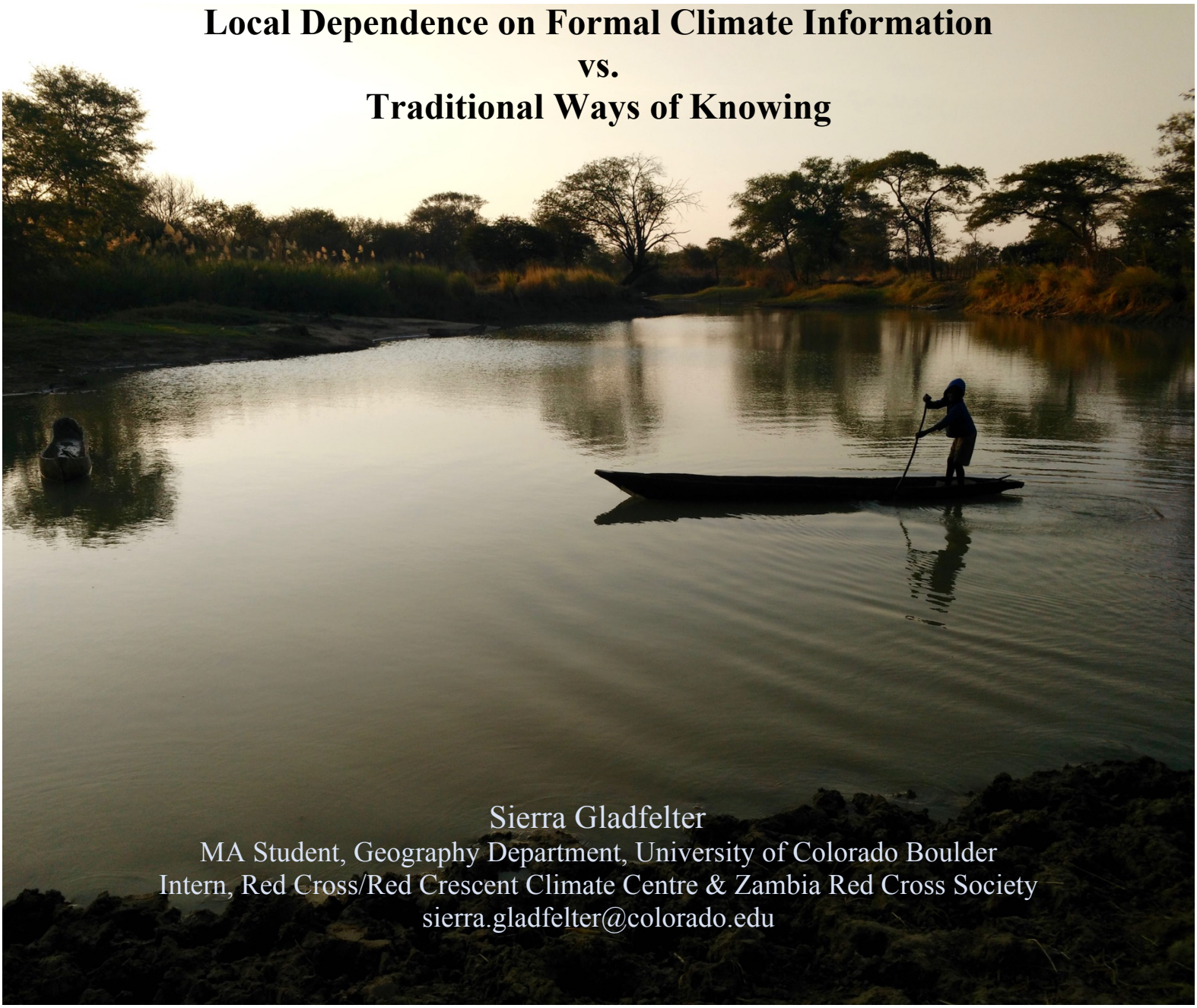
ANTICIPATING DISASTER:

Local Dependence on Formal Climate Information
vs.
Traditional Ways of Knowing



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1. Executive Summary

Introduction and Research Objectives

Rural Zambian communities living on the floodplains of the Zambezi River are increasingly suffering from climate-induced disasters, with both floods and droughts alternatively striking and eroding their security. In 2009, Thurlow et al. estimated that residents across southern Zambia face a 75-80% chance of experiencing either a severe drought or flood in any given year. The growing frequency and intensity of these extreme weather events have been strategically linked to climate change in media reports and policy documents since the mid-2000s, particularly in the aftermath of the 2006 and 2008 floods which devastated thousands of residents across Kazungula District of Zambia's Southern Province. Even today, communities here receive limited support in terms of advanced forecasts and early warnings that might enable them to better prepare for disasters. As a result, many residents continue to rely on traditional ways of anticipating and adapting to floods and droughts in order to secure their families and livelihoods.

This report is based on two weeks of qualitative data collection conducted during July 2016 in rural communities located in Kazungula District, Southern Province of Zambia. The specific goals of this study were to detail current barriers that communities face both in coping with and adapting to climate-induced disasters and to identify potential culturally-appropriate and feasible mechanisms to improve access to early warnings and enhance preparedness. Communities across Kazungula District have been beneficiaries of the Zambia Red Cross Society (ZRCS)'s Zambezi River Basin Initiative implemented from 2012-2015 and continue to be integrated in activities as part of the Building Resilient African Communities project scheduled to end in 2017. As a result, the ZRCS is deeply interested in understanding resident experiences with the growing challenges of climate change, in documenting existing technologies at the local level to cope with these changes, and in analyzing opportunities to enhance both preparedness for disasters and climate adaptation through targeted interventions. Thus, this research intends to provide data on these topics that can guide the ZRCS's ongoing activities and future interventions in the region.

Methodology

In order to triangulate information central to the study's research objectives, I employed a multi-method approach. This involved 1) three focus groups with members of the ZRCS's Satellite Disaster Management Committees (SDMCs) representing villages in Kawewa, Sikaunzwe and Kasaya, 2) 13 semi-structured interviews with key stakeholders at the district level as well as with local residents, 3) participant observation of ZRCS evaluation and monitoring activities of existing interventions, and 4) site visits and photo documentation of flood and drought impacts as well as local adaptive strategies for these disasters.

Results and Analysis

In the body of the full report, I provide an overview of 1) the primary disasters that residents face; 2) local strategies for coping with floods and droughts; 3) local access to formal weather and climate information that may guide these actions and barriers to its dissemination; 4) traditional mechanisms for predicting disasters in the absence of formal data; and finally 5) community perspectives on the utility of each source of information. These overviews are followed by an analysis of existing interventions to institute formal early warning systems (EWSs) in the region and addresses barriers to such interventions more broadly. In this section, I also include a detailed picture of existing informal communication structures at the community

level for relaying critical information from upstream in the absence of robust cell phone networks or radio signals.

Next, I include a section of recommendations that focuses on two areas: 1) identifying opportunities for enhancing community-based EWSs already functioning in the region and 2) making suggestions for low-tech climate adaptive strategies proposed by residents that would not be feasible without either technical or financial assistance from an institution like the ZRCS. Specifically, on the topic of EWSs, I suggest leveraging the river gauges that already exist on tributaries to the Zambezi River by linking their trained gauge readers to downstream communities that would directly benefit from an early warning and clear lead time before being struck by floodwaters. Furthermore, by installing additional basic river gauges in the upstream, more residents may be integrated into a localized EWS even in the absence of formal forecasts by simply linking upstream communities with access to live river level data to downstream villages. These systems, I suggest, could leverage both the informal communication structures already present on the ground and ZRCS's SDMCs to formalize a more effective structure for dissemination. In addition to these detailed recommendations on ways to enhance community-based EWSs, I also present several potential climate adaptive strategies for mitigating local loss to floods and droughts that were generated by informants during interviews and focus groups.

Ultimately, I conclude that while profound barriers restrict the dissemination of formal forecasts that would enable communities to take early action prior to disasters, there are also significant opportunities to leverage information already available on the ground and use informal communication structures to provide early warnings at the community level. Additionally, by taking seriously place-based knowledge on opportunities to respond to the localized effects of floods and droughts, institutions like the ZRCS may work collaboratively with communities to identify feasible, low-tech climate adaptive strategies to support residents in adapting to climate change across the Zambezi River floodplain.

2. Introduction

Rural Zambian communities living on the floodplains of the Zambezi River are increasingly suffering from climate-induced disasters, with both floods and droughts alternatively striking and eroding their security. In Kazungula, an underdeveloped district located in the Southern Province upstream from Victoria Falls, residents receive limited support in anticipating such disasters. In spite of this, climate change promises to only exacerbate the increasing insecurity residents face in sustaining their subsistence and agricultural-based livelihoods.

In the past two decades, Zambia's Southern Province has experienced an increasing number of extreme events, including both destructive floods and chronic droughts (Mweemba et. al, n.d.). Flooding on both the Zambezi River and along its tributaries is most often caused by extreme precipitation events upstream, particularly in the headwaters region of the Northwest Province. This process of recurring inundation, however, is also essential to local agro-pastoral production systems. Nonetheless, there have been an increasing number of severe floods over the past two decades, including particularly devastating events that impacted Kazungula residents in both the 2006/2007 and 2008/2009 rainy seasons (Mweemba et. al, n.d.).

Figure 1. Map of Zambia including Southern Province

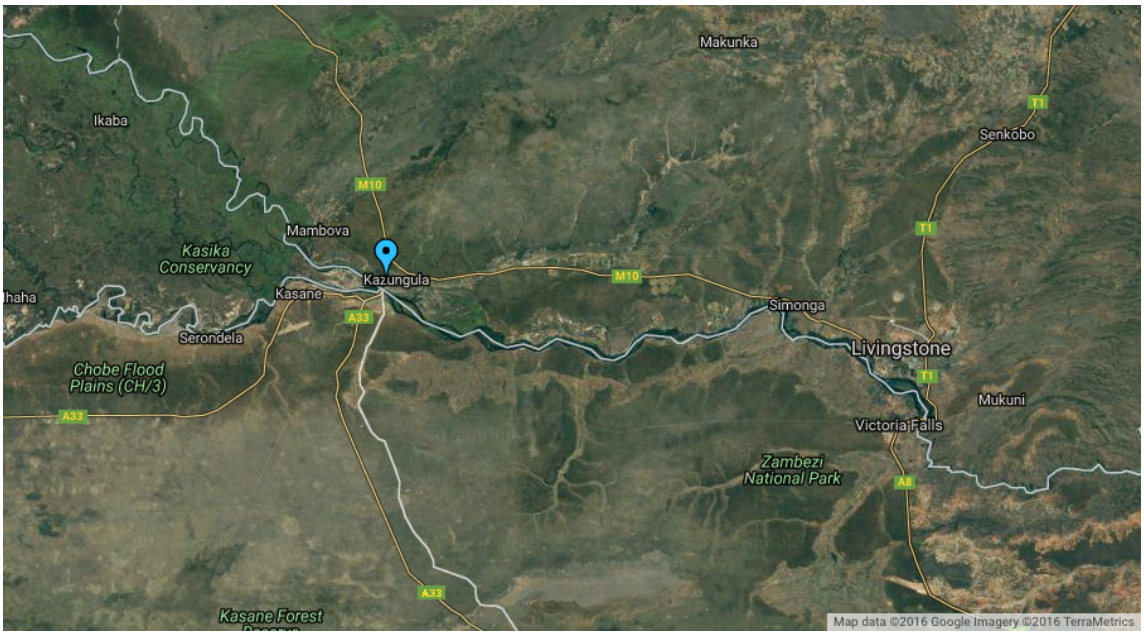

Figure 2. Map of Kazungula District, Southern Province

In addition to violent floods, droughts increased in frequency and severity, with two extreme droughts per decade during the past 20 years. Furthermore, a growing number of localized dry spells continue to erode the food security and resilience of rural, subsistence farmers across the region. These situations combined mean that Kazungula residents, like many communities across the Southern Province, increasingly face both severe droughts and floods in alternating and at times even overlapping years. In 2009, Thurlow et al. estimated that residents across southern Zambia faced a 75-80% chance of experiencing either a severe drought or flood in any given year.

The growing frequency and intensity of these extreme weather events have been strategically linked to climate change in media reports and policy documents since the mid-2000s, particularly in the aftermath of the 2006 and 2008 floods which devastated thousands of residents across Kazungula. Certain climatic trends have been confirmed by science, such as noting a gradual increase of 0.6 degree Celsius in mean summer temperature from 1997-2007 and an overall decrease in rainfall over the past 30 years (Mweemba et. al, n.d). However, direct links to climate change have been less easy to confirm for extreme events like floods and droughts tend to have compounded causes.

Regardless if climate change is the sole cause of floods and droughts in the region, the Southern Province has witnessed a greater increase in overall temperature and a more significant drop in average annual rainfall than other parts of Zambia in recent decades. This trend has

greatly impacted rural maize-growing farmers who depend almost exclusively on rain fed agriculture. Additionally, since the 1980s, the rainy season has become shorter and shifted in its onset from late October/early November to the second to third week of November (Kasali, 2008). In spite of this, average rainfall amounts have remained the same overall, albeit becoming increasingly concentrated. This intensification may explain the growing number of destructive flash floods that have impacted the region in recent decades. For all of the reasons outlined above, the Southern Province is considered to be the most severely impacted and vulnerable region to climate change in the nation (Mweemba et al., n.d).

This is also a region that has historically been targeted by ZRCS interventions. Communities in the districts of Kazungula and Sesheke have been beneficiaries of the Zambezi River Basin Initiative (ZRBI) implemented from 2012-2015 and continue to be integrated in ZRCS activities as part of the Building Resilient African Communities (BRACES) project scheduled to end in 2017. As a result, the ZRCS is deeply interested in understanding resident experiences with the growing challenges of climate change, in documenting existing technologies at the local level to cope with these changes, and in analyzing opportunities to enhance both preparedness for disasters and climate adaptation through targeted interventions.

This research seeks to address some of these areas requiring further investigation in order to provide data that can guide the ZRCS's ongoing activities and future interventions in the Kazungula district of Zambia's Southern Province. The specific goals of this project are to detail current barriers that communities face both in coping with and adapting to climate-induced disasters and to identify potential culturally-appropriate and feasible mechanisms for communication to improve access to early warnings and enhance preparedness through climate adaptive strategies. The hope is that this information will assist the ZRCS in supporting ongoing preparedness activities in these communities and in developing new proposals that consider opportunities for building local climate resilience.

3. Methodology

This report is based on two weeks of qualitative data collection conducted in rural communities located in Kazungula District of Zambia's Southern Province in July 2016. In order to triangulate information central to the study's research objectives, I employed a multi-method approach involving; 1) focus groups with community members, 2) semi-structured interviews with key stakeholders and local residents, 3) participant observation of ZRCS evaluation and

monitoring activities of existing interventions, and 4) site visits and photo documentation of flood and drought impacts as well as local adaptive strategies.

Key stakeholders at the community and district level were targeted for semi-structured interviews and focus groups using purposeful sampling. Also referred to as chain or snowball sampling (Bernard, 2006), this recruitment method involves an existing informant referring the research team to other qualified contacts with particular expertise to participate in the study. Purposeful sampling is often used when research must be conducted in a limited amount of time and where the research objectives require interviews with individuals with specialized knowledge (here, stakeholders with training in the implementation of formal early warning systems (EWSs), agriculture extension officers responsible for the dissemination of climate information, etc.) more than a representative sample of the larger population.

The information synthesized in this report is based on three focus groups (n= 30) with members of the ZRCS's Satellite Disaster Management Committees (SDMCs) representing villages within the school districts of Kawewa, Sikaunzwe and Kasaya. Recognizing focus groups as a research tool for efficiently collecting a wealth of data and being able to compare diverse perspectives within one discussion (Hay, 2010), the objective of these focus groups was to uncover the discursive landscape of risk and needs within flood and drought prone communities in Kazungula. Topics included local perspectives on access to formal weather and climate information, current adaptive strategies used to mitigate loss to floods and droughts, and the execution of initiatives to predict disasters (both traditional EWSs and formal early warning mechanisms) in the region. Two of the three focus groups were conducted in English, Zambia's national language, while one was conducted in Lozi due to participants' greater comfort expressing themselves in their local language. The discussion was translated by one of the SDMC members fluent in both English and Lozi.

This study also integrates data generated during semi-structured interviews (n=13) executed with key stakeholders at the community level (n=8; including lead farmers, individual SDMC members, ZRCS program beneficiaries, government and NGO-trained gauge readers, residents trained in formal EWS programs), informants at institutions at the district and provincial level (n=4; including representatives from the ZRCS, the Zambia Meteorological Department, Department of Water Affairs, etc.), and individuals at critical offices at the national level engaged in providing live river level data for EWSs (n=1; Water Management Authority).

Following recruitment, all interviewees and focus group participants who expressed interest in participating in the study were asked for their consent to participate in research activities following the University of Colorado Boulder's Institutional Review Board protocol. Since the adult literacy rate in Zambia is only 61.4%, verbal consent was obtained from all research participants. Moreover, hard copies of consent forms were also made available to all participants. A detailed list of interview and focus group questions organized by thematic topic are included in the Appendix of this report. Comprehensive hand-written notes were taken during all interviews and focus groups that were later typed, thematically coded, and analyzed in order to produce this report.

In addition to joining ZRCS District Project Officers and field staff on monitoring and evaluation trips to meet with beneficiaries in Kawewa, Sikaunzwe and Kasaya, I also organized several site visits to communities outside of the ZRCS's current areas of project implementation with logistical support from ZRCS District Project Officer Emmanuel Mudenda and Kazungula Branch volunteer, Zumbo Mbambara. These site visits included Namapande, a village also located in Kazungula District to which households in Kasaya impacted during the 2006 and 2008 floods were relocated, and Samahala, a fishing village located on the floodplain at the confluence of the Kasaya and Zambezi Rivers currently excluded from the dissemination of data collected from upstream river gauges. Wherever possible, I used these field visits and monitoring and evaluation trips with ZRCS staff to photograph impacts from past floods and current droughts and to document local adaptive strategies for mitigating losses to these disasters. These images are embedded throughout the report in order to provide greater context for the specific challenges and opportunities Kazungula communities face in adapting to climate change.

4. Findings

In the following sections, I provide an overview of 1) the primary climate-induced disasters that Kazungula residents face; 2) local strategies for coping with these events; 3) local access to formal weather and climate information that may guide these actions and barriers to its dissemination; 4) traditional mechanisms for predicting disasters in the absence of formal data; and 5) community perspectives on the utility of each source of information.

4.1 Primary Climate-Induced Disasters Impacting Communities

Droughts and floods were consistently cited as the two most common disasters experienced by communities across Kazungula District. These events profoundly impact rural populations

through property and crop loss, associated starvation, and the outbreak of diseases among both human and livestock populations due to compromised drinking water sources and waterlogged pastures in the aftermath of floods. Residents generally stressed droughts as the worst disasters they face and noted an increase in the intensity and extent of dry spells experienced in recent years. This may be a reflection of their most immediate experience, as the past two to three years have been characterized by severe water stress, while there have not been any major floods in the region in several years. Nonetheless, local experiences with growing water stress certainly reflects both regional climate predictions and documented trends of increasing temperatures and a reduction in overall precipitation for Zambia's southern region.

Figure 3. Water-stressed residents in Kawewa draw drinking water and irrigate their fields.

Floods, which also frequently strike the communities included in this study, are experienced more unevenly than drought. This has to do, in part, to the distinct nature of flooding in each locale due to distinct topography and hydrology. While some communities are flooded by the Zambezi River directly, or the backlogging of tributaries that feed it, others primarily experience flash flooding on tributaries due to rainfall in upstream areas. Villages in Kawewa, for example, are more likely to witness gradual flooding and waterlogging that rarely causes violent destruction of life and property, while people living in Sikaunzwe are more likely to face flash flooding on small streams. In Kasaya, where people live in much closer proximity to the Zambezi River, household and property loss to flooding has historically been higher than in other regions leading some families to permanently relocate to higher ground to avoid further loss. These distinctions in flood experience, directly affect the kinds of adaptive actions that households take in both preparation and response to these events. However, unlike droughts

which were strictly described in terms of their negative impacts, people also recognized the positive roles that floods play in fishermen's livelihoods as well as in supporting soil fertility on the floodplain.

Figure 4. In the fishing village of Simalaha, residents illustrate water levels during the 2006 floods.

4.2 Local Coping Mechanisms and Adaptation Strategies

In describing the ways in which people cope with floods and droughts, residents of Kazungula primarily described adaptive behavior in terms agricultural decision making. This may reflect the fact that seasonal forecasts, both formal ones provided by the Zambian Meteorology Department (ZMD) and informal ones deduced from environmental indicators, are the primary sources of information guiding local decision-making. Because most agriculture is strictly dependent on rainfall without irrigation, farmers will select either late, medium, or early maturing crop varieties based on anticipated rainfall for the growing season. When expecting particularly low levels of precipitation, some farmers will also choose to plant specific drought-resistant crops such as sorghum and bulrush which were grown indigenously in the region.

Besides crop selection and shifting the timing in which one plants, however, there are limited actions that farmers can take to secure themselves from drought. One method that farmers in Sikaunzwe described involved each household keeping fields in both upland and lowland areas. While the upland fields are never lost to inundation, the fields located in the floodplain tend to do better during droughts and also typically have more fertile soils due to period nutrient addition during floods. Some farmers described planting the same crops in both their upland and lowland fields, while others selected different varieties based on their capacity to thrive in dry or wet conditions and with varying soil fertilities.

Since most households have maize planted in their lower fields during the time of the rainy season, many people secure their crops from floods by constructing earthen ridges around their fields. Although these are present year-round, when villagers anticipate an impending flood, they go straight to their fields to reinforce these structures with additional soil. In addition to these ridges, farmers also described digging furrows to drain any fields that become submerged in floodwaters in order to prevent crop loss due to waterlogging.

Beyond these agricultural adaptations to protect crops from loss to floods and droughts, most residents described seasonal or temporary relocation as a commonly practiced adaptive strategy. Unlike much of the world where land tenure is dominated by private property, such fluid movements to and from the river are much more feasible in places like Zambia were tribal and customary law still dominates. Most residents described at least some members of their household shifting to the upland for a period of time during the rainy season with their cattle for grazing. There, some people have permanent structures, while others prepare temporary ones each season. In more flood-prone communities like the fishing camp of Simalaha on the riverbanks of the Zambezi, people retract to permanent villages annually where they live in homes constructed on human-made humps of soil to elevate themselves above the floodplain. In the event of a major flood, the whole Simalaha community will move to higher ground, either in upland areas of the bush or on the elevated tarmac road, where there is greater accessibility to relief. Actions that people can take to secure their homes are generally limited to basic reinforcement with wooden poles. Most structures are merely left and subsequent damages have to be repaired or reconstructed after floodwaters recede.

Figure 5. Homes, even those constructed on earthen mounds, often suffer irreparable damage.

A similar migration occurs in reverse during the dry season, particularly at times of severe drought when water levels in streams and ponds drop significantly. At such times, it is not uncommon for whole communities to shift to the banks of the Zambezi River with their livestock especially when watering holes dry up in other places. Here, people may also fish for supplemental income when their crops are suffering.

While these various adaptive strategies practiced by communities across Kazungula District play an important role in mitigating loss to floods and droughts, most actions must be taken in the absence of formal forecasts. The reasons for this will be explained in subsequent sections. Beyond seasonal forecasts provided by the ZMD, the majority of people rely strictly on their own experiences with seasonal weather patterns and observable environmental indicators to guide precautionary action and agricultural decision-making.

4.3 Local Access to Formal Weather and Climate Information

While the ZMD prepares and disseminates forecasts as part of its mandate to provide advisory services, the kind of data it is able to provide in terms of resolution and time scale remains limited. Currently the ZMD distributes three types of forecasts including six-month seasonal forecasts with detailed information on how weather and climatic patterns like El Niño and La Niña will influence rainfall over the region, as well as 10-day and daily forecasts. This information, however, formulated at the national level and downscaled for each province, is not as nuanced as it could be due to the ZMD's limited number of weather stations and ability to collect and transfer data in regions with limited technical infrastructure. Furthermore, the ZMD receives a lot of intermittent, volunteer-generated rainfall data from interventions coordinated by nongovernmental organizations (NGOs) that later transfer responsibility for data management to this government department. This means that rainfall data is not always reliable or standardized in collection, forcing the ZMD to depend on a limited number of weather stations for generating its forecasts.

Upon preparation at the central office, these forecasts are disseminated by email to key stakeholders such as ZRCS Disaster Management staff, agriculture extension officers, local government officials, and individuals who formally request to be added to the department's list. This is the same mechanism through which people are warned in the event of an impending disaster. However, in a country where much of the rural population lives isolated even from radio and cell phone service the impact of electronically distributed forecasts and advisories

provided by the ZMD is significantly limited. The only formal climate and weather information that consistently makes it to the ground are seasonal forecasts which are printed on pamphlets and distributed annually by the ZMD. This fact is particularly tragic considering that in the Southern Province alone, the ZMD has eight automatic weather stations collecting live data. Furthermore, while the ZMD's headquarters has the technical capacity to prepare flood forecasts and issue advisories based on precipitation and live river level data collected upstream, its current system of relaying information electronically prevents meaningful lead times from reaching the most at-risk people on the ground who often lack electricity and cellular networks, not to mention working internet connections.

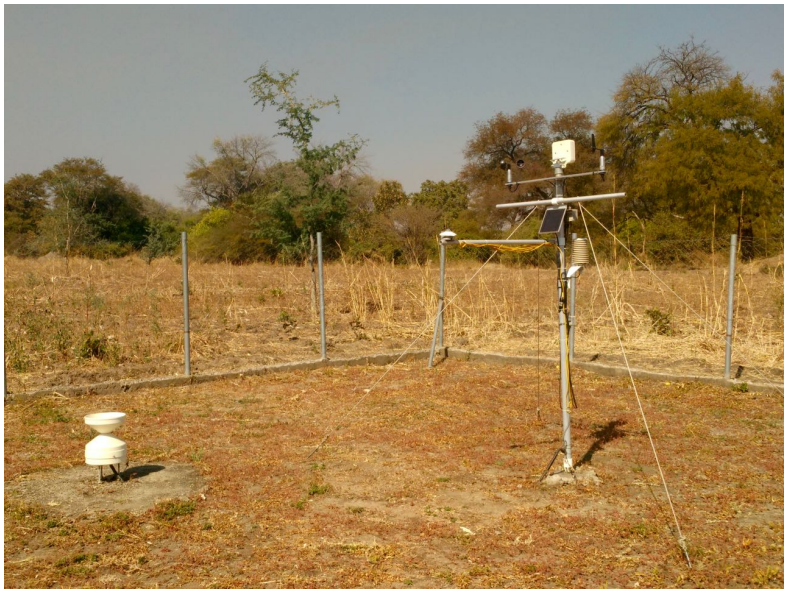

Figure 6. Automatic weather station in Sikaunzwe, which sends data directly to the ZMD, but is not disseminated locally.

For all shorter-term forecasts and weather advisories, the burden of dissemination to local communities falls on the shoulders of the nation's agriculture extension officers employed by the Ministry of Agriculture and Livestock in each district. These individuals serve as the primary intermediaries between the ZMD and rural farmers in both providing and translating weather and climate information for local decision-making. However, these agriculture extension officers face their own set of limitations. Besides having rare access to email which is linked to the intermittent cellular network, rapid dissemination of even 10-day forecasts is compromised by the fact that many agriculture extension officers are stationed in rural communities with no other means of transportation than a bicycle. For example, the agriculture extension officer

interviewed in Kazungula had not had a functional motorbike in over a year and was only able to access the more remote communities he was responsible for by coordinating transport with other institutions operating in the area. Thus, in order to obtain information from their agriculture extension officers, villagers may have to walk or bike long distances or wait for the next village meeting that the agriculture extension officer will be attending to access information.

In terms of urgent weather advisories, the ZMD notifies radio stations and news outlets through its formal email list, yet only a few stations include these forecasts in their broadcasts. Moreover, even these few broadcasts rarely reach the southern bush, where people along the Zambezi River are more likely to pick up airwaves from nearby Namibia's radio stations. As a result, not one of the residents whom I interviewed in communities throughout Kazungula had ever received a formal warning from the ZMD in advance of a major flood or other disaster.

These communication and logistical challenges mean that although ZMD regularly produces useful information to disseminate, even 10-day forecasts rarely reach rural Zambians while their content is timely. Thus, in spite of its lack of precision and often-questionable accuracy, the ZMD's seasonal forecasts are currently the closest thing to a formal early warning most communities receive in advance to floods and droughts.

4.4 Uses of Formal Climate Information

While knowing that floods or droughts are predicted within the season certainly does enable rural Zambians to take some precautionary measures, many people are left with great uncertainty as to when, specifically, these events will occur. Thus, most residents whose livelihoods depend on rain-fed agriculture, described the utility of the ZMD's seasonal forecasts for determining crop types and adjusting the timing of their planting. For example, if a drought is predicted farmers will plant drought-resistant varieties or traditional crops like sorghum that can handle a limited amount of water. In the case of seasonally predicted flooding or excessive precipitation, people choose late maturing crop varieties. However, at the broad timescale of a seasonal forecast, the kind of actions that people can take without any actual lead time prior to a disaster, are severely limited. For this reason, Zambians living in communities in Kazungula depend equally, if not more, on traditional mechanisms for predicting floods and droughts.

4.5 Traditional Mechanisms for Predicting Floods and Droughts

Rural farmers living in the communities of Sikaunzwe, Kawewa, and Kasaya described the most common indicators embedded in the landscape that they have historically relied on and

continue to rely on to anticipate floods and droughts. By far the most common was the significance of cobwebs suspended in the atmosphere as a portent for impending floods. Although the precise details of how these cobwebs emerge and the timing from when they are visible until a flood occurs remains unclear, informants consistently cited the presence of these nets of whitish silk that hover in the atmosphere as one of the surest signs of inundation. Similar phenomena of spiders escaping floodwaters on winds have been documented in places as diverse as Tasmania, Australia and Sindh, Pakistan (Safi, 2016; Phelan, 2012).

In Zambia, when the webs are transported on northwest winds coming from upstream and settle onto trees in the bush, local residents can reliably expect floods in a short time. In fact, several people were so confident that every time they see these webs they will get flooded, that this sign alone is cause for relocation to the uplands. One informant who had lost his home and 39 animals in the devastating 2006 flood, said that he had seen the cobwebs prior to that event and so when he saw them again during the 2008/2009 rainy season took early action to prevent more loss. Sure enough, in only a short time another devastating flood had struck the region.

In addition to the cobwebs that balloon over the bush prior to floods, residents pay close attention to the movement of birds, especially swallows. When seen in large numbers and moving in unison, residents know that heavy rains are on their way. On the other hand, in the months and weeks leading up to a major drought, people described large numbers of rats emerging from the bush and invading houses and fields, where they consume all food sources available.

Besides animals, the flowering of specific trees are also used to anticipate the nature of the approaching season. Repeatedly during interviews and focus groups, people pointed to the mango trees above their heads which were already flowering profusely in July. This, people assured me, meant there would be "enough rains"—and likely floods—this year. Individuals also reference the fruit of the baobab and *masuku* trees as environmental indicators of rainfall. If their fruit is profuse, one can expect drought. If it is sparse, there will be significant rain. Furthermore, local residents watch the timing that trees shed their leaves leading up to the dry season to anticipate its intensity. Since at the time of this research in late July, many trees were still hanging onto their leaves, residents suggested they could expect rain and anticipated some relief from the long drought they have been suffering.

While many of these environmental indicators are more useful for anticipating seasonal shifts in precipitation then impending disasters, people predict more immediate weather patterns by watching the formation, movement and type of clouds on the horizon. This, in tandem with studying wind direction, can be used to predict rains within a window of a few days. Residents also described how watching the water table in their deeper wells also provides some advanced warning to floods. Often, people explained, the day before a flood the water in their wells becomes cloudy due to seepage.

Figure 7. Sikaunzwe SDMC member illustrates how early blossoming trees indicate good rains.

The deeper the research got into these questions about traditional ways of anticipating floods and droughts, the more it became obvious that there were signs of climate conditions everywhere embedded in the landscape, if one only knew where to look. “Everything is telling us that there will be rain this year,” one focus group participant in Sikaunzwe expressed. Such certainty exists even without the seasonal forecast from the ZMD. Local signs in nature are the primary guides for local adaptive action. Based on what they observe in the landscape, people make decisions about when to protect their fields with earthen ridges, reinforce their homes, move their cattle to the upland, or relocate out of the floodplain.

4.6 Perspectives on Formal Climate Information vs. Traditional Ways of Knowing

Most residents in Kazungula claimed to rely on both formal and traditional sources of information for anticipating floods and droughts and in guiding their adaptive strategies. Yet when asked which way of knowing they trusted most, formal data or local environmental indicators, residents provided mixed responses. Overall, most people valued having access to government forecasts, but approached them with varying degrees of skepticism. It was only in

Kasaya, however, that people were on the verge of losing faith in formal data, after the ZMD forecast for the previous season indicated good rains that never came. Since people had wholeheartedly embraced the forecast despite contrary indicators in the landscape, they had lost certain crops. This year, residents asserted, they would rely on their own methods, even if these local predictions contradicted ZMD's forecasts. Significantly, even among those individuals who asserted that ZMD forecasts were essential to their decision-making, no one had fully abandoned or lost traditional ways of anticipating climatic conditions. Rather, all of my interlocutors seemed to find the greatest value in supplementing their indigenous ways of knowing with improved climate data.

Fortunately, in Kazungula, the value of synthesizing multiple forms of knowledge is a reality recognized not only by residents, but also by the local agriculture extension officer. Although responsible for disseminating weather and climate data from the ZMD to communities, the agriculture extension officer serving the district also saw profound value in the place-based knowledge residents continue to rely on. "Those of us at grassroots level, who work directly with farmers see the value in this," he explained. Therefore, when he holds meetings to disseminate the ZMD's seasonal forecasts, he also asks villagers to share how they expect the season to be based on local environmental indicators. Together he and community members analyze to what extent the multiple sources of information match or provide contradictory evidence. While all decisions made in the increasingly precarious conditions of climate change will have some degree of uncertainty, it is in the spaces where multiple ways of knowing overlap and come together that people may have the most confidence in their actions.

5. Analysis

In this section, I analyze existing interventions to institute formal early warning systems in the region and document existing informal structures for relaying critical information from upstream. This part of my analysis deals with the limits of existing interventions to institute EWSs, provides a description of existing community-initiated EWSs that already function on the ground, and finally discusses traditional strategies for exchanging critical information.

5.1 Formal Early Warning Systems and Interventions

Although the ZMD, in tandem with the Zambian government's Disaster Management and Mitigation Unit, operates several early warning systems based on its forecasts and live data, these advisories largely do not reach rural communities in Kazungula. Even information

collected at local ZMD-supported weather stations and the Water Management Authority (WARMA)'s live river level gauges is not actively being used or distributed locally. Instead, the data is either sent automatically, in the case of the ZMD weather station in Kazungula, or sent manually by gauge readers employed by WARMA to their headquarters. For whatever reason, either due to capacity issues or disinterest, formal weather and climate information generated in the region is strictly being extracted without being applied to the needs of local communities. Similarly, neither live precipitation data recorded by the ZMD nor live river level data registered by WARMA gauges in the upstream are disseminated to downstream communities who could take early action to avoid losses to floods based on such information.

Figure 8. The gauge reader at the Kasaya Bridge takes river level readings three times daily for the Water Resource Management Authority.

To date, there have been a limited number of nongovernmental institutions that have taken interest in working with communities of Kazungula to set up more formal EWSs at the community level. These interventions, initiated by the ZRCS and Community Based Natural Resource Management (CBNRM) Forum both occurred in response to the series of devastating floods which struck communities in the Zambezi floodplain in 2006 and 2008.

The CBNRM Forum, with support from Oxfam, initiated a Climate Justice Initiative with an early warning component from 2013-2015. After placing river gauges and rain gauges in strategic locations throughout Kasaya and along the banks of the Zambezi River, volunteers were trained on data collection, particularly on how to use the instruments, identify normal levels, and document the information. This data was sent to both the local officers for the ZMD and Department of Water Affairs in Livingstone, as well as disseminated locally via monthly

stakeholder meetings. During an interview with a past project officer, it became evident that after the project ended in 2015 and was handed over to the government for continued implementation, neither the gauges nor their readers were still functional. After doing my own investigation in Kasaya and Simalaha, I found that since the intervention had phased out, most of the gauges had been damaged, no one had returned to replace them, and those who were trained to disseminate early warnings have spent the past years more concerned about droughts and their withered crops than inundation.

In addition to the CBNRM Forum's intervention, the ZRCS also organized a training in EWSs for 40 community members and stakeholders in 2014 as part of its Zambezi River Basin Initiative (ZRBI). From conversations with attendees, the system in which participants were trained was to disseminate information received from the ZMD whereby the SDMCs would formally call the village headman and then he would share the warning within the community. This system, however, has never been tried as no major floods have occurred since the intervention to trigger the process of dissemination.

5.2 Limits of Existing Interventions to Formalize Early Warning Systems

There are many reasons why the existing interventions to institute EWSs in the region have been largely ineffective. To begin with, in stressing the dissemination of the ZMD's weather advisories that have never before reached the community level, interventions overlooked the limits of the actual data provided by the ZMD, the barriers to relaying it on the ground, and the actions people would be capable of taking even with an early warning.

Most significantly, however, none of the interventions discussed above involved a component to integrate alternative sources of information (e.g. natural indicators, local knowledge from upstream communities) that might also inform early action. Furthermore, there was no discussion of how weather knowledge could be shared in the absence of a reliable cell phone network or radio signal through existing communication structures. Besides providing general guidance on how one *might* relay an early warning, these trainings did not work with communities to identify specific adaptive actions linked to danger thresholds based on live river data or reliable information from upstream villages. There was no effort to coordinate a list of contact people in the event of an emergency nor the establishment of safe shelters on higher ground.

5.3 Additional Barriers to Formal Early Warning Systems

Besides the existing EWS interventions that have been tried in communities across Kazungula District, there are many barriers that restrict the institution of any formal EWS in the region that will have to be considered prior to any intervention to enhance disaster preparedness here. These can be understood in terms of communication barriers, institutional limitations, and the nature of flood exposure.

As discussed above, timely early warnings based on formal data from the ZMD are constrained by the current electronic, email-based system for dissemination that requires internet. This greatly restricts access in rural Zambian communities who must depend strictly on their resource-strained agriculture extension officers for early warnings. Furthermore, poor cellular networks and radio signals dramatically circumscribe access to this essential information.

The ZMD also has its own capacity challenges, with a limited number of weather stations that makes the production of localized forecasts a challenge. Volunteer-generated data is also inconsistent, leading many NGO interventions to expand the ZMD's data sources of limited utility for improving local forecasts. Additionally, early warnings have also been circumscribed by the limited degree of coordination between the ZMD and the Department of Water Affairs, which share a memorandum of understanding but function under separate ministries and do not always effectively share or integrate precipitation data with live river level data.

Furthermore, recent changes in the institutional arrangement for managing live river level data generated by the nation's automatic gauges and employed gauge readers provides uncertainty. In October of 2015, WARMA took over responsibility for all management of live river level data generated by the 320 gauge stations (168 of which are functional) previously managed by the Department of Water Affairs. Since this transition, WARMA has been operating only at the national level from its headquarters in Lusaka as its staff work to set up offices at the catchment level for Zambia's three major river basins. This has meant that there has been a lack of institutional presence on the ground despite WARMA's long term plans to decentralize water resource management, and it is unclear the extent to which gauge readers have been adjusted—and supported through—this institutional transfer of responsibility. However, according to an informant at WARMA's national office, current gauge readers still receive a 500 kwacha (~50 USD) stipend per month and will be supported with water resistant phones and bicycles or motorcycles in the near future.

Finally, because floods are not disasters that strike communities annually, it is difficult for interventions to sustain a high level of preparedness among households that face more pressing concerns. This is particularly true in villages of Kazungula, where residents often face droughts and exacerbated water stress during the years they do not experience floods. Interventions targeting specific disasters, like inundation, then will need to account for the ways in which people's attention is pulled in other directions as well. Furthermore, the inconsistency with which floods are experienced in Kazungula makes it difficult to establish critical thresholds on newly installed gauges, to link specific water levels with the extent of inundation and anticipated impacts, and to set up lead times between upstream and downstream gauges. All of this is necessary for establishing an effective early warning system, but can only be based on historical data and lived experience.

5.4 Informal Community-Based Early Warning Systems that Exist on the Ground

As illustrated above, formal early warnings rarely reach the community level during dissemination. For this reason, actions taken in the days and hours leading up to a major flood event, such as securing personal property, reinforcing structures, and evacuating to higher land, are guided strictly be early warnings observed in the environment and informal ways of exchanging information between upstream and downstream communities. In addition to the traditional environmental indicators described above, including the presence of cobwebs and changing cloud and wind patterns, villagers also observe water levels against the trunks of certain designated trees. By tracking the rate at which floodwaters advance, people can anticipate the extent of flood inundation in their village and on the floodplain downstream.

Furthermore, local communication chains provide an implicit structure for conveying this critical information to households and villages downriver. Since communities are generally situated linearly along small tributaries that run into the Zambezi River, those located on the floodplain usually have other villages upstream that they depend on for informal information on upstream precipitation and water levels.

When interviewing stakeholders in Sikaunzwe, Kawewa, Kasaya and Simalaha, I found that all communities were linked through informal communication systems to people upstream who often warned them of impending floods. Depending on the location and reliability of the local cell phone network, some people described receiving this information by cell phone or text. More common, however, were warnings provided by people traveling downstream on their way

to the main road for trade or travel. As they pass through villages on the way to their destination, such individuals share information about conditions in the upstream, including when waters have reached a level of concern.

This information is then distributed locally by the village headman and his personal messengers, sometimes with the help of the ZRCS's SDMCs at whatever village meetings, church congregations, and collective events like funerals already planned. These venues enable rapid and wide dissemination in places with limited communication infrastructure. In urgent situations, people sometimes use bicycles to go house-to-house, though this form of transportation is difficult in the rainy season when roads and paths are deeply rutted. Depending on the type of precipitation event upstream, these method of dissemination can be effective, but in flash flood events they often fail to provide adequate lead time.

Figure 9. Community meetings provide an efficient avenue for rapidly communicating early warnings.

5.4a Sikaunzwe

The community of Sikaunzwe, for example, situated along the Lingwazee Stream, has been relying on information conveyed from the 52 villages located upstream for more than five years (likely since the MTN cell phone network became reliable enough to make phone calls). A warning from the furthest village, located approximately 15-20 kilometers away, can provide up to a two to three-day lead time before floodwaters strike Sikaunzwe. This enables residents to reinforce the earthen ridges around their fields, remove drums sunken in sand to protect their water sources, and assemble their livestock and portable valuables for evacuation. Interesting, rather than relying on a single individual or instituting a formal structure for disseminating the

warning, in this community-initiated EWS any person can call to alert an acquaintance of family member. From this individual, information spreads rapidly throughout the entire community.

In some ways, this more nebulous system of responsibility ensures resilience in a place where mobile service is spotty, people's phones are often switched off or out of balance to make calls, and living off the grid makes charging devices a daily challenge. If a more formalized communication structure were established here, where key individuals were responsible for calling others on a list, such barriers to communication would need to be accounted for so that if one person was not reachable there would be several backups who could be notified.

5.4b Kasaya

People living along the Kasaya River described a similar system to the one in Sikaunzwe. whereby residents receive information from several villages strung along the waterway 20-25 kilometers upstream. When residents in Kasaya are warned by Silibani, the furthest village they have contact with, the rest of the community is warned by phone (for those who have them), and announcements are made at church and village meetings. Based on these warnings, people prepare to evacuate with their livestock to the uplands, a distance of 10 kilometers from their permanent residence on the Zambezi floodplains.

5.4c Kawewa

In the community of Kawewa, residents described their local EWS from upstream villages as supplemented by a local gauge located on the Kmadobi Stream that frequently floods their households. During an interview with one of the community's lead farmers trained in 2014 by the ZRCS as part of their ZRBI program, he explained that he shares his daily readings every month at a community meeting held at the local school throughout the rainy season. This information is also sent to the District Council in Kazungula for integration into their plans and preparation for disaster management and response.

Locally, he explained his strategy for informing residents through traditional communication structures. During a situation in which the gauge on Kmadobi Stream reads dangerous river levels, the gauge reader informs the *sabuku* or local headman who is then responsible for notifying all other villagers. This is usually accomplished through the headman's personal messenger, who goes from house to house usually by foot or bicycle disseminating the important information and detailed directions from the headman. This is the customary way through which residents receive all essential information. Furthermore, since the headman's official messenger

is responsible for providing the information, residents can trust that the content of the early warning and instructions for preparedness are from a reliable source and not simply rumors.

The same messenger will then be responsible for informing the headman of the next village downstream, who theoretically will then mobilize his own local structure of dissemination through his personal messenger. Although imperfect, and certainly not capable of always providing adequate lead time, these links between upstream and downstream communities currently function as the closest thing to an EWS that exists on the ground in Kazungula District.

5.4d Simalaha

Residents in the fishing village of Simalaha located 18 kilometers downstream from Kasaya on the banks of the Zambezi River explained that in addition to receiving no early warnings from the ZMD, they also are disconnected from information recorded at gauges upstream including the one at Kasaya Bridge. This isolation is due, in part, to the fact that most residents in this community are fishermen and are thus not as directly connected or invested in by the district's agriculture extension officers who are the sole source of information from the ZMD. Furthermore, from interviews with gauge readers upstream in both Kasaya and Kawewa, riverbank communities like Simalaha seem to be perceived as seasonal and temporary.

While it is true that people here occupy makeshift dwellings on the shores of the Zambezi River during part of the year, the more permanent villages they retract to during the rainy season are no more than a few kilometers away and still very much exposed to flood damage. This misconception about downstream exposure has meant that Simalaha fishermen rely strictly upon informal rumors traveling downstream and when Simalaha residents happen to travel to the road to sell their fish and can then access information from the gauge reader or others more connected to the agriculture extension officer serving Kasaya.

Information on flooding along tributaries to the Zambezi River, particularly the Kasaya River, can be useful to Simalaha residents. However, these households are also directly affected by the Zambezi River which does not have any local river level gauges on it to guide preparedness and evacuation. While there is a formal gauge on the Zambezi River upstream in Sesheke previously managed by the Department of Water Affairs, now WARMA, there is no formal distribution by radio or phone of this information to downstream communities occupying the floodplain in Simalaha despite the fact that most networks are functional here. Instead,

residents in Simalaha have no option but to rely on Namibia's more extensive radio broadcasts that disseminate data from their own gauges along the Zambezi River.

6. Recommendations

In the next section, I offer several recommendations based upon my data collection and analysis of local access to formal climate and weather related data, the limits to past and current efforts to enhance formal EWSs, and the existing informal EWSs that support local preparedness and adaptation to disasters. It it my intention for these suggestions to be capable of being incorporated into the ZRCS's ongoing efforts to assist communities in adapting to increased floods and droughts in Kazungula. Additionally, these may be taken into consideration or proposed in future interventions as the ZRCS develops new programs to support local climate resilience.

6.1 Opportunities for Improving Community-Based Early Warning Systems

On the topic of EWSs, despite the number of significant barriers that constrain the dissemination of government forecasts, there still seem to be a number of ways in which interventions could support more robust EWSs at the community level based on this research and my critical reflection. I discuss each of these below in detail.

6.1a Link Existing Gauges and Trained Readers to Local Downstream Communities

First, there are a number of existing gauges and trained readers who are currently providing data to the ZMD and WARMA and who could also be leveraged to provide localized early warnings to communities downstream using either SMS (see suggestions below) or through existing informal communication structures discussed above. There is a gauge at the Kasaya Bridge, for example, that has been operational since 2000, but which does not officially communicate its data with any local communities. River levels are collected three times daily by a dedicated gauge reader and sent to the district headquarters in Sesheke. Though he has taken it upon himself to advise nearby communities on occasion when the Kasaya River reaches dangerous levels, using whatever personal contacts he has stored in his phone's contacts, there are opportunities for the data he collects to be disseminated more broadly.

Based on my interviews, many households in Kasaya did not receive information on water levels from the gauge at the Kasaya bridge. This is because the Kasaya River marks the boundary between the Southern and Western Provinces and the gauge station technically serves the Western Province, with data being collected and sent directly to the provincial headquarters

in Mongu. Although villages downstream in Kasaya are also directly impacted by the river, they are located with the Southern Province's Kazungula District and thus technically outside of the gauge's jurisdiction. This means that even during the devastating 2006 and 2008 floods, households within Kazungula are not provided with data from the gauge on the Kasaya River. Setting up a system for disseminating information across such political and jurisdictional boundaries, would enable existing gauges and data being collected to benefit more stakeholders. Furthermore, according to some interviews, the cellular network and percentage of the population with phones were cited as sufficient for initiating a more formal structure for transmitting warnings by SMS in tandem with traditional mechanisms to downstream communities. A deeper investigation of the actual extent of cell phone coverage in these areas is needed in order to determine if such a system would be possible.

6.1b Add Additional Gauges in Upstream Communities to Establish Clear Lead Times

Even if simple gauges were added along waterways in the headwaters, it would be possible to establish clear lead times between upstream and downstream locations, which would enable people to predict when and how they would be impacted by floodwaters. With a historical record of 16 years at the Kasaya Bridge gauge, it would be feasible to establish specific danger thresholds based on water levels measured during historic floods that could be linked to preventative actions. For example, the gauge reader at Kasaya explained that during the 2006 floods, the river peaked at 7.9 meters, but that whenever the water level reaches five meters, he knows nearby villages will begin to suffer. Leveraging this kind of situated knowledge to mobilize local action would greatly enhance people's capacity to prepare for floods and mitigate their losses.

6.1c Engage At-Risk Communities through Participatory Risk Mapping

Recognizing that residents in Kazungula do not face floods on a consistent basis and are also consumed with the challenges of coping with other climate-induced disasters like droughts, it is necessary to engage at-risk communities in more robust participatory activities to enhance preparedness. This is particularly essential since all interventions initiated after the 2006 and 2008 floods to encourage preparedness and establish EWSs, have since phased out and are no longer functional. One effective way to build this awareness in a way that is not only instructive, but that also involves active community participation in identifying their own vulnerabilities, is through participatory risk mapping (Cadag & Gaillard, 2012; Devkota et al., 2013; Gaillard &

Maceda, 2009; Gaillard & Pangilinan, 2010). Such processes not only allow citizens to actively participate in both planning and agenda setting, but may enable intervening institutions to productively engage their beneficiaries in ways that may inform more effective interventions and policy (Wachinger et al., 2013). This cannot be a reactive strategy to cope with climate change for it to be effective and thus should be executed well in advance to the next major flood.

Through such participatory mapping exercises, facilitators can also initiate a discussion about how this locally-produced picture of risk can be translated into meaningful actions taken by residents to prepare for disasters and mitigate their effects. For example, the community may identify the most flood-prone households located in close proximity to water bodies and also map those homes with particularly vulnerable residents (e.g. elderly individuals, people with disabilities) who would need extra assistance during an emergency. Additionally, participants may locate safe places for evacuation in the upland or identify dangers along the route that residents may have to travel to the road in order to access relief materials. This kind of visual representation of risk can provide the basis for developing concrete community-initiated contingency plans that will enable residents to prepare for and respond to disasters in the absence of state support or until formal assistance arrives.

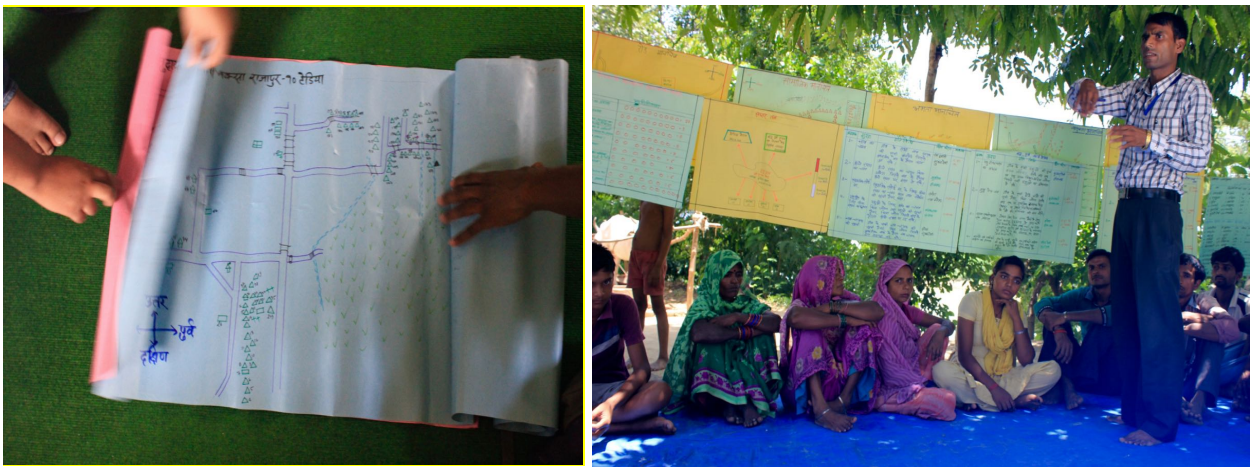

Figure 10. These participatory risk maps and community sensitization meetings offer an example from a community-based early warning system instituted by Practical Action in India and Nepal.

Furthermore, intervening institutions may work collaboratively with at-risk communities to map their exposure during previous disasters. This may help in the establishment of lead times between upstream gauges and downstream communities by linking peak flow rates during a particular known event (e.g. the 2006 or 2008 flood) and the extent of impact experienced in specific communities. Establishing this relationship between water levels and local impacts can

be used to guide a list of specific actions to secure property and resources when a warning is relayed from upstream.

6.1d Formalize a Culturally-Relevant and Practical Communication Structure

Certainly, informal communication strategies already exist for relaying critical information in advance to disasters. However, as residents noted, these systems are not always effective at providing adequate lead times and their informal nature also means that not all stakeholders consistently receive the information. Thus, an intervention informed by more extensive interviews and focus groups with stakeholders in Kazungula communities could determine whether or not a more formal structure for communicating lead times to downstream communities would be useful. My suggestion is not that an intervention should seek to replace, or even inadvertently displace, existing communication strategies that function locally, but rather that there may be ways in which greater formalization—if supported by residents—could enhance existing systems and increase local preparedness across Kazungula.

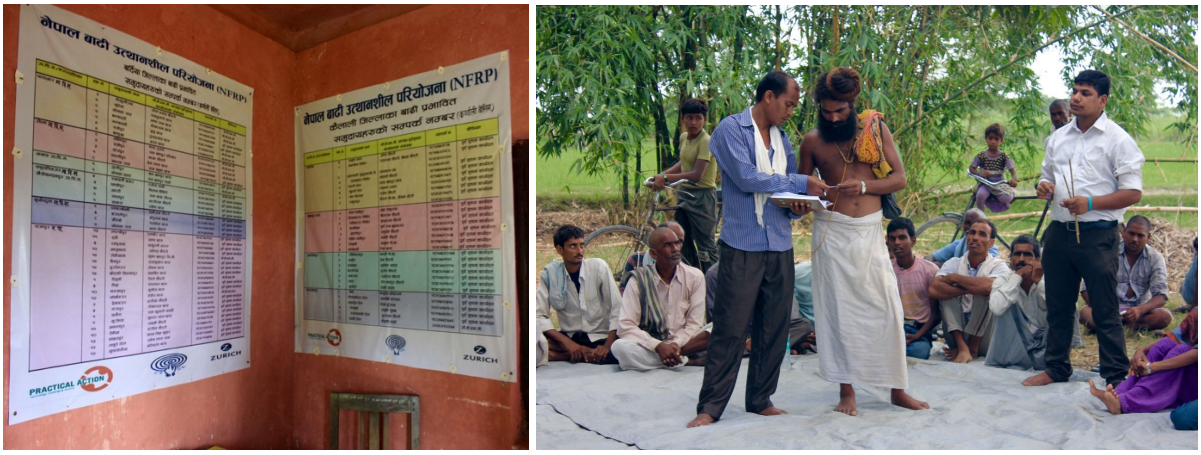

Figure 10. In Nepal and India, Practical Action has developed a formal list of downstream contacts and their updated phone numbers (Image Left), and has also paired individuals in upstream and downstream communities to exchange personal contact information (Image Right).

For example, the current structure for relaying information from communities 15-20 kilometers upstream from Sikaunzwe to households here and further downstream is clearly a nebulous system in which all residents share the responsibility for dissemination. While collective participation in dissemination is resilient in some ways, particularly in a region with unreliable cell phone service and poor access to electricity for charging devices, it also risks failing to reach many stakeholders. Developing a clear list (and back-up list) of key contact people in each community and their cellular numbers, with a communication tree for

dissemination, would greatly improve the effectiveness of existing community-based EWSs at reaching the maximum number of residents. However, for such an intervention to be effective it would have to initially engage communities in a discussion about their perspective on opportunities to support existing communication structures at the local level rather than imposing a top-down scheme for controlling dissemination.

6.1e Partner with Regional Cellular Networks to Provide Early Warnings via SMS

Finally, given that residents throughout Kazungula identified MTN as the most reliable cellular network which currently provides functional service to most of the region, it may be worth establishing a partnership with MTN in order to disseminate early warnings via SMS. The viability of instituting such an EWS will only increase over time as MTN, and potentially other providers like Zamtel and Airtel, install more cellular towers across the region. Additionally, residents described more and more households having a phone due to the growing accessibility of cell phones in terms of cost. All of these trends indicate great potential for reaching massive numbers of people with early warnings either formulated at the national level from data synthesized by the ZMD or by upstream gauge readers who could maintain a list of downstream residents who can receive early warnings by group text.

Setting up such a system would certainly have its challenges and barriers that would need to be considered in consultation with communities. One such example is the need to consider both language barriers, potentially having SMS messages translated and distributed in multiple local languages. Furthermore, high levels of adult illiteracy would also prevent certain individuals from accessing early warnings distributed by text. All of these factors would have to be considered in setting up a system that would effectively reach the widest number of stakeholders.

6.2 Suggestions for Low-Tech Climate Adaptive Strategies

In addition to the recommendations I have listed above targeting EWSs specifically, I also include the following suggestions for climate adaptive strategies that may integrate traditional knowledge with formal intervention. These suggestions are based on conversations with residents and key stakeholders and are specific actions that local residents would like to take, but that in order to do so they require external financial support or technical advice.

6.2a Construction and Deepening of Reservoirs

This climate adaptive strategy to deepen existing and construct additional reservoirs recognizes the dual disasters of floods and droughts that communities across Kazungula face. In

all focus groups and during several stakeholder interviews, residents described that the greatest challenge they face with floods is the haphazard way in which they occur without warning. Furthermore, other than relocation and some basic strategies to secure their crops and property, residents are essentially at the mercy of the floodwaters. Particularly in areas like Sikaunzwe where households are impacted by flash floods, waters advance and retreat rapidly.

Residents, however, recognize an opportunity to transform the disaster of floodwaters into a resource that could actually protect them against the dangers of drought. Many individuals described the need to devise a mechanism that could channel floodwaters into collection ponds that would hold water for an extended period of time. While several reservoirs like this exist in the form of natural wetlands, Kazungula residents seem very interested in deepening these ponds so that they can maintain a water supply for drinking and irrigation well into the dry season.

In Sikaunzwe, for example, I was taken to Nakalonzya Dam near Nduna village to a natural pond on the floodplain. This reservoir, I was told, provides drinking water for both people and livestock until September when it typically dries up. However, due to the clay-like soils on the floodplain that provide a natural seal, if deepened residents were sure that the reservoir would be able to hold water for several months longer and provide significant relief from the increasing number of dry spells experienced locally. Supporting community-initiated adaptive strategies such as this could work to address the dual climate-induced challenges of floods and droughts experienced in Kazungula communities.

Figure 10. Site of the Nakalonzya Dam in Sikaunzwe where residents hope to deepen a natural wetland to store floodwaters and enhance their water security.

6.2b Positioning of Strategic Boreholes to Increase Local Access to Drinking Water

Considering the recent water stress experienced during the past two years of drought, residents expressed the need to increases local access to drinking water through the strategic positioning of boreholes. While some communities have existing boreholes compromised by salt and other minerals, particularly in Sikaunzwe, residents explained that by using local knowledge it would not be difficult to identify appropriate places to sink boreholes. Specific native species like the *munga* and *mubalota* trees serve as indicators of where the ground water is free of salt. Leveraging this place-based knowledge alongside interventions to increase water access could have a significant effect on reducing local water stress.

6.2c Establishment of Local Seed Banks to Preserve Indigenous Drought-Resistant Crops

A final suggestion for a climate adaptive strategy marrying traditional knowledge with formal intervention would be the establishment of local seed banks to preserve the continued use of indigenous drought-resistant crops. In conversations with agriculture extension officers in Kazungula, I learned that as of 10 years ago people had almost completely abandoned growing sorghum and other indigenous drought-resistant crops. Instead, most farmers and small scale gardeners were aggressively switching to different imported crops, particularly hybrid varieties. Part of the reason was that many of these vegetables sold better in the market as consumer preferences changed. This transition to hybrid non-indigenous crops and practice of growing single crops, however, has meant that farmers, especially those dependent on rainfall and without mechanisms for irrigation are increasingly vulnerable to droughts. Furthermore, indigenous crops like sorghum and bulrush are becoming difficult to obtain seeds for. These trends suggest the need to establish local seed banks where indigenous open pollinated varieties can be collected, stored, and germinated in order to ensure that traditional, drought-resistant crops are not lost. Having access to these indigenous varieties may continue to support local adaptation in the face of climate change.

7. Conclusion

Ultimately, while profound barriers restrict the dissemination of formal forecasts and climate information that would enable communities to take early action prior to disasters, there are also significant opportunities to leverage information already available on the ground and use informal communication structures to provide early warnings at the community level. Additionally, by taking seriously place-based knowledge on opportunities to respond to the

localized effects of floods and droughts, institutions like the ZRCS may work collaboratively with communities to identify feasible, low-tech climate adaptive strategies to support residents in adapting to climate change across the Zambezi River floodplain.

In moving forward with interventions focused on climate adaptation in these locales, however, it is important to acknowledge that while both traditional knowledge and modern forecasts each have their role in disaster preparedness and in building climate resilience, for many local communities the luxury of using both in tandem does not exist. Without access to improved forecasts and climate information, the most vulnerable and remote residents are often left only with the knowledge they have been relying on for generations. While in many cases this may be effective, and deserves to be deeply respected, it should also not be romanticized. After all, as community members repeatedly expressed, while traditional knowledge continues to be their most reliable source of information, many still feel that their ability to use environmental indicators to anticipate floods and droughts is becoming more and more difficult with climate change. Farmers in Kazungula, like anyone, ultimately desire the best information available to secure themselves and their property from disaster. Thus, hybrid forms of knowledge that synthesize information from diverse sources—including both radar and cobwebs—may best support adaptation and ensure survival in the face of climate change.

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Sikaunzwe, Kawewa, Kasaya and Simalaha who were so generous with their time and shared so much of their lives with me. I am endlessly grateful!

Figure 11. Data collection with Zumbo Mbambara, Kazungula Branch Volunteer (Image Left) and ZRCS District Project Officer, Emmanuel Mudenda (Image Right).

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10. Appendix

Topic	Sample Prompting Questions
Local Exposure to Climate-Induced Disasters	• What are the most common disasters/extreme weather events experienced in this community? Can you describe them? • How have infrastructure and livelihoods in the community been effected by these climate-induced disasters in the past (e.g. property damage, crop damage, loss of livestock, etc.)? • Have you noticed an increase or decrease in the timing, frequency or intensity of these event(s) in recent decades/years? If so, in what way? [solicit description of patterns witnessed]
Access to and Use of Existing Climate Information/Formal Early Warnings Systems	• To what extent do you trust and/or rely on weather forecasts/climate information to make decisions and plan for disasters? • To what extent do you trust and/or rely on live river level data to avoid flood loss? • How do you access this information [ID sources and technologies]? • Are there certain barriers (social, economic, practical) that prevent you from accessing this information? If so, what are they? • How do you use these forecasts and/or live data? • Are there reasons you choose not to use this information even if it is accessible? • Are you formally enrolled in an early warning system of any type? If so, how? What has been the extent of your participation? • What kind of information, and in what form, would be most useful for guiding your decision making process and for enabling you to be more prepared for climate-induced disasters?
Local Strategies for Climate Adaptation/ Traditional Early Warnings	• Are there traditional ways in which this community has predicted floods, droughts, etc.? If so, how? • Who are these predictions made by? Are they actively practiced today? [If possible, speak with elder members] • How was/is this information shared within the community prior to an event? • How does this community relay critical information among members in the absence of critical infrastructure (e.g. cell phone network)? • How do you prepare for floods, droughts, and other climate-induced disasters? What actions do you take to reduce you/your family's loss from these events? • In what ways have you changed your behavior based on past experiences with disasters to prepare for subsequent floods, droughts, etc.? • How did your (great)-grandparents prepare for floods, droughts, etc.? Were they the same or different than the actions you take today? • Did your (great)-grandparents ever tell stories about particularly large flood events, devastating droughts, etc. and what happened?

	• Do you know of any 'traditional' strategies that people used to use or still use to prepare for and/or repair damages from floods, droughts or other disasters? • How effective have these strategies been during recent events? • Are there any recent modifications to traditional prediction or coping strategies that have been developed locally to limit exposure and prevent losses?