Policy Brief 2

Mapping Climate Risk and Vulnerability in the Zambezi River Basin: Policy Responses for Water – Droughts and Floods

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1 Introduction

The Zambezi River Basin (ZRB), the fourth largest river basin in Africa, is home to about 40 million people. Crossing eight countries that span the southern African sub-continent from the Atlantic to the Indian Oceans (1.37 million km^2), it is the most shared river basin within the SADC region. The main river (Zambezi) and its tributaries, (Kabompo, Lungue Bungo, Luanginga, Cuando/Chobe, Gwayi/Sanyati, Kafue, Luangwa, Manyame/Luenya and Shire) can be divided into 13 sub-basins (World Bank, 2010). Rainfall and runoff vary considerably across the basin, with generally high rainfall and runoff in the north and lower rainfall and runoff in the south.

The ZRB is biologically diverse and includes water-based ecosystems (rivers, catchments, wetlands, lakes, coastal estuaries), productive rangelands and significant forests. It supports a range of livelihoods, predominantly rainfed subsistence, smallholder agriculture and livestock keeping. Whilst the livelihoods of most of the Basin's population depend on natural resources, the economy of the Basin is driven by hydropower, mining and commercial agriculture, with significant contributions from fisheries and tourism. Industries in the Basin depend on the electricity produced by its hydropower plant. While there is significant untapped potential for irrigated agricultural and hydropower development, the Basin suffers from poor infrastructure, high levels of poverty and low levels of human development in general.

Growth – in population, urbanization, economies and infrastructure – will dominate the unfolding story of the ZRB over the next decade and beyond, with a population of 46 million projected for 2025. The six large urban areas (Lusaka, Kabwe, Ndola, Harare, Lilongwe and Blantyre) will continue to grow rapidly. To keep up with infrastructural needs and supply basic services such as clean water, improved sanitation and energy services will be an ongoing challenge.

The rural areas suffer from a lack of access to water, poor health care and limited markets, with constrained, predominantly biomass-based energy resources. The most highly populated sub-basins are the Kafue, Kariba, Tete and Shire River & Lake Malawi/Nyassa/Nyasa.

The impacts of climate change on development are likely to be varied. Climate change is primarily a socio-economic development challenge within a changing climate (Pegram et al., 2011). The key focus will be on managing for energy, food, health and ecosystems around climate and water, particularly the allocation of water, development planning and infrastructure operation. Regional integration and the leveraging of comparative advantage around these important concerns provides a central reason for the development of ZAMCOM, and that improved cooperation between the riparian states will provide an important adaptive response to climate change and disaster challenges. Developing disaster preparedness and managing responses to droughts and floods will be one of the core challenges. Extensive droughts can reduce GDP by several percent. Better access to improved water sources and sanitation will reduce the risks of epidemic diseases linked to droughts or floods.

2 Policy recommendations

Develop and improve beneficial and protective infrastructure in the ZRB, in order to drive higher levels of socio-economic development and activity, thereby increasing the population's development status, with resultant increases in resilience.

Trigger the appropriate responses from early warnings by conveying severe weather warnings within the cultural context in which they must be received. Improve the levels of consultation and education of the targeted communities in order to build the understanding of the specific actions required in the case of early warnings. Provide the early warnings with sufficient accuracy, timeliness and reliability that will instill trust in the message content, these actions will enhance the sufficiency of the required responses.

Improve the capability of communication links throughout the ZRB, which is large and many places are isolated with deficient forms of communication. Overcome these barriers to disseminating extreme weather early warnings and other relevant information by putting in place or improving the levels of technology utilized. Strengthen recognized and trusted pathways of early warning propagation with sufficiently trained people who will interpret the messages according to local cultural affiliations and conditions.

Reduce flooding in urban and peri-urban areas, which will significantly lessen the rate of disease outbreaks in the urban settlements in which human populations are expanding at a rate of 3 – 6% in the region at present. Improvement of sanitation is a simultaneous corresponding requirement as flooding of present facilities is closely linked to outbreaks of diarrhoeal disease such as cholera.

Focus strongly on the health effects of floods during and immediately after the event. The priorities of disaster risk mitigation and response should be to secure supplies of good water quality first before a flood occurs, and then to supply emergency medications, adequate food and shelter and then, as flood waters recede, insecticide-treated mosquito nets (ITNs), in that order. The pathological effects of contaminated water are fast acting, cholera and other watery diarrhoea can kill within hours to days, therefore prevention is imperative and after the fact, speed is of the essence.

Engage in long-term planning and actions against drought vulnerability by creating a cyclic response strategy that seeks to support livelihoods at different times in the different stages of a drought. Avoid creating dependencies and interfering with local markets. It is often cheaper to preserve livelihoods and improve self-reliance than it is to simply provide food aid during and after a crisis. As regional economies develop, conflicts between water allocations to the agricultural and hydropower uses of water will intensify, with significant implications for productivity in the regional economy. Drought risk mitigation requires long-term planning, a multipronged approach and a sustained commitment to changing behavior in the targeted community.

Focus disaster risk mitigation efforts in the most vulnerable areas first. The districts in the southern parts of Malawi and in the far western portions of the ZRB are most vulnerable to flooding. Flood risk mitigation activities should target these areas first. This approach will have the largest impact for the investment. The western, southern and far south-eastern parts of the ZRB are most likely to experience an increase in future drought intensity and frequency.

3 Mapping drought and flooding-related vulnerability in the Zambezi River Basin

Drought and flooding-related disasters have a long history in the ZRB. Although not exhaustive in its data presentation, Table 1 shows that periodic droughts have made life difficult since the beginning of the 20th Century, when population levels were considerably lower (between half and 1 million people). The predominantly rural population of the Basin traditionally depended on native crop types (until maize became a significant feature of the economy). Flood recession agriculture was practiced, with people choosing to live near rivers or tributaries where yields were higher because of greater moisture availability. While the history of regional floods and their effects on rural people has not been well documented, there is considerable local and indigenous knowledge on the subject, and people living in the western part of the basin and the Shire river valley are finely attuned to seasonal changes in water levels.

Road infrastructure in the early days was limited, with a very low penetration of motor vehicles. Malaria, trypanosomiasis (African sleeping sickness) and other tropical diseases took a heavy toll on people and livestock. The Rinderpest outbreak of 1895 destroyed huge numbers of livestock and wiped out people's wealth across the southern and east African regions. Severe droughts and locust plagues were to follow, and the resources of local populations became so depleted that their resilience in the face of difficult environmental conditions was severely compromised.

Despite greater exposure to climate risks as a result of rapid population growth (about 3% per annum), an increase in the general resilience of the population has gone hand-in-hand with the construction of roads and infrastructure, more diverse crop types, economic linkages with towns and the development of the mining industry. Increases in economic opportunities lead to increased resilience, and while large numbers of people are still affected by drought, with malnutrition remaining high across the basin, very few people die as a direct result of drought.

Another factor contributing to the safety of the population of the ZRB has been the construction of major hydropower dams, which has resulted in some stabilisation of river flows. However, the loss of indigenous local knowledge of seasonal river movements and high and low water conditions has also had a negative impact, with rapidly rising flood conditions taking some communities in the lower parts of the Basin by surprise. For example, a notable number of deaths have occurred in the remote rural flatlands of the Caprivi area of Namibia and Botswana, where floods spread rapidly.

Current and recent historical climate risk:

Table 1. Climate-related hazards with the highest impact on people and the economy across the Zambezi River Basin from ca. 1950 to 2011. [To be fine-tuned]

Hazard	Event year(s)	Spatial impact	No. People affected	No. People died	Economic impact
Drought	1907-1920	Regional			Significant duration of low flows below average (World Bank, 2010). Affects flood recession agriculture all along the river, especially in the lower basin
	1983-1984	Zambia, Moz.			Extensive loss of crops (FAO). This drought is associated with an intense El Niño.
	1991-1992	Zambia, Zimbabwe (-1995)	>2 million		Excessive food prices (Lekprichakul, 2008; FAO ; EM-DAT/CRED
	1994-1995	Zambia	1.3 million		(Lekprichakul, 2008; EM-DAT/CRED
	1997-1998	Angola, Zambia			(Lekprichakul, 2008; FAO
	2000-2001	Zambia, Moz.			(Lekprichakul, 2008)
	2002	Zambia			
	2004-2005	Zambia	1.2 million		Extensive crop loss ~ 50% for cereals (Lekprichakul, 2008; EM-DAT/CRED
Floods	1957 - 1958	Regional, lower			Construction of Kariba Dam

	1963 Dec-Feb	Regional			(World Bank, 2010)
	1969 Dec				(World Bank, 2010)
	1970 Dec				(World Bank, 2010)
	1971 Jan				(World Bank, 2010)
	1978 Jan-Mar			45	US$ 62 million (World Bank, 2010)
	1989 Feb				(World Bank, 2010)
	1997	Shire, lower Zambezi			Local infrastructure losses in Caia province, Moz.
	2000	Regional, lower Zambezi	650,000+	81+	Loss of crops, infrastructure (Scudder, 2005)
	2001 Mar	Regional	150,000	81 - 700	US$ 43 million (World Bank, 2010; Artur, 2008) and others
	2003	Caprivi, Kalabo	120,000		Crop losses
	2004 Mar 31	Caprivi	12,000		
	2007 Jan-Feb	Regional	331,000	71	US$ 71 million (World Bank, 2010, Artur, 2008)
	2008 Jan 27	Zambezi R.	80,000+	50	US$ 100 million (World Bank, 2010; Marc, S; 2011)
	2009 Mar	Regional		100+	
	2011	Caprivi	10,000+		Displacement, crop losses and higher food prices (FewsNet)

Future climate risk

Climate change is as evident in Africa as in other parts of the globe (Boko et al., 2007). Mean annual temperatures have increased across southern Africa over the last 40-50 years, and the number of hot days per year has increased whereas the number of cold nights per year has decreased (Boko et al., 2007). Regional climate change projections (Christensen et al., 2007) indicate that southern Africa may warm by between 3.1°C and 3.4°C, with warming of up to 4.8°C possible towards the end of the 21st century. Heat stress events will be more frequent in future (Battisti and Naylor 2009), and it is likely that heat thresholds will be exceeded more regularly. Warming could be higher during late winter and early spring (Hewitson, 2007). Strong warming before the start of the rains and the planting season would significantly reduce soil moisture during this period through high rates of evapotranspiration from plants and soil. Warming also increases evaporation of water from surface bodies such as reservoirs and wetlands, affects crop suitability and biodiversity, and increased frequency and intensity of wildfires.

The southern African region is prone to climatic extremes of prolonged droughts, dry spells during the rainy season, heavy rainfall, severe floods and flash floods (EM-DAT, 2011). There are high levels of inter-annual, inter-decadal and multi-decadal variability, particularly with respect to rainfall, and the frequency and severity of these variations appear to be increasing (Easterling et al., 2000). The results of these trends include seasonal shifts in rainfall, with the timing of the first summer rains becoming less predictable and occurring later than at present. The intervals between rainfalls are likely to become longer, but when they do come, the storms will be more intense and release more rain, especially in mid- to late-summer. These disrupted weather patterns will play havoc with traditional cropping cycles and harvesting practices, contributing to yield losses and exacerbating food insecurity.

Climate change in the ZRB may affect the location of the Intertropical Convergence Zone (ITCZ), which drives much of the variability of southern African seasonal rainfall and temperature. The location of the ITCZ is controlled, in part, by the El Niño Southern Oscillation (ENSO), which is the sea surface temperature atmospheric pressure relationship in the Pacific Ocean. It varies between El Niño and La Niña conditions and is often associated with dry and wet conditions respectively in much of southern Africa, including the ZRB. Global warming could push ENSO towards more frequent El Niño or La Niña conditions, but this is not well understood by climatologists at present.

There is also still much uncertainty over rainfall changes in the summer rainfall regions. However, heavy rainfalls already make up an increasing proportion of total rainfall in the Zambezi River Basin (New et al., 2006; McSweeney et al., 2008). The wetter areas of the region (northern-eastern Zambia and Malawi) are likely to experience increasingly heavy rainfall, along with a higher risk of flooding in late summer. GCM projections indicate a decline in the September-October-November rainfall and more intense rainfall in the December-January-February period. The south-western parts of the Basin (including Zambia, Zimbabwe and smaller parts of Namibia and Angola) are drier and more vulnerable to the effects of climate change. Large changes in annual rainfall are not predicted for the region, however (McSweeney et al., 2008).

However, rainfall is likely to diminish in the west and south of the ZRB, in the headwater catchments of the Zambezi River, in Angola, northern Zambia and parts of Zimbabwe (See Figure 1). Less change is expected in the north and east, although higher rainfall levels are a possibility. These differential changes are likely to multiply variability across the whole river system, reducing dry season flows and exacerbating drought impacts. The smaller changes and higher rainfall in the east and north-east will have relatively little effect on the Zambezi River in its lower reaches. The Shire River system is likely to be affected by increased water levels in Lake Malawi, leading to increased flooding in the most southern parts of Malawi and the Shire River basin (see Figure 3).

Regardless of annual rainfall trends, increasingly long dry periods can be expected across the Basin. Later onset of rains and intense dry spells will result in a shortening of crop growth periods, while increased rainfall variability will affect crop production and livestock health. Some of these effects are already being experienced.

Temperatures across the Basin have increased more than 1°C since 1960. This rise in temperature is more rapid in the dry winter season. Hot days and hot nights (those that exceed the 90th percentile level) have increased by about 12%, mostly in the autumn and summer periods (McSweeney et al., 2008). Temperatures are projected to keep increasing to about 1.2-3.4 °C greater than the current long-term mean by 2060, continuing the trend of increasing numbers of hot days and nights. Temperatures are expected to increase slightly faster in the south and west of the Basin than in the moister north and east (McSweeney et al., 2008) (see Figure 2). Temperature changes will have an important effect on hydrological functioning and water cycles in the western part of the Basin. Higher temperatures mean higher levels of evaporation and lower runoff in the Zambezi River. During drought years, this will lower river water flows. The other effect of increased temperatures will be to reduce crop yields. Some cultivars of maize, for example, while potentially very productive, are also highly sensitive to heat waves.

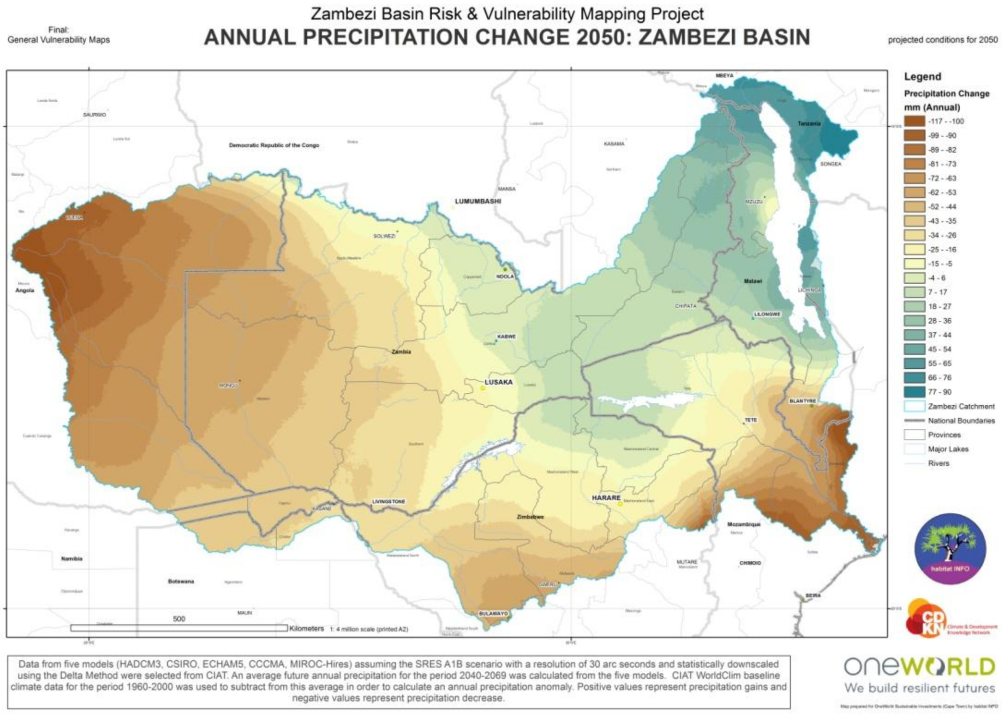

Figure 1. Map of projected annual rainfall changes across the Zambezi River Basin for the period 2040-2069 relative to 1961-2000, using five downscaled GCMs and the SRES A1B scenario. Changes range from decreases in rainfall of up to 117mm per annum in Angola (dark brown), to increases of up to 90mm per annum in Tanzania (dark blue). Davies and Wroblewski, unpublished.

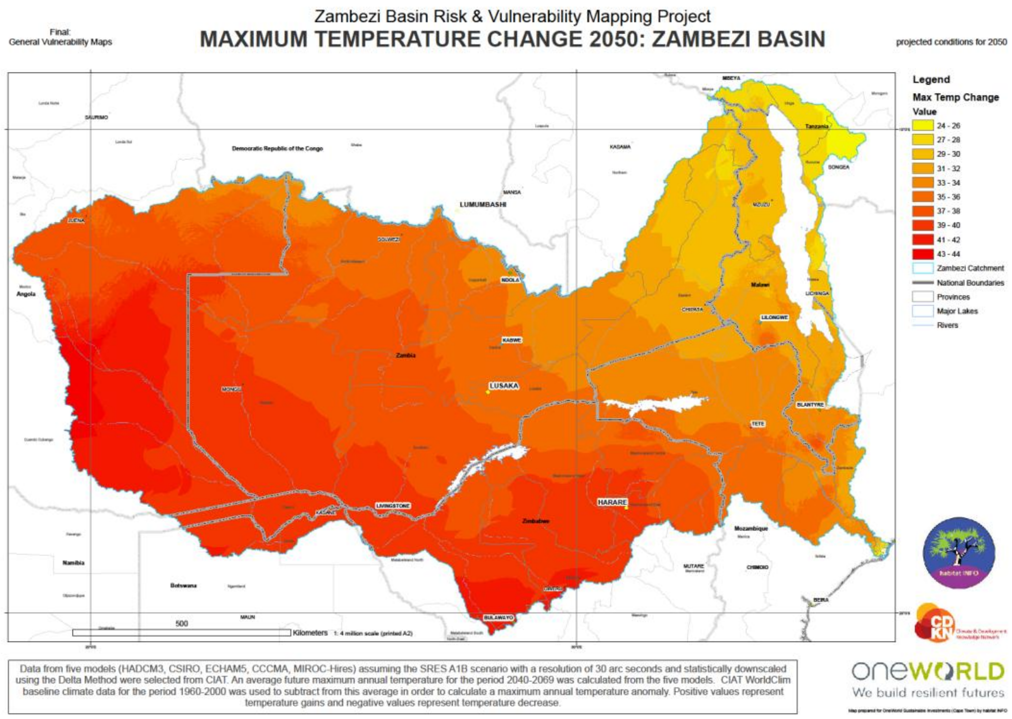

Figure 2. Map of projected changes in mean maximum temperature across the Zambezi River Basin for the period 2040-2069 relative to 1961-2000, using five downscaled GCMs and the SRES A1B scenario. Changes range from increases of 2.4°C in Tanzania (yellow) to increases of 4.4°C in Angola/Namibia/Botswana (dark red). Davies and Wroblewski, unpublished.

Vulnerability in the agricultural sector and the impact of hydropower schemes

The agricultural sector in the southern, central and western parts of the ZRB will become more vulnerable to drought over time, as temperatures increase (See Figure 1 and 2). To the north and east, however, rainfall is less likely to be affected by changes in regional circulation. In the south, soil moisture is likely to be reduced by hotter air. Where too many people occupy and work the land, soil quality will be degraded, making such areas more vulnerable to extreme weather events.

Hydropower generation has long been as synonymous with development in the ZRB. Some 5,000 MW of capacity has been installed in the Basin, spread across 12 installations. Cahora Bassa is the largest of these, generating 2,075 MW, while Kariba generates 1,470 MW, Kafue Gorge Upper generates 990 MW, and other installations produce lesser amounts. More hydropower installations could theoretically be constructed, but these would place even greater demands on water supply (World Bank, 2010). Another developmental pathway is linked to an increase in irrigated agriculture (World Bank, 2010). Future competition between these sources of water demand could result in highlighting the impacts of policy divergence, especially when severe droughts occur, as they will, more frequently (see Figure 1). Evaporation driven by higher temperatures will be another cause of water loss.

Flooding primarily takes place along the riparian zones, but also in the settled areas of the peri-urban and urban environments, where it is a factor in disease outbreaks. Poor sanitation and hygiene then contribute to the occurrence of water-borne diseases, or those diseases in which water is an essential component of the vector life-cycle. There are frequent cholera outbreaks in Lusaka, tied to the rainy season and the intensity of rainfall that leads to standing water, overland flow and flooded pit latrines.

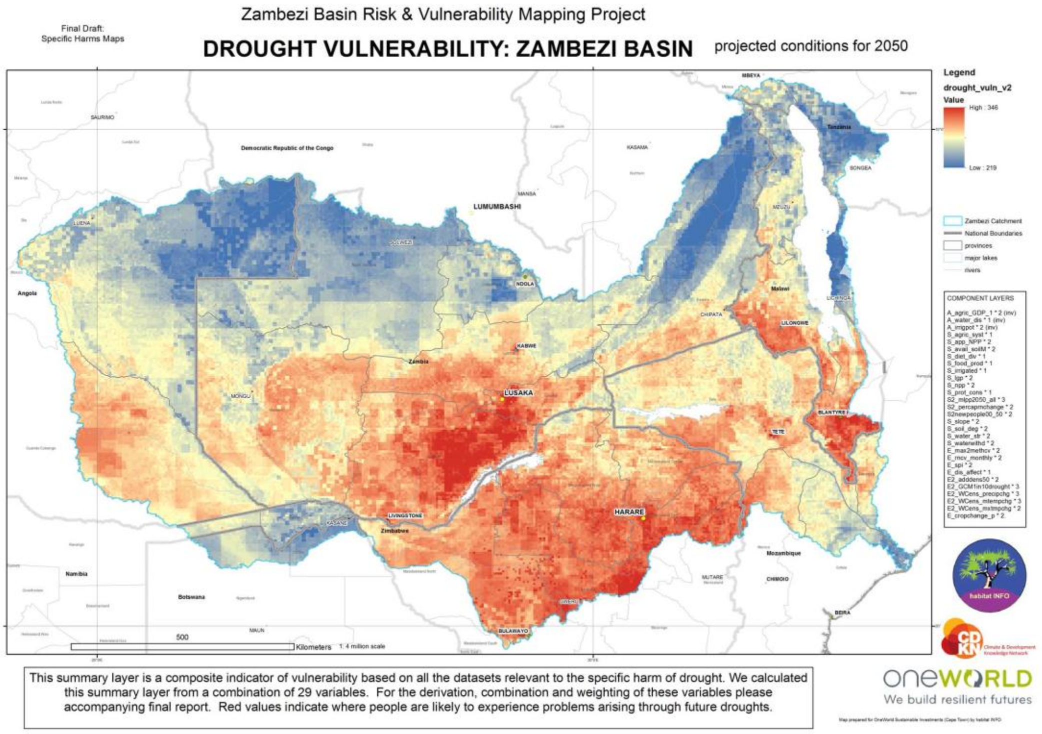

Figure 3. Map of projected future vulnerability to drought across the Zambezi River Basin. Davies and Wroblewski, unpublished.

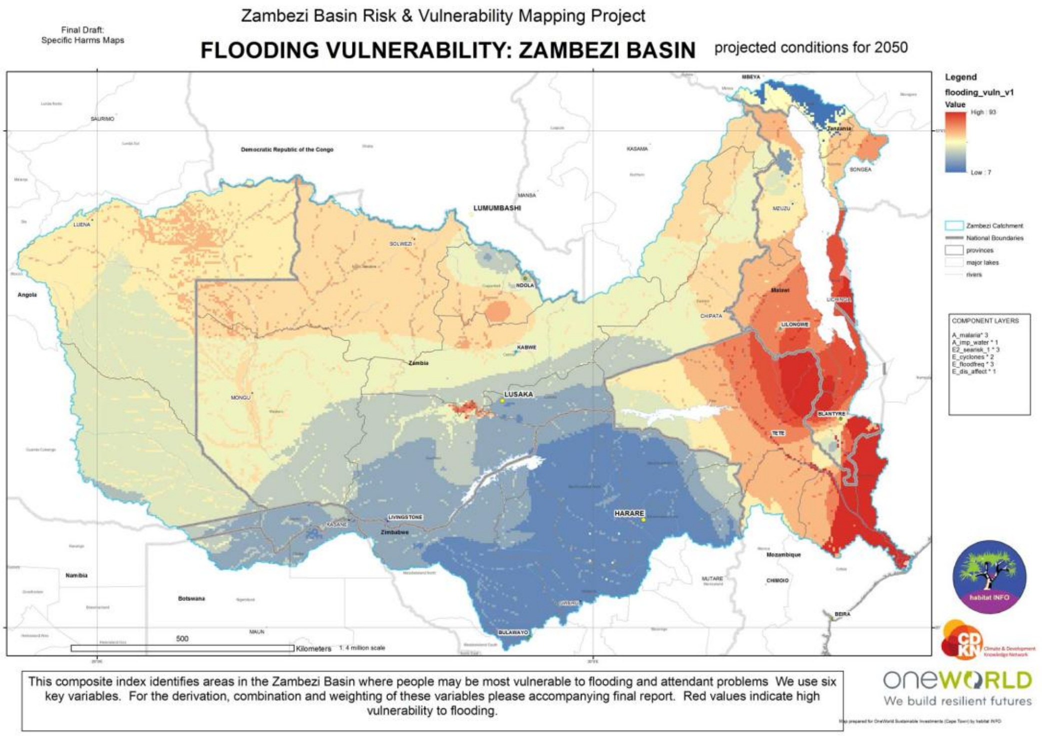

Figure 4. Map of projected future vulnerability to flooding across the Zambezi River Basin. Davies and Wroblewski, unpublished.

4 Basin-wide institutions and policies for water hazards

Institutions:

The ZRB's premier river basin institution, the Zambezi River Basin Commission (ZAMCOM) aims " to promote the equitable and reasonable utilization of the water resources of the Zambezi Watercourse as well as the efficient management and sustainable development thereof." The eight countries that share the river are all signatories ZAMCOM (with the current exception of Zambia). The occurrence of extreme weather and the need to refer to it are clearly referred to in the ZAMCOM Agreement. Article 10 (c (ii)) refers to the need to develop and establish early warning systems to alert stakeholders and communities to imminent dangers posed by imminent extreme weather. The Agreement also makes note of the responsibility to communicate such warnings.

However, in practice, the currently existing institutional framework is not meeting the transboundary needs of the Basin. For example, the synchronisation of flood responses should be one of Zamcom's most crucial functions. Currently, however, the dams on the Zambezi River are not synchronised. Individual dams presently open their floodgates according to their own operating rules and safety requirements, often without taking potential downstream consequences into account, while the lack of adequate communication channels at the local level increases downstream risks.

Present resources that need to be pulled together to meet the transboundary requirements of river basin governance and coordination include implementation of the recommendations of the SADC project on dam releases and flood synchronization, the implementation of a Joint Operations Technical Committee (JOTC), and implementation of a functioning System Operating Forum. While the ongoing roll-out of increased cellphone and satellite coverage is making an important contribution to the improvement of telecommunications across the ZRB, strategies and protocols need to be in place to coordinate institutional cooperation, especially when it comes to preparing for, and responding to, extreme weather events like droughts or floods . These activities need to take place across all scales, from national to local levels of government and societal interactions.

One of the quickest ways of saving lives during a rapid onset disaster is the leveraging of military resources for providing air and land transport. Therefore, disaster event management in the ZRB should have military representatives in which a coordinating function could be supplied. Further, a centrally coordinated response with the necessary means of communication is required. An improved precipitation and flow forecasting system has been recommended by the SWRSD Zambezi Basin Joint Venture (SWRSD-JV, 2010) but this still needs implementation.

Policy framework:

While the various existing SADC regional protocols and strategies relating to water hazards give little information as to what specific actions are required, they do nevertheless indicate the scope for action and provide for freedom of approach and direction. The realisation that disaster risk reduction and response is inherently a transboundary matter is affirmed, and mandates to engage multi-laterally on disaster issues are in place. The SADC Regional Water Policy and the SADC Climate Change Adaptation Strategy for the Water Sector both refer to the means of responding to climate change adaptation requirements. Specifically, the SADC DRR Strategic Plan provides the framework for interlinking regional and global policies and plans regarding both floods and droughts. Specific DRR activities can be carried out within several encompassing policies and plans. The frameworks exist; what is required is to determine specific actions and implementing them.

Table 2: Regional and sub-regional (SADC) policies, plans, strategies, protocols and programmes of action with relevance to climate risk and vulnerability in the water sector, and cross-cutting theme of disaster risk reduction and management. All the ZRB countries are SADC Member States.

Name and status	Relevance to climate risk and vulnerability
Revised SADC Protocol on Shared Watercourses[1] **2003[2]**	Calls for the establishment of shared watercourse agreements and institutions (SWI) to facilitate and coordinate the joint management of shared watercourses. Parties may form river basin commissions, joint water commissions or technical committees, or joint water authorities.
SADC Regional Water Policy **2005**	Provides a framework for the sustainable, integrated and coordinated development of national and transboundary water resources in SADC.
SADC Regional Water Strategy **2006**	A long term planning instrument, implemented nationally through National Water Strategies and regionally through the Regional Strategic Action Plan (RSAP), which addresses transboundary issues, extending over periods of five years.
SADC Climate Change Adaptation Strategy for the Water Sector **2011**	Improving climate resilience in Southern Africa through integrated and adapted water resources management at regional, river basin and local levels
SADC Regional Strategic Action Plan on Integrated Water Resource Management and Development (RSAPIWRM) ***Adopted 2011 for 2011–2015***	The RSAP is designed to provide an effective and dependable framework contributing to poverty reduction, regional integration, peace and security and socioeconomic development. It promotes interventions in three strategic areas: i) water governance, ii) infrastructure development and iii) water management. Within each of these strategic areas the RSAP provides a coherent set of activities to contribute to the achievement of three strategic objectives: i) capacity development, ii) climate change adaptation and iii) social development.
Hyogo Framework for Action (HFA) **2005-2015**	First internationally accepted framework for DRR. Sets out an ordered sequence of objectives with five priorities for action. Focus on building the resilience of nations and communities to disasters; linked to the development and humanitarian agenda. Implemented from global to country levels
SADC DRR Strategic Plan **2006-2010 (under review for up to 2015) POA under development**	Provides a regional framework for coordination and partnerships in disaster risk reduction and management among SADC Member States governments and all partners and stakeholders. Harmonizes the SADC strategy with global and regional frameworks; provides guidance for strengthening of regional and national capacities in disaster risk reduction.

[1] SADC Regional Strategic Action Plan – Integrated Water Resources Management and Development, 2011.
[2] First ratified in 1998; revised in 2003 to reflect the principles adopted in the United Nations Convention on the Law of Non-Navigable Uses of International Watercourses. Signed by all SADC member states in 2000 and entering into force in September 2003 after obtaining nine ratifications.

5 Cooperative risk reduction: droughts and flooding

Early warning systems tend to work much better in theory than they do in practice, and appropriate responses by the recipients are often meager or entirely absent. Where different modes of response are required, matters become even more complicated. Different strategies are required for droughts, for instance, than for floods. Floods are rapid onset events that call for immediate, localized and unambiguous responses, with rapid follow-up support. Response drills can be clearly prescribed and well rehearsed, and a temporary relocation of people, for example, can save many lives. Responding to floods is often a matter of quick and effective decision-making and clear tactical thinking.

Responding to droughts requires longer-range, less immediately actionable strategies. Droughts are creeping events with a large spatial influence. This makes their severity and impact a challenge to quantify, even though they affect more people than any other type of disaster. It is not always easy to distinguish in advance a serious drought from a disastrous one. The point where a drought moves in status from a problem into an emergency is difficult to predict, and the realisation that disaster has struck often occurs long after remedial measures could have been effective. A good example of this is destocking of livestock as a response to drought. Early destocking, or even destocking at the peak of a drought, can be a very effective adaptation strategy, bringing much-needed revenue at a crucial time, and establishing effective levels of self-reliance. Destocking too late, after the animals have lost condition, can result in serious loss of income and resources. Clearly, timeous destocking is far preferable to emergency food programmes as an adaptation strategy, but requires careful planning and good management (Hedlund and Clarke, 2011).

Features of flood management

Cholera and other diarrhoeal diseases: These diseases are a common feature of flood disasters because of surface water contamination by exposed human faeces. In the rapidly expanding urban areas where new settlements are often unplanned and unserviced by acceptable water supplies, sanitation and sufficient stormwater drainage, the risks of contracting diarrhoeal infections is very high. Contaminated water can result in months of crisis for overpopulated localities. There are many such areas in the ZRB.

Where disasters have occurred, rapid surveys of health infrastructure should immediately be undertaken by national disaster response teams. Thereafter, efforts to mitigate the danger of infection by separating potable and contaminated water, and where possible eliminating the latter, need to be prioritized. Subsidies for freshwater storage containers should be considered, and since maintenance of the quality of stored water is imperative, cheap water purification chemicals for use during times of crisis could also be subsidised. Local implementers who are trusted by a community need to receive training in the use of such chemicals.

HIV/Aids and orphaned and vulnerable children: The HIV/Aids pandemic in southern Africa has resulted in many orphaned and vulnerable children. Rapid responses during and immediately after a flood, need to locate these children and remove them to places of safety, which should have been identified previously by local disaster committees. The psychological health of the affected communities needs to be addressed by establishing a level of normalcy as fast as possible, especially through the ongoing education of children.

Risks of returning to flooded areas: People are often quick to return to risky but fertile lowlands where their farms are located, either during a flood event or immediately thereafter, in order to safeguard their assets. This behaviour is difficult to police and control, and should therefore not be discouraged. Instead, it should be anticipated and supported by placing emergency supplies close to where those activities take place.

Features of drought management

Early warning systems: Building community resilience against drought takes time, and requires substantial long-term planning. Early warnings are particularly difficult to develop and manage, given the range of uncertainties that exist, and the high levels of technical infrastructure and expertise that are required. Early warning systems in the ZRB are inadequate, and transboundary meteorological and hydrological monitoring networks and data-sharing between government institutions are insufficiently developed. Another problem is that early warning information tends to be too technical. Another is that, due to lack of expertise, seasonal forecasts are unreliable, and therefore not trusted. Clearly defined triggers that will initiate plans of action are lacking.

The requirements are therefore to improve the quality and accuracy of early warning messages, develop them in terms of understandable actions (which have been planned beforehand), and increase the number of nodes of reception of these communications. Projects around the implementation of hydrometeorological monitoring need to be implemented. The Standardised Precipitation Index (SPI) is a useful tool to measure the progress of a drought, but it requires a reasonable density of reporting raingauges. Given modern cellphone networks and the prevalence of this technology, it is not excessively expensive to install, operate and maintain this technology. Consideration should be given to use of satellite image interpretation, as these technologies can give a good spatial indication on the progress of a drought through measures of vegetation greenness and photosynthetic activity.

Balanced measures: Planning for drought response requires foresight and long-term inter-disciplinary planning. Local economies, livelihoods and practices need to be taken into account. Experience has shown (see Hedlund and Clarke, 2011) that food aid on its own is an inadequate response. It seldom meets humanitarian needs, and may impact negatively on local food markets negatively. Drought responses work best when they include a balanced basket of measures, including cash, water provision, fodder and seeds (during droughts, people consume their seed capital). While the food-first policies of emergency response agencies are easy to understand, they need to be modified towards a focus on protecting livelihoods (Hedlund and Clarke, 2011).

Community responses and strategies: It should also not be assumed that emergency response authorities are always able to accurately predict the real and pressing priorities of the affected people. The misidentification of appropriate interventions is a common feature of disaster relief programmes. It should always be borne in mind that communities have their own drought response strategies and coping techniques, often developed over long time periods. Supporting these may be more effective that trying to launch new strategies. Livelihood preservation is often a much cheaper option than attempting to save lives through food aid (Hedlund and Clarke, 2011). External support might be better directed, for example, to the provision of assistance to markets, the improvement of agricultural technologies, measures to increase trade, or destocking programmes. A good response is to develop a form of "drought cycle management", in which different appropriate inputs and actions take place at different stages through the drought cycle (Hedlund and Clarke, 2011).

Vulnerable groups: Vulnerable groups, especially the very young and the very old, require special attention. For example, a disaster response agency might not fully appreciate the dire situation of elderly people who have sacrificed food to feed infant children. The establishment of Vulnerability Assessment Committees (VACs) have proved successful and this practice should be expanded (Hedlund and Clarke, 2011).

Farm planning: Farm planning needs to be taken more seriously. Experience has shown that expansion of crops into areas to which they are not suited for that crop can lead to very significant losses during drought (Lekprichakul, 2008; IFAD, undated). Remoteness is often a good indicator of vulnerability to drought and potential for food insecurity. Other strategies include: Preserving the resource base by improving soil and water conservation techniques; diversifying crops and including more drought-tolerant cultivars (although there are some counter-intuitive examples of the accelerated failure of the more drought-tolerant species in comparison to more drought-sensitive species during a drought), improvements in infrastructure and early warning systems; diversification of income sources, and improved post-harvest storage. Concentrating on anticipating drought occurrences and developing appropriate responses to them is long process and much of the activity comes down to farm-level and local responses. Increased resilience is developed however by expanding market access, improving communications and promoting efficiency of government responses as well as farming operations.

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