Flood Modelling and Assessments for Downstream Communities of Koka Dam, Ethiopia

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Executive Summary

The following report presents the findings of the author's research from May to August 2017 with support from the International Federation of Red Cross and Red Crescent Societies; Ministry of Water, Irrigation and Electricity – Ethiopia; Ethiopian Red Cross Society; and Red Cross Red Crescent Climate Centre (Climate Centre). The study area was Koka Dam and its downstream communities, located in the Oromia Region of Ethiopia. The study's objectives were to (1) identify forecasts of natural phenomena that can help anticipate flood events; (2) assess what is known and what needs to be known to link forecasts with anticipated impacts; (3) suggest actions worth taking as soon as the forecast exceeds a predefined threshold of risk; and (4) outline proposed next steps for a forecast-based contingency plan. The author used the flood modelling software HEC-GeoRAS and community assessments iteratively to achieve the objectives.

Flood modelling was performed using HEC-GeoRAS, a software developed by the United States Army Corps of Engineers. The program allows users to view modelling results geospatially to determine the extent of flooding along a river or stream. The results from the HEC-GeoRAS analysis showed that agricultural land is the most vulnerable area to flooding. Therefore, minimizing flood impacts would improve the livelihoods of the agricultural workers living alongside the river by reducing damage to their land.

Following preliminary flood modelling, community assessments were performed in seven communities and two facilities downstream of Koka Dam. Focus groups were organized to elicit information. The results of the assessments showed that each community and facility suffers from flooding. The primary consequence of flooding is the destruction of agricultural lands, which confirmed the modelled results. Farming is the primary income-generating activity in the interviewed communities, and communities expressed a strong desire to improve flood management to improve their earning capacity. In addition to loss of income, communities reported an increase in the number of malaria and acute watery diarrhea cases following floods. Minimizing flood impacts can improve the livelihoods and health of the communities living downstream of Koka Dam.

Perceptions on the existing early warning system (run by the Awash Basin Authorities) were also elicited from community assessments. Communities are notified via media (e.g., television, radio) about scheduled releases from Koka Dam, while Sodere and Wonji are notified via phone calls and in-person meetings. Suggestions from communities for improving the existing warning *mechanism* included in-person notification, mobile phone calls, SMS messages, or notification of local irrigation officers. Representatives from Sodere and Wonji were satisfied with the existing warning mechanisms. Suggestions from communities, Sodere, and Wonji to improve the existing warning *content* included earlier warnings and details on the predicted impacts of flooding.

Recommended next steps for the project include exploring the feasibility of FUNES implementation and continuously engaging with the project's stakeholders. FUNES is a self-learning algorithm software for hydropower dams developed by the Climate Centre. It was successfully piloted in Togo in 2016. The software uses hydrologic and precipitation data to improve flood predictions and the timing of controlled releases to minimize flood impacts to downstream communities of hydroelectric dams. The existing mechanism for controlled releases from Koka Dam is to simply release water from the reservoir when it reaches a certain level, and the downstream communities suffer from regular inundation of agricultural lands. In the future, FUNES could be implemented to better time controlled releases to minimize flood impacts and improve livelihoods in these communities. To ensure the successful implementation of the software, the project's stakeholders should remain continually engaged. The project stakeholders include both government organizations and Red Cross affiliates.

Project Background

Project Goals and Objectives

The project's objectives, per the researcher's Terms of Reference, are as followed:

1. Identify forecasts of natural phenomena (e.g., precipitation and hydrology) that can help anticipate flood events.
2. Assess what is known and what needs to be known to link forecasts with anticipated impacts on communities.
3. Suggest actions worth taking as soon as the forecast exceeds a predefined threshold of risk before the impacts materialize.
4. Outline proposed next steps for a forecast-based contingency plan, including definition of specific trigger designs, linking forecast parameters with corresponding preventative measures.

The following paper present the results of the work performed in the summer of 2017 in fulfillment of the objectives mentioned above.

Motivation

A 2014 paper estimates that 3700 new hydroelectric dams (producing over 1 megawatt [MW] of power) are either planned or under construction. These projects are expected to increase global hydropower production up to 73% (Zarfl, Lumsdon, Berlekamp, Tydecks, & Tockner, 2014). While dams provide benefits such as the regulation of water for irrigation purposes, they can also contribute to problems such as flooding downstream following controlled releases. These problems are particularly challenging in the context of developing countries, where there is often limited data available to appropriately time releases to minimize impacts for downstream communities.

The Red Cross Red Crescent Climate Centre has piloted an innovative, new computer model to assist with improving the timing of controlled releases. Named FUNES, the model uses machine learning to optimize releases from hydroelectric dams to minimize impacts on downstream communities. In addition to fulfilling the project's objectives, this report explores the potential for FUNES to be implemented for Koka Dam.

Koka Dam

The construction of Koka Dam began in 1957 and was finalized in 1960, making it Ethiopia's oldest hydroelectric dam. It is located in the Awash River Basin of the Oromia Region and feeds into the Awash River. The dam generates about 1% of Ethiopia's electricity (110 GWh/year), limited in power generation when compared to other dams. At the time of construction, electric power generation was the primary purpose of the dam. It now also provides and regulates irrigation water for downstream communities and government facilities per instruction of the Awash Basin Authorities.

The study area is Koka Dam (**Figure 1**) and the communities downstream of the dam. The project extent is shown in **Figure 2**. It examines flood impacts from directly downstream of Koka Dam to Sodere Resort.

Figure 1: Location of Koka Dam

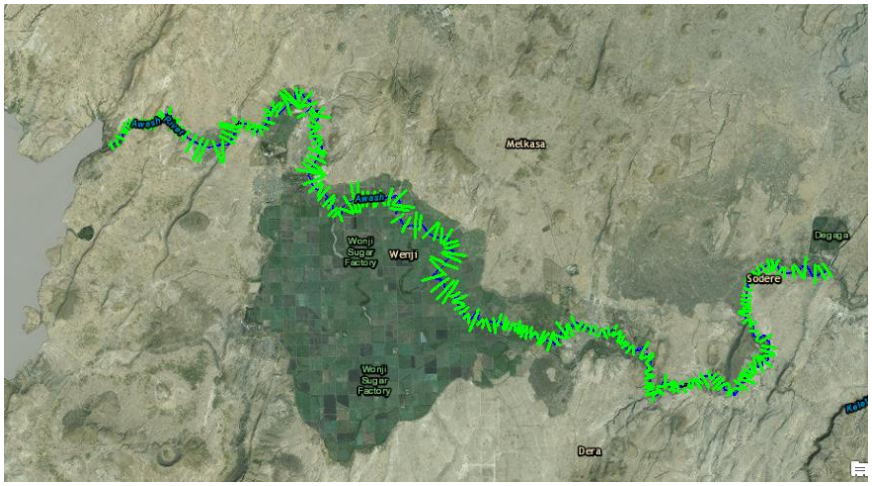

Figure 2: Extent of flood modelling and early warning evaluation

Safety concerns with Koka Dam include sedimentation and the timing of controlled releases. Sedimentation was noted by the dam manager as a problem, as it minimizes the water holding capacity in the reservoir. When coupled with increased precipitation during the rainy season, this may lead to more frequent and intense controlled releases of water which contributes to flooding in downstream communities. Relating to the water releases, there is a need to better optimize releases to minimize flood impacts on downstream communities and communicate with these communities on planned releases and the risks associated with them.

Downstream Communities and Facilities

Over the course of fieldwork, seven downstream communities were visited. The author conducted focus groups with the help of staff from either the Ethiopian Red Cross Society (ERCS) or the Dam Safety Department at

the Ministry of Water. Focus groups were organized in each community to elicit information from participants. In addition to communities, representatives from Wonji Sugar Factory (Wonji) and Sodere Resort (Sodere) were interviewed. Wonji is a government-owned facility that employs the local population and houses 35,000 people within its borders. Sodere is a popular local and tourist travel destination. The names and locations of the visited communities and facilities are listed in **Figure 3** and **Table 1**.

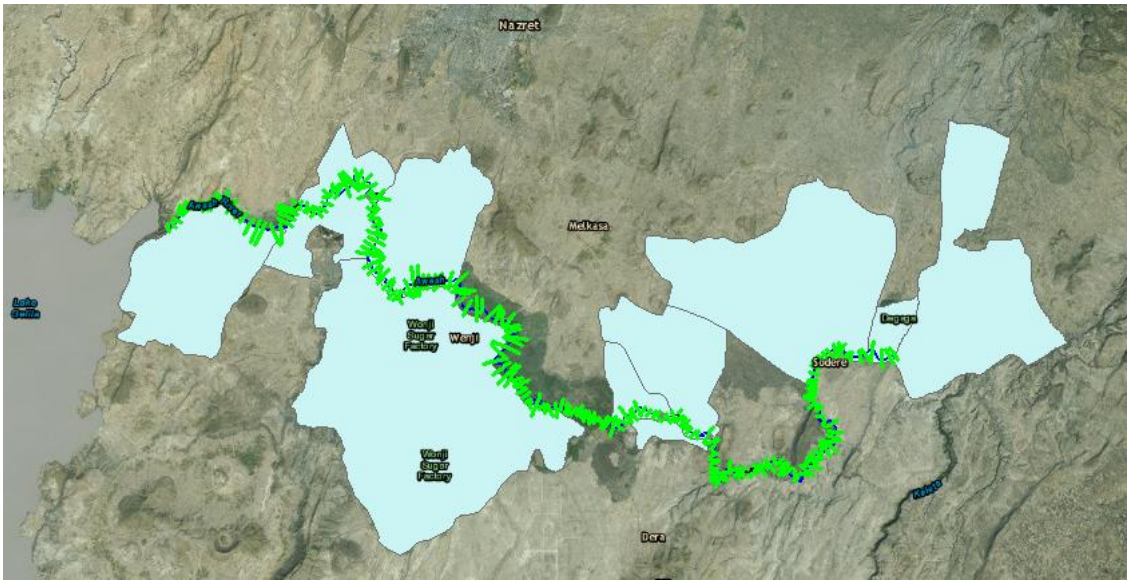

Figure 3: Location of study areas

Table 1: List of communities and facilities visited

Communities	Facilities
Kuriftu	Sodere Resort
Botu Kurabu	Wonji Sugar Factory
Awash Melkasa	
Bati Germana	
Qechachule Guja	
Koloba Bli	
Bato Degaga	

Flood Modelling Findings

Software and Modelling Background

HEC-GeoRAS is a geographic river analysis system developed using ArcGIS Desktop with ArcGIS Spatial Analyst and 3D Analyst extensions. The geodatabase design supports analysis of spatial data for hydraulic modelling and floodplain mapping. Engineers can develop geographic data for import into a HEC-RAS hydraulic model and view the results in a geospatial context. The results of the GeoRAS analysis can be used for flood damage computations and flood warning response and preparedness (US Army Corps of Engineers). **Figure 4** illustrates the flood model process.

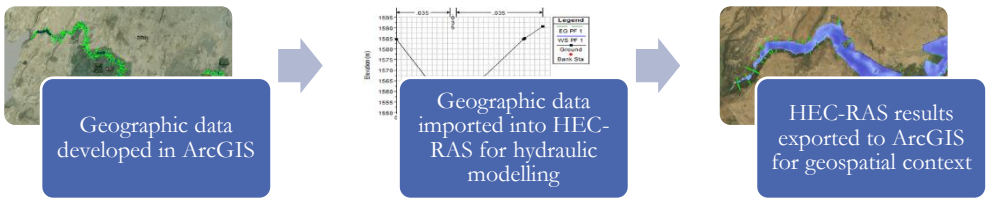

Figure 4: HEC-GeoRAS model process

The generation of flood inundation maps through HEC-GeoRAS typically answers the following questions:

1. Which areas will flooding inundate?
2. What will the likely damage be?
3. What downstream impacts will flooding have under different environmental conditions?

Several sources of input data are needed to run the HEC-GeoRAS model. **Figure 5** shows the information input into the HEC-GeoRAS model, along with the information's source. Most notably, channel geometry is not included as an input into the model, as recent and accurate channel geometry was not available. The limitations due to the lack of this information is discussed in the *Modelling Challenges* subsection.

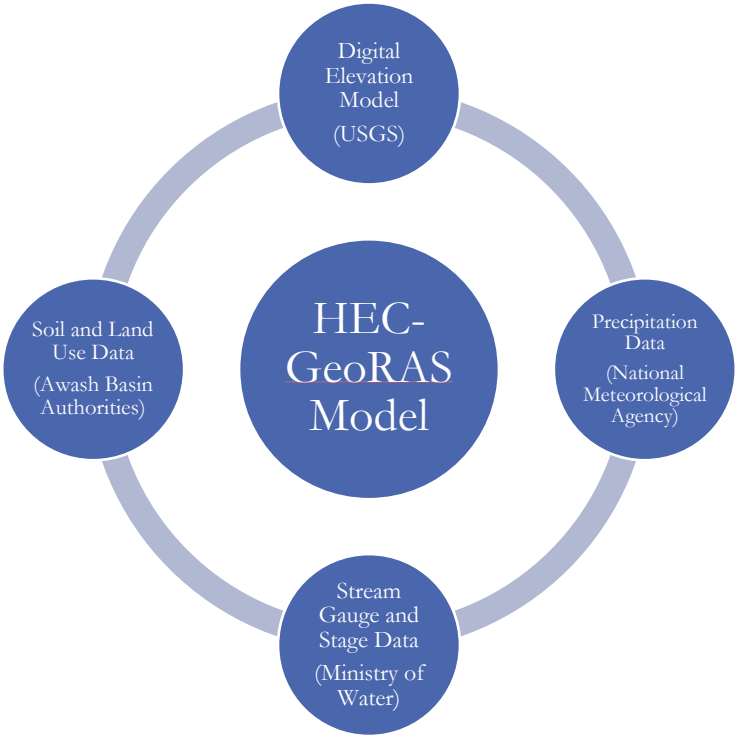

Figure 5: Input data into HEC-GeoRAS model

Multiple guides for the generation of HEC-GeoRAS models exist. For this particular study, the United Nations Office for Outer Space Affairs (UN-SPIDER) guide *Step by Step: Flood Hazard Mapping* was utilized to generate the models.

Findings

Data from two stream gauge and three precipitation stations were available in the study area. Stream gauge stations provide daily measurements for river flow (m^3/s) and height. Precipitation stations provide daily measurements for rainfall. **Figures 6 and 7** show the locations of the various stations.

Figure 6: Location of stream gauge stations

Figure 7: Location of precipitation stations

Summer (June – August) is Ethiopia's wet season and coincides with the highest flows and precipitation events. **Figures 8 and 9** show the monthly highs for flows for two stations, Awash @ Below Koka and Awash @ Wonji.

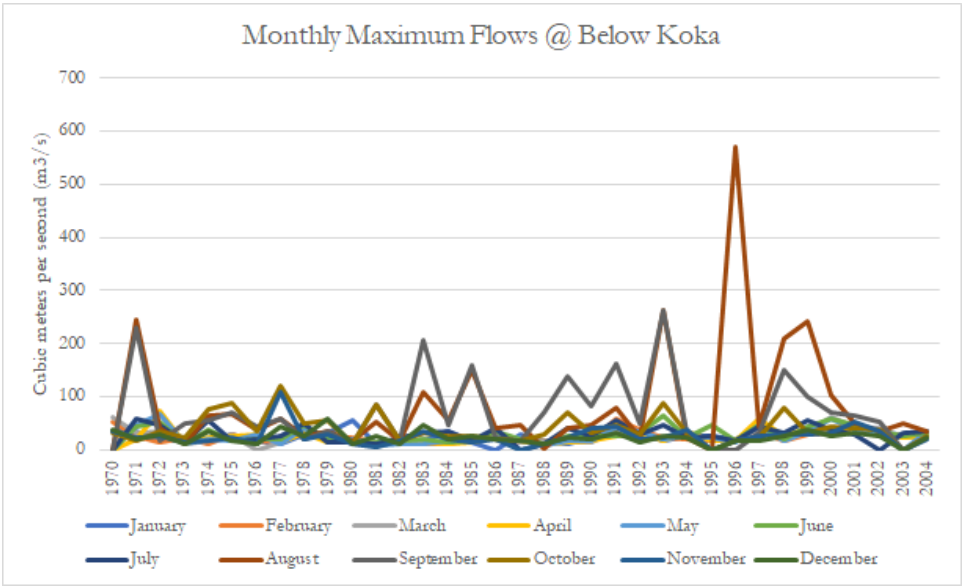

Figure 8: Monthly maximum flows at Below Koka station

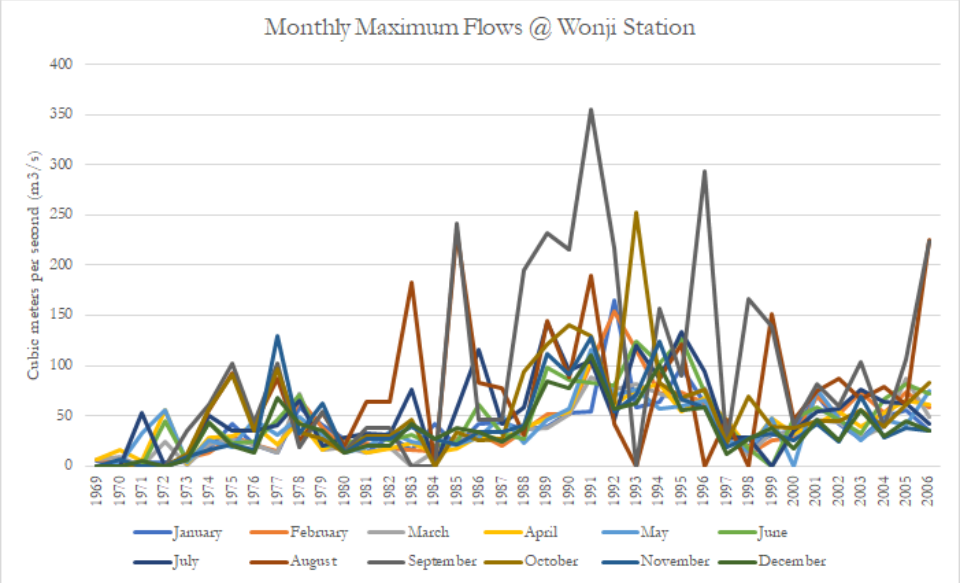

Figure 9: Monthly maximum flows at Wonji Station

The inundation of farmland is the primary consequence of flooding along Awash River. The houses are constructed outside of the floodplain, and are not affected by flooding from the River. **Table 2** shows impacts of flooding in downstream communities. Spaces and gaps in the flooding extent are due to the quality of the Digital Elevation Model and further discussed in the *Modelling Challenges* section. *Appendix 1* contains more detailed information on individual communities, including location.

Table 2: Flood impacts in downstream communities

AREA	ANTICIPATED IMPACTS
BATI GERMANA	 Bati Germana contains agricultural lands that are vulnerable to flooding from Awash River.
BOTU KURABO	

Botu Kurabo contains agricultural lands that are vulnerable to flooding from Awash River.

MELKA ADAMA

Melka Adama contains agricultural lands that are vulnerable to flooding from Awash River.

SODERE RESORT

Sodere Resort's riverside cottages are vulnerable to flooding from Awash River.

BATU DEGAGA

Batu Degaga contains agricultural lands that are vulnerable to flooding from Awash River.

QECHACHULE GUJA

Future work should identify *how much* water can be released from Koka Dam without causing negative downstream impacts. To answer this question, channel geometry is needed to identify how deep the river is at various points downstream.

Modelling Challenges

A computer model is only as accurate as the quality of the information that is input into it. The following are potential sources of error in the model:

1. **Channel geometry** was not available for the study area. Channel geometry is the shape of the channel perpendicular to flow. It provides information on the channel such as depth, width, and side slope. It can be used to determine factors like the maximum flow and height of water allowed through a channel before it overflows into the floodplain. **Figure 10** shows an example of channel geometry. The lack of channel geometry data made it impossible to determine *how much* water can flow through Awash River before it floods downstream communities. Rather, flood scenarios were grouped into low and high risk.

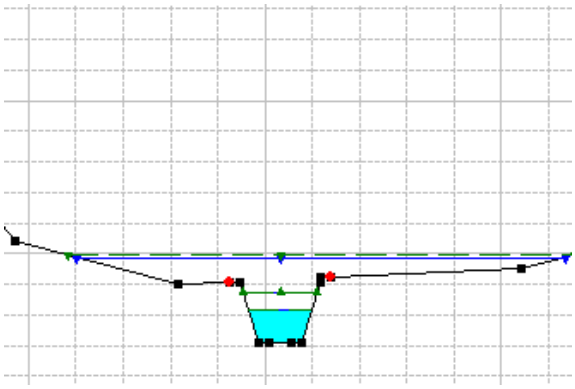

Figure 10: Example of channel geometry

2. **Stream gauge data** was only available at two locations in the study area. These two locations were shown in **Figure 6**. Flow and stage beyond the second gauge were estimated from the nearest gauge, and do not account for additional precipitation that may have entered the river following the second gauge. As the Awash River moves further downstream, it is fed by the surrounding watershed and tributaries, potentially increasing in flow and affecting results. Stream gauge data was only available before the year 2007, and there were gaps in the information available as shown in **Figure 11**.
3. **Precipitation data** was only available in the locations previously shown in **Figure 7**. Precipitation data at the Sodere and Dewero stations were only available from the years 2007-2017, and did not align with stream gauge data.
4. The **construction of dikes** along the Awash River was documented during community assessments. The dikes are not accurately represented in the Digital Elevation Model obtained from the United States Geographical Survey. This could be due to the accuracy or age of the satellite imagery. As there are a mixture of formal (e.g., constructed by the government) and informal (e.g., constructed by communities without government assistance) dikes, it was difficult to accurately model flood impacts in areas where dikes were found.

5. **Sedimentation** was noted as a basin-wide problem by experts at the Awash Basin Authorities. Sedimentation affects the depth of the river, and can decrease the level of flow that will trigger a flood event. As the channel geometry data was unavailable, sedimentation did not affect the results of this project's work. Future work that examines *how much* water can be released from Koka Dam without causing negative impacts downstream must take into account the problem of sedimentation.

Apr	May	Jun	Jul	Aug	Sep
24.165	46.932	28.049	-	51.477	139.604
23.267	47.945	32.309	-	42.593	133.834
24.16	46.932	31.231	-	43.067	89.45
24.1	45.928	30.97	-	43.753	53.902
24.704	46.763	36.224	-	41.869	47.692
24.521	46.763	38.908	-	45.394	46.68
24.825	45.597	39.366	-	53.241	46.866
24.765	44.607	40.295	-	43.365	40.163
24.466	45.43	40.606	-	42.143	38.838
26.692	45.762	41.313	-	50.139	44.334
25.564	46.932	39.229	43.523	44.224	53.298
24.947	47.776	34.686	53.769	47.556	51.409
24.886	45.764	37.704	47.062	56.88	48.816
24.765	43.024	40.297	32.454	63.384	42.521

Figure 11: Missing data in stream gauge information

In addition to the challenges mentioned above, flood inundation has inherent sources of uncertainty. These were outlined in a paper by Bales and Wagner (2009), and are described below:

1. Water level measurements are generally considered accurate to ± 0.3 cm.
2. Streamflow data determined from stage-discharge ratings typically have an accuracy between ± 5-10%. This degree of uncertainty can rise to ± 20% in extreme flood events.
3. The accuracy of inundation maps is highly dependent on the quality of the topographic map used. Inaccuracies in the topographic data could lead to inaccuracies in inundation maps. The topographic map used for this study was an ASTER GDEM map downloaded from the United States Geographic Survey.
4. The flood models were run under steady flow conditions. This scenario assumes that the flow has been constant long enough for all lands that could be flooded are inundated. Though the assumption of steady flow conditions has limitations, Federal Emergency Management Agency (FEMA) flood insurance inundation maps are typically created assuming steady-flow conditions.

Despite the uncertainties associated with inundation mapping, it is a useful tool for visualizing the effects of flooding. While not to be taken with 100% certainty, they can serve as a base for effective prediction of flood impacts and planning of response activities.

Community Assessment Findings

Background

The development of flood inundation maps from controlled releases and increased precipitation provides a preliminary overview of the hazards presented by flooding. The generation of flood inundation maps alone

does not guarantee that flood impacts will be minimized. These maps must be paired with other mechanisms, such as early warning systems, to ensure communities receive the information and can act upon it.

The decline in human and material losses from disasters over the past 30 years is partly due to improved early warning systems (International Federation of Red Cross and Red Crescent Societies, 2012). The most lasting impacts occur when communities have a strong understanding of the early warning system in place. Further, warning systems are only as good as the actions that they catalyze. If a warning is given and no action is taken, then the system will fail. A people-centered approach is essential to ensure warnings reach the most vulnerable communities and they are able to respond appropriately. The following sections provide an overview of the existing warning system in place and suggests improvements for it.

Methods

Community assessments were performed with the assistance of Ministry of Water and ERCS staff. A semi-structured focus group was developed by the author to elicit the information needed. The semi-structured interview used is provided in **Appendix 2**. Focus groups were used to elicit information from communities. Initially, plans were made to hold focus groups with representative samples of communities. However, it was found that flooding specifically from Awash River only affected farmland. Thus, the participants in focus groups became farmers and owners of the land. The participants were male and selected with the help of Ministry of Water or ERCS staff. Not all farmers in communities were included in the assessments. ERCS or Ministry of Water staff coordinated with key informants or contacts in the visited communities to select participants for focus groups.

Results

The following sections present the results obtained through the fieldwork.

Flood History and Livelihoods

Each community and facility interviewed has experienced flooding. This year, flash flooding also affected three communities and Sodere. Communities identified flooding as coming from Awash River, the surrounding areas, or a combination of the two. **Table 3** summarizes the flood sources reported by communities, Wonji, and Sodere during the assessments.

Table 3: Flood sources as reported by communities

Community/Facility	*Experience regular flooding (< 5 years between floods)?*	*Experience annual flooding?*	*Experienced flash flooding?*	*Source of the flooding?*
Kuriftu	Yes	Yes	No	Surrounding area
Botu Kurabo	Yes	No	No	Awash River
Awash Melkasa	Yes	Yes	No	Awash River & surrounding area
Bati Germana	Yes	Yes	No	Awash River & surrounding area
Qechachule Guja	Yes	Yes	Yes	Awash River
Koloba Bli	Yes	Yes	Yes	Awash River & surrounding area

Bato Degaga	Yes	No	Yes	Awash River & surrounding area
Sodere Resort	Yes	Yes	Yes	Awash River & surrounding area
Wonji Sugar Cane Factory	Yes	Yes	No	Surrounding area

Agriculture is the primary source of employment for the downstream communities, and they rely on it for income and food. The communities farm along Awash River and use irrigation pumps to draw water from the river to their farms, growing a mix of onions, tomatoes, maize, and cabbage among other crops. Every community has farmland affected by flooding. In addition to farmland, communities also suffer from increased instances of malaria and acute watery diarrhea (AWD) alongside flooding. **Table 4** summarizes the flood impacts reported by farmers and landowners during the community assessments.

Table 4: Flood impacts as reported by communities

Community	*Primary source of income?*	*Agriculture affected by floods?*	*Malaria following flooding?*	*AWD following flooding?*
Kuriftu	Agriculture	Yes, but not from Awash	No	Once
Botu Kurabo	Agriculture	Yes	No	No
Awash Melkasa	Agriculture	Yes	Yes	No
Bati Germana	Agriculture	Yes	Yes	Once
Qechachule Guja	Agriculture	Yes	Yes	No
Koloba Bli	Agriculture	Yes	No	No
Bato Degaga	Agriculture	Yes	Yes	Yes

During the rainy season, some communities avoid farming in floodplains due to a fear of losing crops. Flooding causes some communities to miss an entire cycle of growing crops, and they expressed a strong desire to grow crops during the rainy season if feasible. Other communities who harvest year-round reported frequently losing crops to flooding. These reported problems led to the author's conclusion that improvements in flood management can lead to improved livelihoods and health.

Findings on Early Warning System

The current warning system is currently utilized solely for controlled releases from Koka Dam. The warning system is between the Awash Basin Authorities and communities. When the Awash Basin Authorities schedule a controlled release from Koka Dam, they notify communities via media. Media notifications include radio and television messaging. Wonji and Sodere are notified via phone calls and in person visits. **Figure 12** shows the various warning mechanisms that are used.

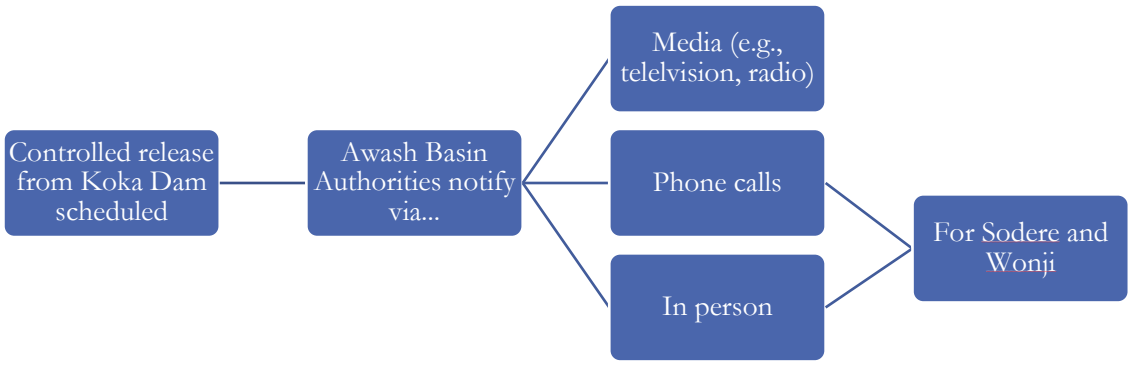

Figure 12: Existing notification methods

The following results present the findings from the community assessments regarding the early warning communication mechanism and content. The *mechanism* refers to the method in which the warning is delivered; the *content* refers to the message given during the warning.

Findings and Recommendations for Early Warning Communication Mechanism

Both facilities, Wonji and Sodere, reported satisfaction with the existing warning mechanism. They receive the warnings, and are able to communicate with the Awash Basin Authorities directly. Generally, communities also receive the warnings, but recommended the following improvements (for detailed notes, see **Appendix 1**):

1. **In-person notification:** Communities were most interested in receiving early warnings in-person. They prefer this method as it ensures the message is received and they can ask questions if needed. In-person notification can either be performed by Awash Basin Authority or ERCS staff.
2. **Mobile cell:** Communities would prefer to be notified about flood events via phone calls or SMS text messages. Phone calls could go to key community members, who would disseminate the information to the appropriate people. SMS text messages could be sent to entire communities via a centralized list of recipients.
3. **Notification through local irrigation officers**: Notifying local irrigation officers, who will subsequently notify communities of controlled releases, was identified by communities as an acceptable form of notification.

Findings on Early Warning Content

Communities, Wonji, and Sodere recommended the following improvements for improving the content of the existing warning system (for detailed notes, see **Appendix 1**):

1. **Details on anticipated flood impacts:** The purpose of the existing notification system is to save lives, but communities want additional notifications if floods will affect their livelihoods. Communities are just told that there will be a release, without specific information describing how severe the release will be. If possible, they want to know the estimated severity of the flood to prepare appropriately.

2. **Earlier notification:** The existing warning system does not give communities enough time to respond. Communities currently have about one day after receiving warnings to prepare for flood events. Communities want to be notified of releases as early as possible to minimize impacts to livelihoods.

Early Actions Taken

A warning is only as good as the actions that it catalyzes. The communities take the following actions upon receiving warnings of releases from Koka Dam:

1. Belongings, including irrigation pumps and livestock, are moved from the floodplain.
2. The floodplain is avoided for personal safety.
3. Sacks are filled with sand or soil to protect homes or farmland.
4. If the flood comes before crops have been harvested, communities harvest as many crops as possible before the flood comes.

Currently, the communities are only provided limited time to react to impeding floods. If they were given additional time to react, they could better prepare for flood events and capitalize on the actions described above.

Recommended Next Steps

Engaging local stakeholders

The successful implementation of any development project requires the successful engagement of all stakeholders. Throughout the project's duration, the following critical stakeholders were identified:

1. **Ministry of Water, Irrigation, and Electricity:** The Dam Safety office at the Ministry of Water, Irrigation, and Electricity oversees aspects related to improving the safety of the country's hydroelectric and irrigation dams. The Ministry oversee the Awash Basin Authorities (described below), and should be coordinated with for any work involving Koka Dam.
2. **Awash Basin Authorities:** The Awash Basin Authorities are in charge of the existing early warning system for downstream communities of Koka Dam. Any changes or improvements to the existing warning system should include them. Additionally, the Awash Basin Authorities control and schedule releases from Koka Dam. Any attempt to optimize the releases from Koka Dam must involve them.
3. **National Meteorological Agency (NMA):** The NMA is the country's central weather and climate agency. If the Climate Centre implements FUNES for Koka Dam, the agency can provide weather forecasts to help with the timing of controlled releases. Historical precipitation data is also available from the NMA.
4. **Ethiopian Red Cross Society (ERCS):** The local ERCS branch is located in Adama and responds to communities in the area. When coordinating response strategies or improvements to the existing warning system, the local ERCS branch should be included.
5. **Involved communities:** The success of any development project hinges on the willingness of the communities to uptake the project. A project can be perfectly designed amongst the stakeholders listed above, but without community participation and engagement throughout the planning process it may not appropriately address their needs. Communities should be involved throughout the project planning process, and the project design should be an iterative process to include community voices.

Incorporating FUNES

FUNES is a self-learning algorithm for flood forecasting which is embedded into hydropower dam and Red Cross operations to manage flood risks in vulnerable downstream localities. This innovation may enable regions with only a few years of data on river flow, precipitation, and local impact to provide flood risk warnings that can save lives and reduce losses in the immediate term, and open prospects for managing floodwater as a productive asset in the long term (Suarez & Mendler de Suarez, 2017).

The existing mechanism for releases from Koka Dam is to release water when the level in the reservoir reaches a certain height. This causes flooding problems for downstream communities, as the releases are often timed alongside precipitation events. The surrounding watershed drains into the Awash River, and when controlled releases coincide with precipitation events in the watershed it leads to high-risk flood scenarios. Incorporating FUNES can optimize the timing of releases to minimize impacts on downtown communities. **Figure 10** shows how FUNES can be incorporated to minimize flood impacts.

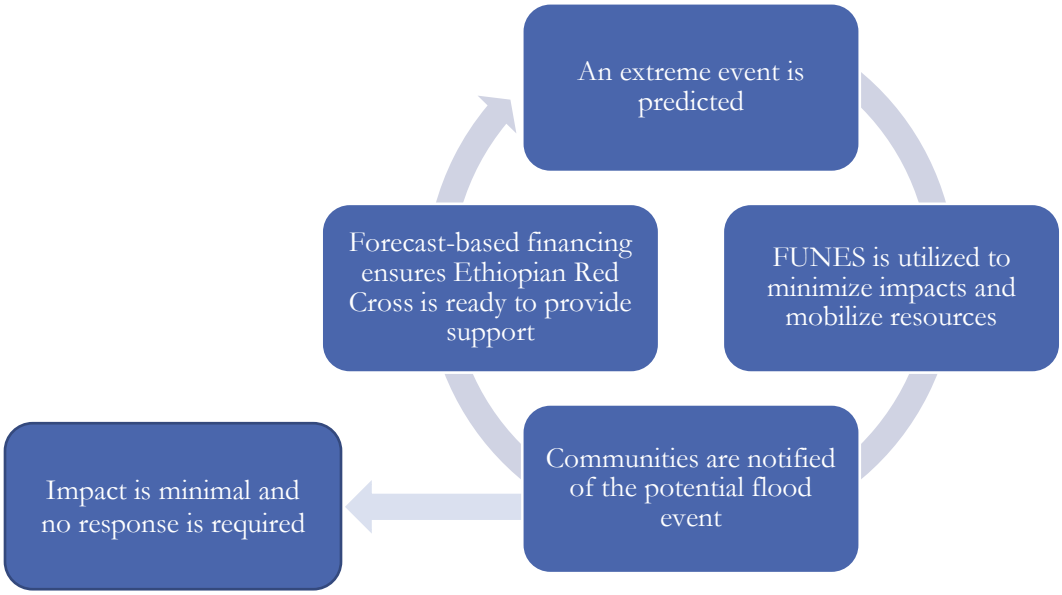

Figure 13: FUNES can be incorporated to improve release timing and mobilize response resources

Infrastructure to enhance resilience

Every community interviewed expressed a desire for infrastructure improvements to increase resilience. The two most common types of infrastructure cited were:

1. **Dikes** built along Awash River to prevent the river from overtopping the banks when levels are high. An example of a dike found is shown in **Figure 12**.
2. **Channels/canals** constructed through the community's farmland to divert water from the community's farms to the river. An example of a channel is shown in **Figure 13.**

Figure 14: Example of a dike (raised earth on the left) found in one community

Figure 15: Example of a channel through one community

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The ideas presented in this paper are those of the author alone and do not necessarily reflect the views of the Red Cross Red Crescent Climate Centre, the International Federation of Red Cross and Red Crescent Societies, or its National Societies.

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Appendices

Appendix 1: Detailed notes for individual communities

Batta Darama (upstream)

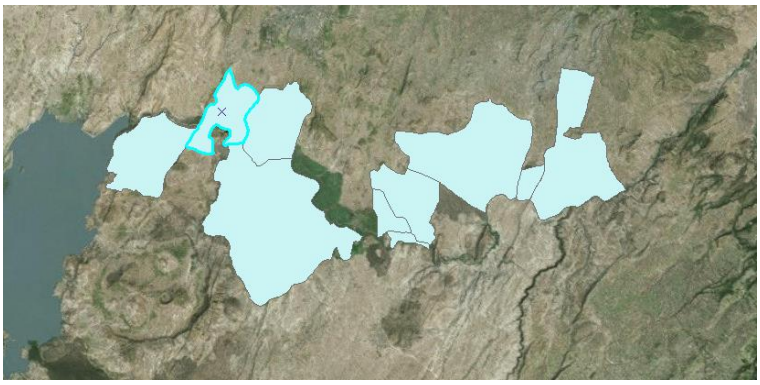
LOCATION	- Upstream
NOTES	- Group of all men participated in interview, varying ages.
BACKGROUND	- 780 households, 200-300 more potential households.
NEEDS	- Clean drinking water, school, health center, fuel for generators.
WATER & IRRIGATION	- Biggest problem is water management and availability for agriculture. Complained that the water from Koka is managed more for big farmers and energy production. Want to utilize more water to raise incomes. - They have over twenty pumps pumping water from the reservoir. Mix of microfinance and private pumps. Have been using pumps for over ten years. - They think that climate change seems to be playing a role in the lower amounts of water. Drinking water directly from reservoir (no treatment) - Water is also used for livestock and a fishery. - Problem: Algae covers water during certain seasons. - No sanitation systems.
HEALTH & NUTRITION	- Malaria, diarrhea, AWD. - Dam provides water for irrigation and livestock, steady water for agriculture which provides source of nutrition.
ELECTRICITY	- Community does not get electricity from dam, would like electricity.
INCOME & EMPLOYMENT	- Primarily agricultural: Maize, onions, tomatoes, green peppers. Cash crops & also for food.
ROADS & TRANSPORTATION	- Use roads constructed by dam to bring crops to the market, schools, health clinics. - The roads aren't good.
COMMUNICATION & PARTICIPATION	- Community has very limited/little communication with dam authorities and management. - First contact with NGO/international organization.
FLOOD CONTROL	- Flooding not a problem.
SOCIAL COHESION	- Prior to building the dam, there was no lake. This community is the original community that was here when the dam was built. - Generally positive thinking regarding dam. Water for irrigation a huge bonus.

Sire Robi (upstream)

LOCATION	- Upstream
NOTES	- Group of all men participated in interview, varying ages.
BACKGROUND	- 650 households.

NEEDS	- Health (only one health center), education (high school), clean water, sanitation.
WATER & IRRIGATION	- Drink water directly from the lake, no treatment. - Also use water for fishing, washing clothes, and some for irrigation though limited households are in farming. - No sanitation - Water management also identified as a problem.
HEALTH & NUTRITION	- AWD & malaria.
ELECTRICITY	- Almost 90% access to electricity, source is dam.
INCOME & EMPLOYMENT	- Only 10 households involved in agriculture. The rest do small jobs (like deliveries). Of the farmers, consume products themselves and also sell. A small number of households have cattle and hunting. - No banking and insurance because they're so difficult to reach.
ROADS & TRANSPORTATION	- Dam bridge used to communicate and trade with other communities, but restricted access poses problems. Can't communicate and trade freely with community on other side. Production on the other side of the dam can't move. Market system can't function and develop. - Two benefits to allowing access: Money/income.
COMMUNICATION & PARTICIPATION	- Community has very limited/little communication with dam authorities and management. - First contact with NGO/international organization.
FLOOD CONTROL	- Flooding not a problem.
SOCIAL COHESION	- Mixed community: Some there before dam, others came during construction. - Believe dams are good nationally. Locally, its presented a lot of problems. Can't freely connect with other communities.

Kuriftu

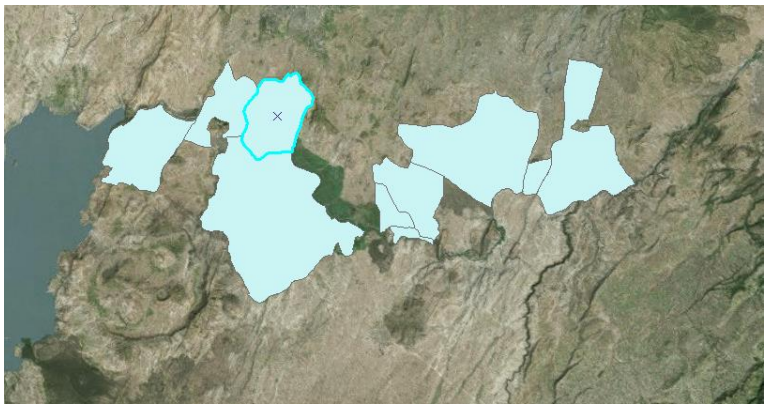


LOCATION	- Downstream.
NOTES	- Three men who are landowners participated.
BACKGROUND	- 777 households

WATER & IRRIGATION	- Irrigation water comes from Awash River. Use pumps to pull water from river, then surface irrigation to crops. There is also a well system for irrigation water. Have enough water for irrigation. - Tap water comes from Adama and is treated at the water treatment plant then piped to the community. When the water gets turbid, tablets are distributed. If there's a problem with the water the facility will notify the community. - Sanitation at household and community level. "Dig a hole". Flooding will get into sanitation systems but they will try their best to protect them. Government organizations came in for sanitation awareness and how to deal with waste. Health extension workers are stationed in the community and educate them on how to treat the waste and advise if improvements are needed.
HEALTH & NUTRITION	- No major persistent community-wide health problems currently. Had an outbreak of cholera/AWD in the past which "began with one person and spread from there". Cholera came with high river flow and flooding. Health extension workers are stationed there to help to control the spread of disease.
ELECTRICITY	- They have as much electricity as they want, metered.
INCOME & EMPLOYMENT	- 80% of community farms, 20% rely on sugar factory for work, and all depend on agriculture in one way or another. They grow onion, cabbage, papaya, tomato, mango, avocado on irrigation from Awash. Maize, beans, and barley on precipitation. They sell most of the products and consume what's needed for themselves.
ROADS & TRANSPORTATION	- Traders go to that community to buy products, come from nearby towns. Roads are shaky, but no major problems. Use car, bike, motorcycle, and cart.
COMMUNICATION & PARTICIPATION	- No interaction with dam managers and limited communication with the Awash Basin Authorities. - Would like to interact more with staff in person.
FLOOD CONTROL	- The floods come mostly from the rain from the town, not Awash River. Following the 1996 floods, a dike was built along the river to protect the farmland from flooding when there are controlled releases from Koka. - Flooding typically occurs twice per year during high rainfall events in summer and winter. - There isn't one thing that's the most inconvenienced during flooding, everything becomes inundated and troublesome (e.g., roads are flooded, kids can't go to school; agricultural fields inundated). - Once they are affected by flooding there's no support from the government, must finance repairs themselves. One man lost two motorbikes and two pumps in three years. - The flood waters are not used in a way that's beneficial to crops; therefore flooding is a problem for crops. They don't use flood waters

	for beneficial purposes because the timing of the flooding varies each year. They just harvest their crops when ready.
EARLY WARNING	- When the dam has planned releases, the regional Awash basin staff are notified by the main Awash office. The local staff then notify communities via cell phone calls and media (e.g., radio, television) notifications. If community members can't be reached via cell phone staff members come in person. This only happens for planned dam releases, not heavy precipitation events. Generally, they think that this process is good for notification. There are no siren systems, but the community would be interested in them.
EARLY ACTION	- Protect agricultural lands using sacks of sand and soil. Put it in when notified of potential flooding events. Move animals and pumps from opposite side of dike when notified of controlled releases.
WHAT DO THEY WANT?	- Want drainage system built (also used terms "channels" and "canals").
DAM PERCEPTIONS	- Know vaguely about dam, 5-7 km away. Most people don't know much about Koka Dam. Know that the dam brings water for irrigation, electricity, and provides flood control so generally a positive perception. - Think that dams are good nationally and that Koka Dam has been good for their community. In 1996 large floods coming from a release from Koka inundated the entire valley and people had to be saved via helicopters. Since then the government built the dike and flooding from controlled releases has not been a big problem.

Botu Kurabo

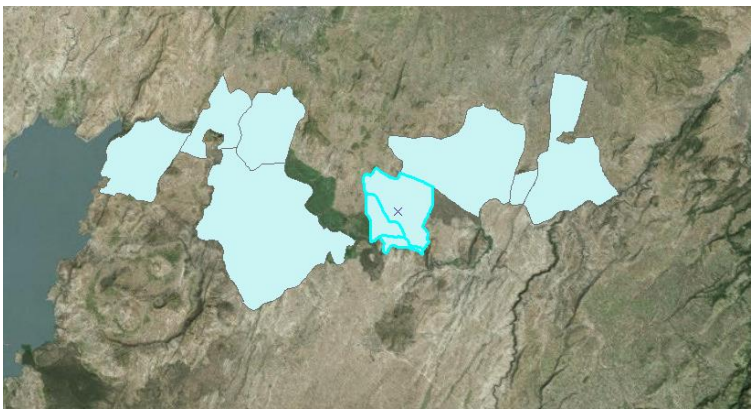


LOCATION	- Downstream.
INTERVIEWEES	- A mixture of farmers and landowners were selected for the focus group. There were four total participants in the group.
BACKGROUND	- 203 landowners. Previous communities have been on the land since before Koka was built. Before they were here the land was also used for agriculture. Current community has been here since about 1985.
WATER & IRRIGATION	- 100 hp pumps bring water from Awash River to farms; pumps are shared amongst community. There's enough water for irrigation.

	- Drinking water comes from Adama Drinking Water Treatment Plant. Treated then piped to community. Drink water straight from tap; don't treat it before drinking. - Mix of household-level sanitation and shared facilities. Interviewees agree with their current practice. Facilities either made of "cement or hollow blocks". - World Vision came in over five years ago to implement WASH services and education, but now it's only the government.
HEALTH & NUTRITION	- No major persistent health problems reported.
ELECTRICITY	- Have electricity, and as much as they want. Metered, so pay for how much they use.
INCOME & EMPLOYMENT	- Harvest crops three times per year. Trade with their neighbors, and most come to this community to trade. Mediators buy their crops and resell at higher prices, making more money than the farmers do. Try to trade directly, but usually must go through mediators. Grow onions, cabbage, green beans, tomatoes, and mangoes. Recent fungal disease has attacked onions and they need herbicide/pesticide.
ROADS & TRANSPORTATION	- To get to the local high school kids must travel a long distance. There aren't enough vehicles to transport the children. They asked the government to fix this problem but no solution.
COMMUNICATION & PARTICIPATION	- Don't interact much with dam staff or Awash authorities, would like more interaction. In-person interaction is best, since they don't use phone or email. The main interaction with Awash authorities is paying taxes.
FLOOD CONTROL	- Flooding is extensive, covers the entire farm area. Doesn't reach the community and people's homes. - 3-5 years ago there was a major flood that took away their agricultural pumps and caused the electricity to fail. The floods don't come alongside rainfall, they're just from the river and controlled releases from Koka Dam when the water is at its maximum level. They're flash floods when they happen. The most inconvenient result is the effect on agriculture. - There's no support when flooding occurs, and they have to rebuild everything with their own money. When floods come they "lose everything." 30,000 birr was their estimated loss from the floods 3-5 years ago ($1300 USD). The sugar factory across the river recently built a dike, which worsened flooding on the community's side since they don't have a proper dike.
EARLY WARNING	- Receive radio notifications telling them about controlled releases from Koka. No in-person or telephone notifications. Don't think this current method is a good way of communication. Think that this notification is there to save lives primarily, but want additional notifications if floods will affect their livelihoods. Want in-person notification or phone calls

	because most people don't have radios or television. Want to be notified of releases as early as possible.
EARLY ACTION	- Move agricultural pumps from the floodplain. Use all types of materials to limit the flow, no one sleeps when floods are predicted. Fill sacks of sand and soil; build artificial dike.
WHAT DO THEY WANT?	- Want flood drainage channels and dikes built.
DAM PERCEPTIONS	- Knew very well about the dam, one member began to give us a history of the dam (lol). Know that it provides electricity and irrigation. - Don't fully understand flood control, constructed dike themselves. - Believe dams are useful nationally and generally good, they just want protection from flooding events. Positives include electricity and irrigation.

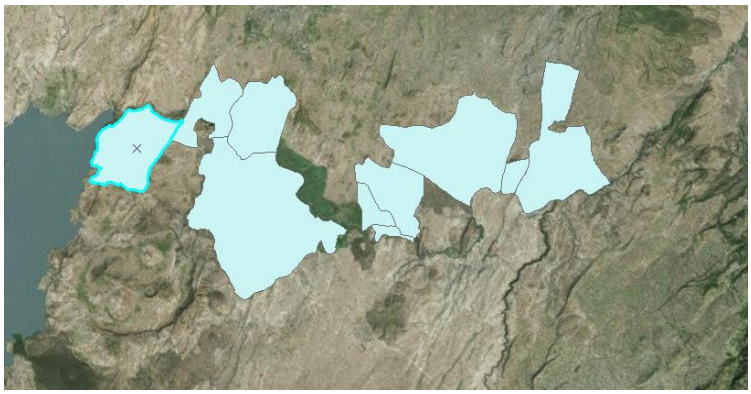
Awash Melkasa



LOCATION	- Downstream.
INTERVIEWEES	- Farmers and landowners were selected for the focus group. There were three total participants in the group.
BACKGROUND	- > 280 people in farming, 3000 households total in Bora. Community there long before Koka Dam. There was an electricity power plant on the other side so they settled here.
WATER & IRRIGATION	- Water for irrigation pumped from the Awash River and gravity-fed by surface irrigation to their farms. There's occasionally a shortage of water, last year there wasn't enough water for irrigation. - Drink tap water from Adama Water Treatment Plant. Spring source, stressed the quality of the water was good (lol). - Have household-level sanitation facilities. World Vision came in for awareness over five years ago.
HEALTH & NUTRITION	- Malaria is a problem when flooding events occur, but no other significant persistent health problems in the community. Food comes from their farms except injera.
ELECTRICITY	- Have electricity and as much as they need. Metered.

INCOME & EMPLOYMENT	- Farming and agriculture are the primary occupations. Some are also working in industry at the factory. Common complaint is the mediator between farmers and selling crops – charge high rates. Mainly grow onion, cabbage, and tomatoes.
ROADS & TRANSPORTATION	- Typically use carts with wheels for transport. Some use cars. Educational facilities nearby, but the road isn't well maintained.
COMMUNICATION & PARTICIPATION	- Don't interact with dam staff, only interact with the power generation facility across the river. When flooding occurs they typically go there. They contact Awash authorities when there's shortages of water.
FLOOD CONTROL	- The power plant across the river built its own dike so a lot of the water now comes to this side. - Flooding mainly occurs in the summer months (July & August). Floods occur nearly every summer. Last year the entire farm area flooded. Floods not just from Koka releases, they also come with rainfall. Since Koka must release water when it fills with rainfall runoff, the events coincide. Community identified the cause of flooding as a combination of runoff from the village, rainfall, and flooding from Awash River. - Community can't grow crops in a certain area of land because they're afraid flooding will affect their crops. Sometimes in the winter if there's a sudden rainfall they'll lose all crops.
EARLY WARNING	- No notification for heavy precipitation events. They believe that the main cause of flooding is the heavy precipitation events, not Awash River. Two years ago, they began communications with the Awash Basin authorities. They use meteorological data and past experience to determine when flooding will occur and when to plant crops. Don't think that NMA is accurate, and it's hard for them to use their data. Noted that climate change has changed the timing of the annual floods. - No help from government when flooding occurs. Its best to notify the community of potential flood events in-person or over cell phone.
EARLY ACTION	- Previously used soil to raise the levels of their farms.
WHAT DO THEY WANT?	- Want to build drainage canals to protect land when flooding events occur.
DAM PERCEPTIONS	- Know about Koka and know that flooding comes from the dam. Think dam is good for agricultural purposes, provides a steady source of irrigation and a "bank of water". - Understand that the dam authorities must release water, but "we're suffering from flooding." Think it's good to have dams nationally for electricity and irrigation purposes.

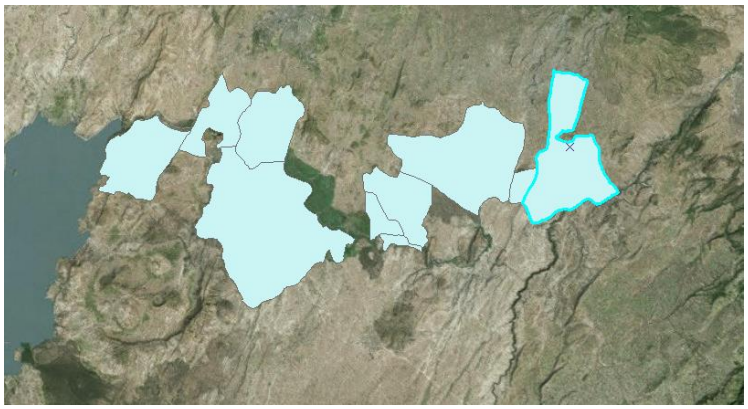
Bati Germana



LOCATION	-	Downstream.
INTERVIEWEES	-	Ministry of Water staff had a connection with a landowner in community. One landowner was interviewed initially, while two farmers joined the interview midway through.
BACKGROUND	-	586 households. Know about Koka, community moved to area after the dam was constructed.
WATER & IRRIGATION	-	Use water from Awash River for irrigation. Pumped then use surface water irrigation. Enough water.
	-	Drink directly from the river and use tablets since there's not enough water from main water supply.
	-	Sanitation coverage at household level.
HEALTH & NUTRITION	-	Malaria comes with flooding, but other than that no major persistent health problems.
	-	One time had a problem with cholera and AWD but health extension workers came to control the outbreak.
ELECTRICITY	-	Have enough electricity.
INCOME & EMPLOYMENT	-	Primary occupation is farming. Grow tomato, onion, cabbage, maize.
COMMUNICATION & PARTICIPATION	-	Many people from community work at Koka Dam as guards, etc.
	-	Have interaction with the dam staff, including social interaction.
	-	Limited interaction with Awash Basin Authorities, mainly for tariffs.
FLOOD CONTROL	-	Flooding comes from a combination of runoff from the community and Awash River. They are only able to harvest twice per year but without flooding could harvest a third time.
	-	Water sits in their fields for a month and they can't grow crops.
	-	Houses are also affected by runoff through the community.
EARLY WARNING	-	Receive radio notifications to warn them of controlled releases. Satisfied with current system.
	-	Flooding occurs after warnings are received, but there's not much they can do.
EARLY ACTION	-	Use bags of sand and soil to prevent household flooding.

	- Remove crops if flood comes before harvest. - Remove pumps and cattle.
WHAT DO THEY WANT?	- Want a dike along the river and channels that take water out of community/farms to Awash River.
DAM PERCEPTIONS	- Generally think dams are good except for the yearly flooding. Bring electricity and irrigation.

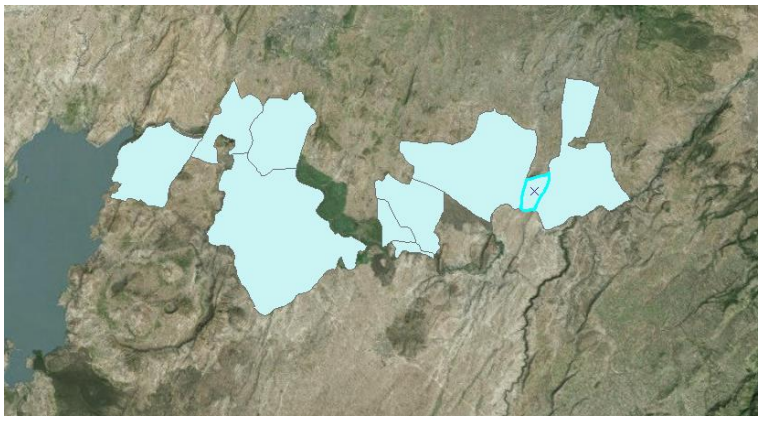
Qechachule Guja



LOCATION	- Downstream.
INTERVIEWEES	- Met with a group of farmers and landowners at a school in a separate community. The road was not good enough to visit this community. Approximately ten people participated in the focus group.
BACKGROUND	- 723 households. Began agricultural practices in 2008 but community has lived in the area for a long time. Not too much knowledge on Koka Dam but see it when passing by.
WATER & IRRIGATION	- Use water from Awash River for irrigation. Pumped then use surface water irrigation. - Treated drinking water comes from Adama Drinking Water Treatment Plant. Sometimes they drink water directly from the River if they're in the fields. Don't believe that this causes health problems. - Have household-level sanitation facilities. Different organizations came in for awareness campaigns, and health officers are stationed in the area. Sanitation infrastructure simple, lined with either wood or bricks. No cement or rocks.
HEALTH & NUTRITION	- Malaria comes with flooding, but other than that no major persistent health problems.
ELECTRICITY	- No electricity but see the distribution lines.
COMMUNICATION & PARTICIPATION	- No interaction with dam staff or Awash authorities but would like more interaction. Only interact with staff to pay tariffs and when there's a controlled release from Koka.
FLOOD CONTROL	- Flash flooding affected the community this year, though this was the first time that it has happened. Just the farmland and agricultural equipment were affected by flash flooding. Pumps taken away by floods. There

	wasn't any rainfall when the flooding occurred; it came from surrounding areas. - There's flooding every year in August, though this year was the first time they experienced flash flooding unexpectedly. Don't farm on areas that experience flooding. - Once the water inundates the farmland it takes a long time to leave. - Believe that their flooding is caused by Koka releases. Seems like it is, generally warnings are accurate and the area floods after warnings.
EARLY WARNING	- Radio notifications of controlled water releases from Koka Dam. - Would like an alarm system for future flash floods. Notifying them in-person or communicating with the local irrigation officers of controlled releases or predicted flood events is also a preferred option.
EARLY ACTION	
WHAT DO THEY WANT?	- They don't have the means to prevent flooding in the future.
DAM PERCEPTIONS	- Believe dams are good and bring consistent irrigation (esp. during dry season) and electricity.

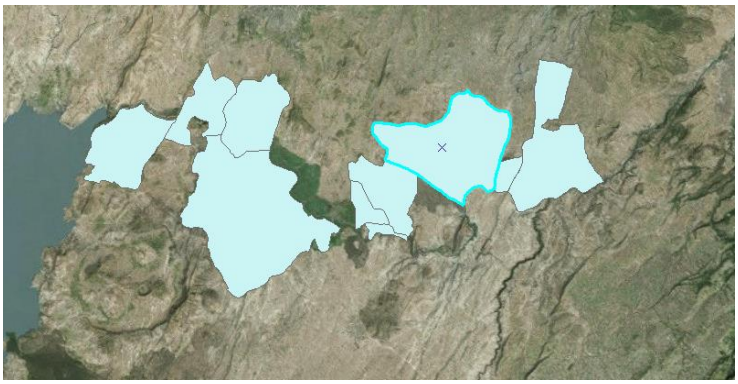
Koloba Bli



LOCATION	- Downstream.
INTERVIEWEES	- A group of farmers and landowners participated in the focus group. Five people participated in the group.
BACKGROUND	- 900 households
WATER & IRRIGATION	- Pumped water from Awash River for irrigation, but pumps were washed away during this year's flash floods. - Use tap water and groundwater for drinking.
HEALTH & NUTRITION	- No major persistent health problems.
INCOME & EMPLOYMENT	- Farming and agriculture are the primary livelihoods. Traders come here for crops, and the roads aren't affected by flooding. Produce cash crops.

COMMUNICATION & PARTICIPATION	- Know about Koka, but don't interact with dam staff or Awash Basin authorities. Use water directly from Awash River with their own pumps, so don't pay tariffs. - Would like to speak more frequently with staff, preferably in-person. If not in-person, then over the phone. - No government support in rebuilding following the flash floods.
FLOOD CONTROL	- Flooding only affects their farmland. - This year there were flash floods (60 people had farmland destroyed; 1.5M birr lost), but normally they can predict approximately when flooding will happen. Predicted floods always happen during summer and the rainy season. Think that Koka Dam also contributes to the flooding, but isn't the sole reason. - To mitigate damage, they only plant maize during the rainy season because everything else would be destroyed.
EARLY WARNING	- Media (e.g., radio) notifications when water is released from Koka, but the main purpose of these notifications is to save lives and their pumps. The warnings don't make an impact on their livelihood because there's no way to stop the flood from affecting farmland.
EARLY ACTION	- Move pumps and animals from floodplain.
WHAT DO THEY WANT?	- It's not possible to build a dike because their farms are so close to the River.
DAM PERCEPTIONS	- Generally think that dams are good, bring irrigation and electricity. Would be better if there was a permanent solution to the flooding because the warnings don't do much for them.

Bato Degaga



LOCATION	- Downstream.
INTERVIEWEES	- Farmers and landowners participated in the focus group. Approximately six people were in the group.
BACKGROUND	- 5000 households total; 2000 households in this sub-community
WATER & IRRIGATION	- Water from the Awash River is used for irrigation. Use electric pump. Have enough water for irrigation.

	- Grow onions, carrots, tomatoes, cabbage, vegetables, and maize. Sell all crops except maize. - World Vision came in to install a groundwater system for drinking water, but the transformer broke and now they're drinking water straight from Awash River. Sometimes use tablets for their drinking water. - Some households have sanitation, but many people practice open defecation in their fields.
HEALTH & NUTRITION	- Noted the smell coming from standing water when there's flooding. - Malaria and cholera/AWD always comes with flooding. Mostly affects children.
ELECTRICITY	- Have electricity and as much as they need.
INCOME & EMPLOYMENT	- Agricultural workers. Traders come here to purchase crops when they're ready. Mostly grow maize.
COMMUNICATION & PARTICIPATION	- There's no interaction with the dam staff or Awash Basin authorities. Want in-person interactions to discuss water shortages and potential flood events. Really want more interaction.
FLOOD CONTROL	- Flooding only affects farmland. Flood event happened two years ago and they weren't notified about a release from Koka Dam. - This year there were flash floods that destroyed all of their crops, took away their pumps, and killed some of their animals. Some people had to climb trees when the flooding occurred. Lots of organizations came and promised things but they haven't received any assistance.
EARLY WARNING	- Notified of controlled releases from Koka over the radio. - Prefer authorities to notify local irrigation officers, then they can receive notification from them. Most people don't have telephones. Would like sirens for flash floods. - Want information much earlier so they can prepare.
EARLY ACTION	- Use sacks of sand and soil for protection when the floods come.
WHAT DO THEY WANT?	- Want a dike built to protect farmland.
DAM PERCEPTIONS	- Know about Koka Dam and know that it provides irrigation water and electricity. Think that the flooding that occurred two years ago was because of Koka. They're don't really know the cause of the flood, but blame Koka (in their own words). - Despite flooding, generally think that dams are good. Bring many benefits like irrigation and electricity. "No question" that dams are good.

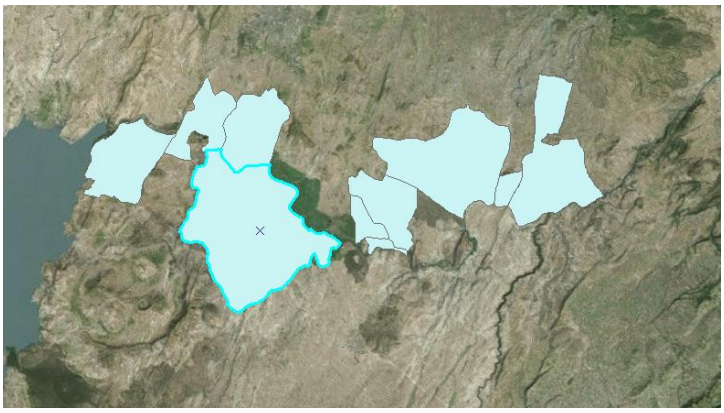
Sodere Resort

Insert location on Google maps

LOCATION	- Downstream.
INTERVIEWEE	- A Sodere Resort manager participated in the interview.
BACKGROUND	- Previously a government facility now a private-owned resort.

WATER & IRRIGATION	- Flash flooding occurred two months ago. The resort lost $15M birr. Pools filled with sediment, spring water was affected, 45 rooms were completely destroyed. Had support from their insurance company to cover damages. Think that the cause of the flash flood was both Awash River and other tributaries feeding into the main river. - Floods typically occur yearly in the summer. This year was the worst because the flooding wasn't expected. Flooding always affects the resort. - Surrounding agricultural lands also affected by flooding.
HEALTH & NUTRITION	- Malaria is a problem when there's flooding.
EARLY WARNING	- If there are controlled releases from Koka they're notified via phone, but this recent flooding wasn't caused by the dam. - They're mostly concerned about flooding due to precipitation events and would like to be notified about these flood events. - Currently use weather forecasts to predict flooding, but they're not really accurate or helpful. - Satisfied with current method of notification about controlled releases
EARLY ACTION	- When they're notified of controlled releases they move property (e.g., televisions and refrigerators) from hotel rooms and take them to safe places.
WHAT DO THEY WANT?	- Constructed protection and a retaining wall. Want to raise the height of these. - Currently, there's a channel that removes liquid waste from the resort. When flooding comes it washes the waste back into the resort. Want to construct a control valve to prevent this from happening.

Wonji Sugar Cane Factory



LOCATION	- Downstream.
INTERVIEWEE	- A Wonji staff member participated in the interview.
BACKGROUND	- Sugar Cane Factory with over 35,000 residents living in its borders. 5000 hectare area factory.

COMMUNICATION & PARTICIPATION	- Agree with current method of communication.
FLOOD CONTROL	- Floods happen yearly in the summer. Due to precipitation events. Floods come from the surrounding areas. Fear floods from the subcatchments the most. Built a dike along Awash River so flooding from controlled releases isn't a problem. - When floods happen everything is inundated, both community housing and farmland.
EARLY WARNING	- Awash Basin authorities notify of controlled releases with a direct phone call. Works well, like this method of communication. - Have own meteorological data and research center that helps to identify when flooding may occur. If they think floods are coming they notify communities living in their borders.
EARLY ACTION	- First priority is to move relocate communities living in their borders to safety.
WHAT DO THEY WANT?	- Want to work more with governments and local communities to protect them from flooding. Want to develop a corporate plan with the government to also include social responsibilities.

Appendix 2: Sample semi-structured focus group

Introduction

- Katie, PhD Student, United States, University of Colorado Boulder, Civil and Environmental Engineering
- Research: Koka Dam - Flood modelling and downstream impacts
- Emphasize: Here for research, not to implement a project

Interview Script

Question	***Follow up question(s)***
Background on Interviewee/Community	
What is the name of your community?	How many households are in your community?
	How long has your community lived here?
Do you know about Koka Dam?	What are the ways in which you interact with the dam (e.g., water for irrigation, flood control, electricity)?
Do you interact with any dam staff members (e.g., government officials, dam managers, Awash Basin authorities)?	If so, how often? About what?
	If not, would you like to interact more with dam staff? How would you like to interact with them (e.g., cell phone, in-person, email)? About what would you like to interact with them about?
Income and employment	
What is your primary occupation (e.g., how do you make money)?	
Health and nutrition	
Do you/your community suffer from health problems?	If so, what health problems?
	What do you think causes these health problems?
	Do these problems come alongside flood events?
Electricity	
Do you/your community have electricity?	How much electricity do you have (e.g., one lightbulb, a tv)?
	Does flooding affect your electricity?
Irrigation and water	
Do you use the water from the dam for irrigating crops?	If so, how do you irrigate your crops?
	Is there enough irrigation water?
	What crops do you/your community grow?
	Does flooding affect your crops?
Where is the source of your drinking water?	Do you treat your water before drinking it?

Do you have access to sanitation facilities?	If so, what treatment system do you use (e.g., boiling, ssf, etc.)?
	Does flooding affect your drinking water?
	If so, what types of facilities?
	Does flooding affect your sanitation facilities?
Roads and transport	
How do you use the roads (e.g., transportation to school, selling agriculture)?	Are the roads well maintained?
	Does flooding affect your roads?
Flood control	
Does your community suffer from flooding?	When was the most recent occurrence of flooding? Is flooding annual?
	Does flooding occur alongside rainfall events?
When flooding occurs, what is affected (e.g., agriculture, irrigation, sanitation, water, shelter, roads)?	Of the things that are affected, what is the most inconvenient to you?
Do you spend any of your own money rebuilding following floods?	If so, how much?
How are you currently being notified about potential flooding events?	If yes, are you satisfied with this current method of notification? What are the things you would change?
	If not, what are the ways that you would like to be notified?
	What would you change about the warning content (e.g., does it come on time, give you the necessary information)?
What actions do you currently take when flooding events occur?	How do you think we can prevent flooding from occurring in the future?
Perceptions on dam	
What problems has the dam caused for you/your community?	What do you think should be done to resolve these problems?
What are the things that you like about the dam?	

Appendix 3: Useful contacts

Name	Position	Contact Information
Ali Aman	Dam Safety – Ministry of Water, Irrigation, and Electricity	aliaman8@yahoo.com +251 91 116 3990
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Miki Birhane	Information Management Expert – Awash Basin Authorities	mikibirhan27@gmail.com +251 92 097 6700