood crisis. Flood-affected people in Habru, north Wello, sold their livestock to gain access to cash to buy grain and supplement household food needs. Likewise, rural residents in Akaki attempted to mitigate the livelihood impacts of flooding (including production losses) by selling livestock and using the money to purchase items needed for their households. In the Afar sites, however, flooding significantly affected livestock keeping and production. Although livestock production is one of the main livelihood activities of people in Asayita, the impact of flooding on markets significantly impaired the option of receiving income through livestock sales.

Awash Basin Migration

Following successive flooding problems, migration has become a significant response mechanism in flood-affected areas, especially in North Wello. The impacts of flooding on people's livelihoods led to increased reliance on remittances. Respondents in north Wello indicated that in the past three years, in particular, migrant households had increasingly relied on remittances. They indicated that many people in the area had children who had migrated to Saudi Arabia for work. Households who sent their children to the Gulf got support from these children in the form of remittances. Following households' losses of important livelihood assets due to flooding, many migrant households have reportedly become more dependent on remittances. Migration to the Gulf has also increased in the past three years, following the adverse impacts of flooding. A young female respondent in Mehal Amba observed that "The community is extremely prone to irregular migration due to loss of hope; particularly the youth are becoming more susceptible to illegal migration because of this."

Community efforts

Dealing with the impact of flooding on people's livelihoods seems to have been beyond community capacity in many areas. A key informant in Mehal Amba in north Wello described this by saying: "The river is too big to make interventions through community capacity. It is difficult to build barriers in the community. How would it be possible to prevent it!? It is huge." In the other research sites in Afar and Akaki, people mentioned the challenges of dealing with flooding at their community level. However, people in flood-affected areas have not been passive observers of the problem. They have also taken action in their way, regardless of being successful or not.

Communities in North Wello, Habru engage in campaign-based conservation activities. They do bund-building in upland areas to protect against soil erosion. This is done every year for 2-3 months after planting crops. People interviewed indicated that bunding work has helped mitigate the problem of soil erosion, thereby contributing to maintaining farmlands. Nevertheless, the capacity of existing bund work is limited to prevent the current problem of flooding. Local respondents insisted that the flood-prone areas cannot be restored through bund work.

In Afar, people work together to reinforce embankments and barriers that hold back flood waters. They erect wooden poles and reinforce these with sacks filled with soil. Such community activities involve in-kind contributions in the form of resources such as wood, sacks, and labour. In Akaki, residents attempt to solicit cash contributions from community members to clean drainage infrastructure.

Supra-community interventions

In terms of supra-community interventions, respondents in the Awash Basin site of north Wello insisted that there had been little intervention by government and non-government agencies to avert flooding. They mentioned attempts at erecting gabion walls in some parts of the Guni river sub-basin, accomplished some three years ago by the woreda in partnership with FAO. The gabion structure was meant to serve as a flood wall. However, interviewed people indicated that the structure had already started collapsing, attributing this to the inability of the structure to block powerful floods. During fieldwork, it was also observed that the gabion structure had been damaged in some parts.

Other intervention activities in north Wello include cleaning flooded areas. This is undertaken by the disaster prevention office using support from the housing development office in the form of machinery, although it is only temporary in nature and after flooding occurs. A key informant we interviewed indicated how limited these actions were, saying, “Our work is just like putting out a fire.” Local respondents observed that every rainy season, the woreda attempted to clear sediment from the river. In comparison to the magnitude of the flood, none of the actions are effective, however.

In Akaki, flood responses by government and non-government agencies have been limited. Informants indicated that responses by government structures include cleaning drainage canals and providing support for flood-displaced people. In the latter case, they provide flood-affected people with items such as blankets, mattresses, clothes, food, and cooking materials. In some cases, they also provided displaced people with alternative houses and moved them to government-managed houses. Some NGOs support flood-affected people by renovating and constructing houses. Overall, support provided by government and non-government bodies is largely temporary in nature and there is a lack of sustainable, long-term governance responses.

In the Afar research site in Asayita, district officials highlighted the assistance provided to the community during the 2020 flooding. Emergency responders worked with charities to shelter evacuated people and provide support for their livestock. The Afar Region Water Office closed river breaches, issued early warnings through the media, and urged people in public places to leave flooded areas. These efforts helped save lives and reduce suffering at a community level. However, existing extra-community responses in the form of flood governance are inadequate. Key informants and interviewed community members in Asayita insisted that while government agencies have started taking some measures in response to flooding, they largely focus on temporary solutions. Discussions with local respondents in Asayita suggest the importance of engaging in long-term interventions and durable solutions.

Discussion

Published research on flooding and flood impacts in the Awash Basin is scarce. The limited research that there is mostly focuses on the Upper Awash Basin and uses flow data from before 2014. The lack of recent hydrological data has hindered understanding of the extent of extreme cases in the last 10 years. Recent studies tend to focus on climate change projections based on general circulation climate model data and the use of satellite rainfall applicability for extreme rainfall estimations. The contribution of non-climatic drivers to flood impacts is also not common in the literature covering the Awash Basin.

The findings of this study suggest that there are a range of mechanisms at work, the combination of which will be increasingly serious for the numbers of people affected and potential long-term challenges for the inhabitants of the Awash Basin. Above all, perhaps, the Awash Basin is a complex geography bisected by different topographies, agro-ecological zones, administrative and political boundaries and socio-cultural communities. As climate drivers push the potential for more extreme future rainfall in the basin, the intersections of these factors alongside long-term trends in population growth and urbanization will be critical.

Flood patterns in upper, middle, and lower Awash vary greatly. Urban areas experience flash floods and river overflow necessitating a range of interventions such as buffer zone management for flood plains, better coordination with dam releases upstream, and improved rainfall-river flow forecast information. Long-term interventions such as watershed management to combat land degradation, erosion, and sedimentation challenges will be important to limit the increased runoff generation potential of the basin.

In the middle Awash, there are large, mechanized irrigation systems where maintaining dykes, canals, and other structures ahead of the wet season takes priority. Furthermore, for better adaptation, creating awareness for the investors who are operating in the area to invest in flood protection-related research and implementation including collection of data and information on existing flood risk management options would help in understanding what works well and what needs to be improved in the future.

In the lower Awash, the river left its historical route and created a new river course during the 2020 floods. The need to train the rivers back to their natural path is of high importance. In addition, the Lower Awash (e.g. around Dubti town) experiences flash floods from the Logiya catchment and requires a multipurpose reservoir to delay floodwater intrusion that frequently destroys the town and irrigated farms.

Not only the flood pattern but also the impacts of flooding vary across locations and groups within those communities. The 2020 flooding affected men, women, and youth in different communities by disrupting their livelihoods, increasing domestic duties, disrupting access to basic facilities such as health and education, and causing loss of property and/or reductions in property value. Farmland and pastureland were inundated disrupting the livelihoods of people. In some of these locations, people have not moved back to their original villages since water destroyed their residences and stagnant standing flood water was present until this study was conducted. Disruption of access to health services predominantly affected women (and some men) with non-communicable diseases, and pregnant women and infants, whereas disruption of education services impacted the future incomes of young men and women.

In short, the complex flooding situation in the Awash Basin confronts vulnerable and easily disrupted livelihood systems in all reaches of the basin – but in different ways. Responding in both policy and practice to this situation and making communities safer, reducing future impacts, and climate-proofing people and livelihoods in the basin requires a mosaic of approaches.

Recommendations for future adaptation

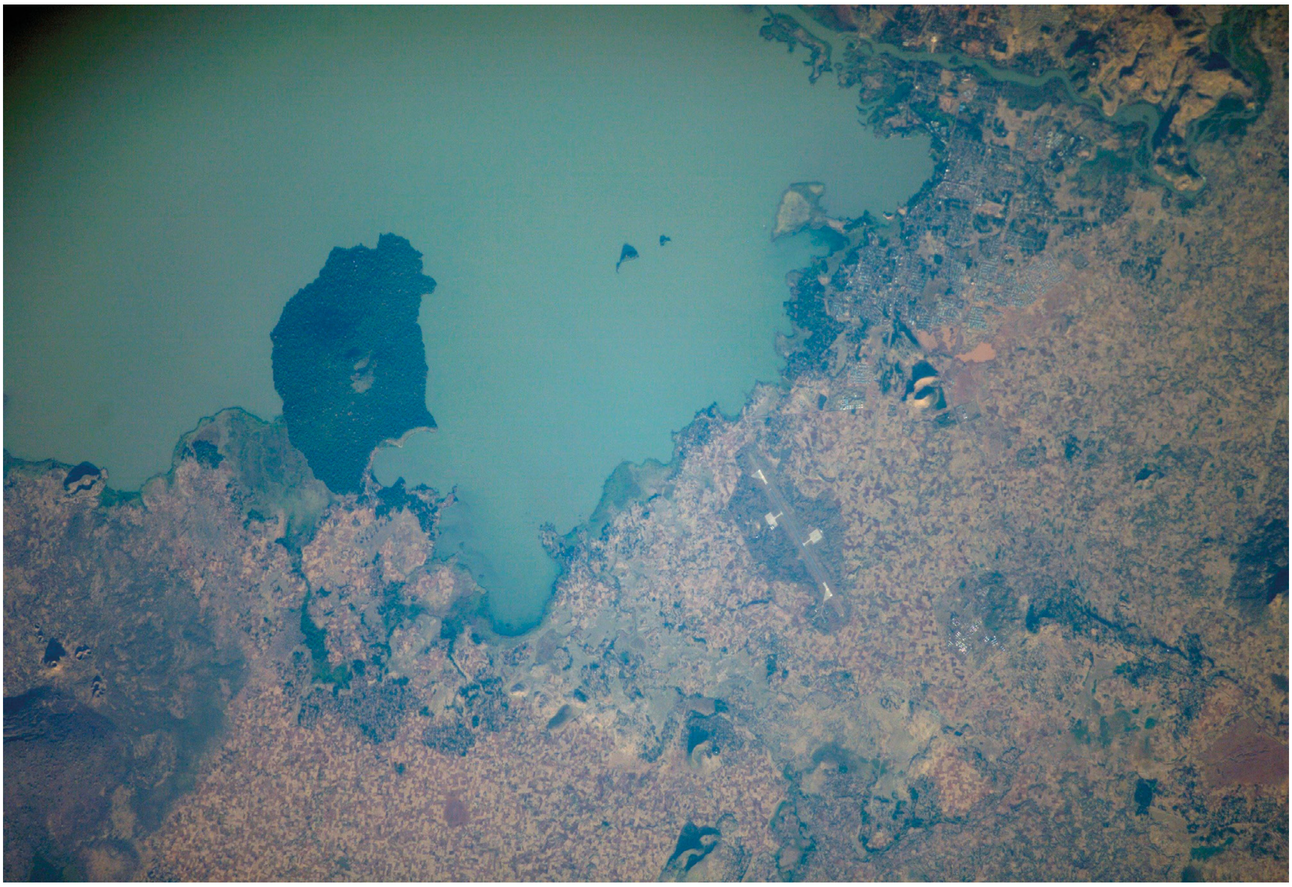
Based on this study and consultations with various stakeholders there are possible improvements that can be made from immediate, medium, and longer-term flood risk management perspectives. In the short-term improving the early warning and flood forecasting system through the support of the research community can be envisaged – this includes both the quality and readability of information, but also its dissemination in formats that are user-centric, including communities where there may be high levels of illiteracy. Ultimately, this concerns the provision of more localized and precise flood forecasting as much as possible to communities in flood-prone areas, including possibly through the use of citizen science-based approaches in conjunction with local authorities. Appropriate research will assist in understanding unique rainfall occurrences and how they translate into flood events and require continuous improvement. Additionally, improvements are needed to communicate early warning information in a timely or understandable manner to communities at the grassroots level so that they can take appropriate action. Examples of citizen-science-based flood early warning in the Akaki basin can and should be built upon.

In the medium term, improving the institutional design for coordinated preparedness and response to extremes is suggested. With the existing situation, the lack of effective coordination among different institutes and water users has considerable implications on how financial and information flows work, and how preparedness for flood events is handled in the future. In most cases, responses to floods are better coordinated than early prevention and preparedness. This calls for a stronger institutional coordination design that combines resources and information from different groups and stakeholders for efficient prediction, preparedness, mitigation, and adaptation of floods, ideally shared through one clearly identifiable platform with public, open-source information.

In the long-term, infrastructure measures such as multi-purpose dams, river training, rehabilitation of water infrastructure (e.g. dykes, detention/storage ponds, irrigation canals), watershed management activities, and incorporating future climate projections into the design of infrastructure to increase their climate-resilience are all-important measures that are required for better management of extreme rainfall and associated flooding in the Awash Basin.

Land-use planning that is 'flood-centric' in its thinking and approach will be needed from central, through state governments all the way down to woredas and kebeles. This means identifying (and protecting) flood zones near build-up areas and identifying zones that can be allowed to flood to absorb the impact of extreme events. This will require careful flood risk mapping and, crucially, the incorporation of this mapping into planning processes across sectors and at different levels. In all the above, particular care is needed to ensure that decision-making processes incorporate particular gender-based needs especially associated with the most marginalized and vulnerable communities.

Finally, the benefit of taking a transdisciplinary approach in conducting research and implementation is highlighted in this study as the causes and impacts of floods are various, and constantly evolving. As shown above, floods are multi-causal, and their impacts are multi-dimensional. Given the most recent changes that have occurred in the basin (both climate- and human-related), it is important to look at previous studies, revise where necessary, and design appropriate measures for flood mitigation across the different flood environments including indigenous specific knowledge and local practices. This would require the expertise of hydrologists, engineers, climate scientists, social scientists, citizen scientists, decision-makers, and communities from rural and urban settings as well as from various socioeconomic backgrounds.



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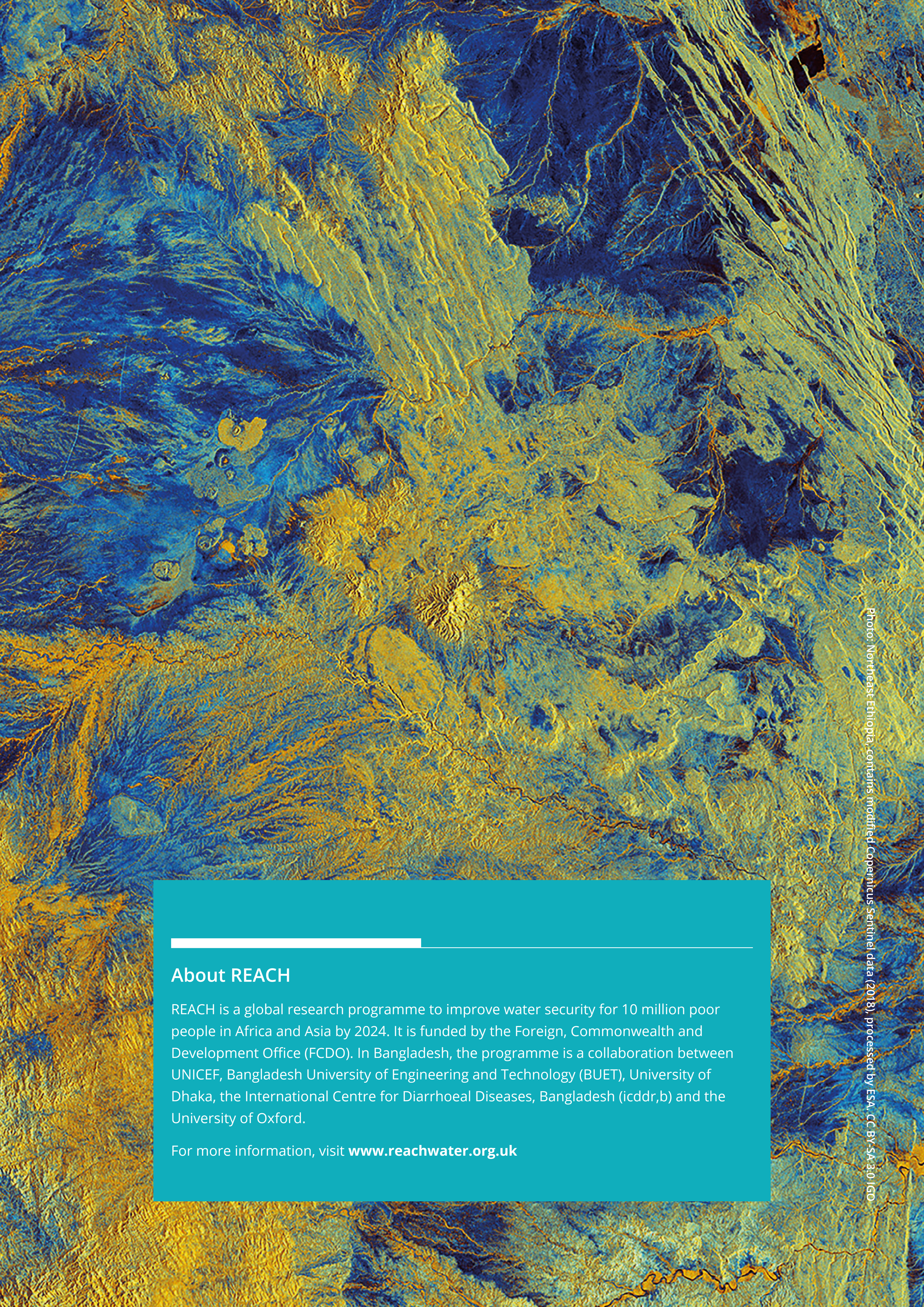

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REACH is a global research programme to improve water security for 10 million poor people in Africa and Asia by 2024. It is funded by the Foreign, Commonwealth and Development Office (FCDO). In Bangladesh, the programme is a collaboration between UNICEF, Bangladesh University of Engineering and Technology (BUET), University of Dhaka, the International Centre for Diarrhoeal Diseases, Bangladesh (icddr,b) and the University of Oxford.

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