Policy Brief 1

Mapping Climate Risk and Vulnerability in the Zambezi River Basin: Basin-wide Responses

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1 Introduction

This Policy Brief is based on a detailed high resolution spatial mapping of climate risk and vulnerability for the Zambezi River Basin (ZRB). It is the first of four, focusing specifically on Basin-wide policy and institutional responses to the risks posed by climate change, and the need to start planning now.

The ZRB is home to about 30 million people within eight Riparian States, spanning the southern African sub-continent. It is characterised by biologically diverse and productive water-based ecosystems and significant forests supporting many livelihoods, with a predominance of rainfed subsistence, smallholder agriculture and livestock keeping. Whilst agriculture and natural resources support key livelihoods for the majority of the population, the basin economy is driven by hydropower, mining and commercial agriculture.

Significant untapped potential for agricultural and hydropower development exists, but the Basin suffers from generally poor infrastructure, low levels of human development and chronic poverty (SADC, 2005). This will change as investment into the region picks up, driving demand for resources such as water and productive land.

The ability to cope with and adapt to climate change will depend on sustained human and economic development at all levels, including strengthened public health systems. Development will continue to depend on the exploitation of natural resources. Sensitive ecosystems and life-supporting ecosystem services in densely populated areas could come under increasing threat. However, they also provide opportunities for adaptive responses.

Climate impacts in the ZRB will have a strong transboundary character. State entities should therefore balance their sovereign needs against the responsibilities of basin-wide governance. The Zambezi Watercourse Commission (ZAMCOM) has a mandate to focus on emerging trends in the ZRB and how those will affect water resources, social and economic well-being, safety and security, as well asto ensure that environmental flows that will support the ecological functioning of the whole system are maintained.

Strong cohesion and cooperation across the Basin are fundamental, underpinned by policies which integrate climate change and disaster risk reduction and management with sectoral responses from Basin-wide to local levels. Spatially explicit decision support tools can play a vital role in this process.

2 Policy Recommendations

- **Support and continue** high-level dialogue and co-operative governance between ZAMCOM, other shared transboundary water management institutions (e.g. SADC Water, GWP-SA) and Riparian States to ensure policy coherence and investment efficiency across the Zambezi River Basin, taking into consideration differential climate-related risks, vulnerabilities and opportunities.
- **Implement** existing policies, plans, strategies, protocols and programmes (e.g. SADC Climate Change Adaptation Strategy for the Water Sector, 2011; SADC DRR Strategic Plan; NAPAs; Dam Synchronization Project) at regional, national and sub-national levels, taking into account the spatial nature of Basin-wide concerns.
- **Factor in** opportunities for enhanced climate-sensitive spatially explicit adaptation and development planning (e.g. water resource use, land use) into planned strategies and plans and those currently under development (e.g. SADC Climate Change Strategy, CAADP process, National CC strategies and plans).
- **Consolidate and strengthen** basin-wide climate forecast and early-warning systems that reduce and mitigate risk through financial, technological and human resources, and adopt an integrated, coordinated and cooperative response, guided by regional DRR platforms (e.g. SADC DRR Regional Forum).
- **Support** multi-country spatially explicit research to develop a stronger evidence-based understanding of climate vulnerability across the Zambezi River Basin.
- **Give attention** to climate modelling and spatial scenario-based risk assessment, hydrological modelling, impacts monitoring, integration between sectors, regional security, indigenous and local knowledge, cost of damages, and investment trade-offs under various risk scenarios.
- **Develop** ZAMCOM's mandate to guide basin-level climate change responses, in close cooperation with SADC (regional mandate) and Riparian States (national mandate) so as to accelerate investment in and implementation of agreed, urgent and prioritised basin-wide adaptation programmes.

3 Context

The Zambezi Basin is characterized by diverse climate systems, ecosystems and habitat and species diversity, land use systems, social and livelihood systems, and economic strengths and weaknesses. These factors combine with climate exposure to determine the climate change vulnerabilities experienced in different parts of the Basin.

The natural climatic variability of the ZRB affects livelihoods: frequent dry spells, droughts and floods reduce crop yields, give rise to diseases and disrupt household and economic activities. The impacts of fluctuating river flows on hydropower generation (the main source of electricity) are particularly far-reaching because much of this electricity is exported beyond country and basin boundaries.

The region is already chronically short of electrical power and advanced plans for a number of new hydropower installations exist. At the same time, the need to produce more food and cash crops has driven the planning of large irrigation schemes. While the ZRB is well endowed with water, especially in the higher rainfall north, water is not an unlimited resource. Availability is highly seasonal, and during dry periods, river flows can decline by 80% or more (World Bank, 2010).

The ZRB has low runoff efficiency (rainfall-runoff ratio) and a high dryness index. This makes it very sensitive to the impacts of climate change, especially rising temperatures which are virtually certain. Global temperature increases of 2°C (widely regarded as the "safe" level) are likely to result in more severe increases of 3-3.5°C over parts of the Basin. Rainfall projections are less certain, but are likely to vary across the Basin, with the south-western parts generally drying. Substantial abstractions of water both from rivers and dams will be needed, particularly in the southern parts. Nevertheless, longer inter-annual droughts, which the region experiences during multi-year El Niños, could result in substantial shortfalls. The risks of heavy rainfall in some parts of the Basin are likely to increase in late summer, leading to flooding and economic losses. For both dry and wet extremes, hydropower production will need to be maintained to enable the continued functioning of national economies.

4 History of climate risk

Climate-related disasters have historically impacted on the ZRB (see Table 1). Around the beginning of the 20th Century population levels were much lower, populations were concentrated mainly in riparian zones where flood recession agriculture was practiced. Occupants of flood-prone areas (e.g. the western part of the Basin and Shire River valley) have always been well-attuned to seasonal changes in water levels, so relatively few people were harmed by floods. But exponential population growth has led to greater number of people affected by flooding in both rural and urban areas.

In the late 19th century malaria, African sleeping sickness (trypanosomiasis) and rinderpest, coupled with severe droughts and locust plagues, destroyed livestock and denuded the wealth of rural populations, especially in the southern and east African regions, where rural people were on occasion reduced to starvation.

Since then, populations have increased at an average about 3% per year, and modernity has brought roads and rail infrastructure, diverse crop types, access to markets and economic linkages with urban areas. Mining has further increased economic opportunities and added to human resilience, reducing overall vulnerability to extreme climate events. Nevertheless, large numbers of people are still affected by these events. While few die from the direct effects of drought, hunger and malnutrition remain high across the basin, indicating a widespread and chronic lack of food security.

While the big hydropower dams (Kariba, Cahora Bassa etc.) have stabilised river flows and thereby increased human safety, the loss of local knowledge and seasonal practices has sometimes led to increased vulnerability to flooding. Rapid flooding now take more people by surprise, especially in remote rural areas where communications are difficult, leading to unnecessary deaths such as those recently suffered in the Caprivi area of Namibia and Botswana.

The 'key elements of climate-related harm' currently experienced in the Basin are shown in Table 1. Droughts and floods are harms across the Basin, and problems of seasonal changes and disease are also widespread. The central parts of the Basin suffer periodically from heat stress. Coastal harms (storms/cyclones, sea level rise) have serious consequences in Mozambique.

Table 1. Key climate elements of climate harm identified for different regions of the Zambezi River Basin by stakeholders present the Harare workshop, November 2011. The harms are listed in order of considered importance.

Basin/country	Key harms
Basin-wide	Droughts, floods, seasonal changes, disease, heat stress
Zambia	Droughts, floods, seasonal changes, disease, heat stress
Zimbabwe	Droughts, floods, seasonal changes, disease, heat stress
Malawi	Droughts, floods, seasonal changes, disease
Mozambique	Droughts, floods, storms/cyclones, sea level rise

Given the above, it is clear that the evolution of vulnerability changes slowly with time. The currently developing global climate change crisis will exert its impacts through the complex overlays of future conditions on historical and current biophysical conditions/harms and socio-economic trajectories (especially population growth), mitigated by ecological, human and economic resilience and coping mechanisms.

Table 2. Climate-related hazards with the highest impact on people and the economy across the Zambezi River Basin from 1900 to 2012. The table is not exhaustive in its data presentation, but merely illustrative.

Hazard	Event year(s)	Spatial impact	No. People affected	No. People died	Reference/comments
Drought	1907-1920	Regional			Significant duration of low flows below average (World Bank, 2010). Affected flood recession agriculture all along the river, especially in the lower basin.
	1983-1984	Zambia, Moz.			
	1991-1992	Zambia, Zimbabwe (-1995)	>2 million		Excessive food prices (Lekprichakul, 2008; EM-DAT, 2012)
	1994-1995	Zambia	1.3 million		Lekprichakul, 2008; EM-DAT, 2012
	1997-1998	Angola, Zambia			Lekprichakul, 2008
	2000-2001	Zambia, Moz.			Lekprichakul, 2008
	2002	Zambia			
	2004-2005	Zambia	1.2 million		Extensive crop loss ~ 50% for cereals (Lekprichakul, 2008; EM-DAT, 2012
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 loss (World Bank, 2010)
	1989 Feb				World Bank, 2010
	1997	Shire, lower Zambezi			Local infrastructure losses in Caia district, Mozambique
	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, 2011) 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, 2011)
	2008 Jan 27	Zambezi R.	80,000+	50	US$ 100 million (World Bank, 2010; Marc, 2011)
	2009 Mar	Regional		100+	
	2011	Caprivi	10,000+		Displacement, crop losses and higher food prices (FewsNet)

5 Future climate risk of the Zambezi River Basin

Temperatures are already increasing across southern Africa (Boko et al., 2007). Further warming will likely be more than 1°C by mid-century and 3°C or more towards the end of the century (Christensen et al., 2007), bringing with it greater risk of heat stress. 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; Fig. 1). Strong warming before the start of the rains and the planting season would signific antly 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 rivers, reservoirs and wetlands. Loss of crop suitability and biodiversity, increased wildfires. increased heat stress in humans and livestock, may result, especially in the Angolan basin, Western and Southern Zambia and western and central Zimbabwe.

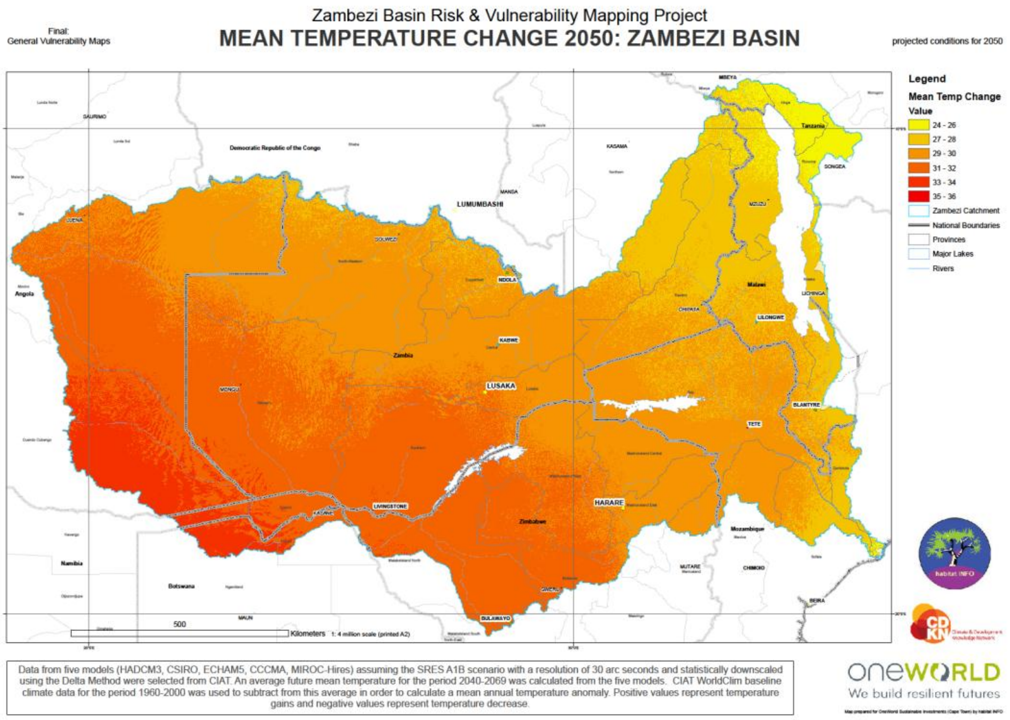

Figure 1. Map of projected changes in mean annual temperature across the Zambezi River Basin for the period 2040-2069 relative to 1961-2000, using five downscaled GCMs and the SRES A1B scenario. Changes range from increases of 2.4°C in Tanzania (yellow) to increases of 3.5°C in Angola/ Namibia/ Botswana (dark red). The circle depicts the area of Case Study 2 below. Davies and Wroblewski, unpublished.

The southern African region is prone to increasing climatic extremes of prolonged droughts, dry spells rainy season dry spells, heavy rainfall and floods (EM-DAT, 2012; Easterling et al., 2000). Rainfall changes remain uncertain, but heavy rainfalls, particularly in late summer, already make up an increasing proportion of total rainfall in the ZRB (New et al., 2006; McSweeney et al., 2008). Northern-eastern Zambia and Malawi will likely be wetter, with higher flooding risks (Fig. 2), offset by dryer spring seasons and longer dry spells. The south-western areas (parts of Angola, Namibia, Botswana, Zambia and Zimbabwe) are drier and more vulnerable to the effects of rainfall change; stronger reductions are expected here (Fig. 2). Changes in rainfall amounts and distribution disrupt traditional cropping cycles and farming activities, contributing to crop losses and food insecurity. Both floods and droughts bring diseases, many of them water-borne, such as cholera and diarrhea.

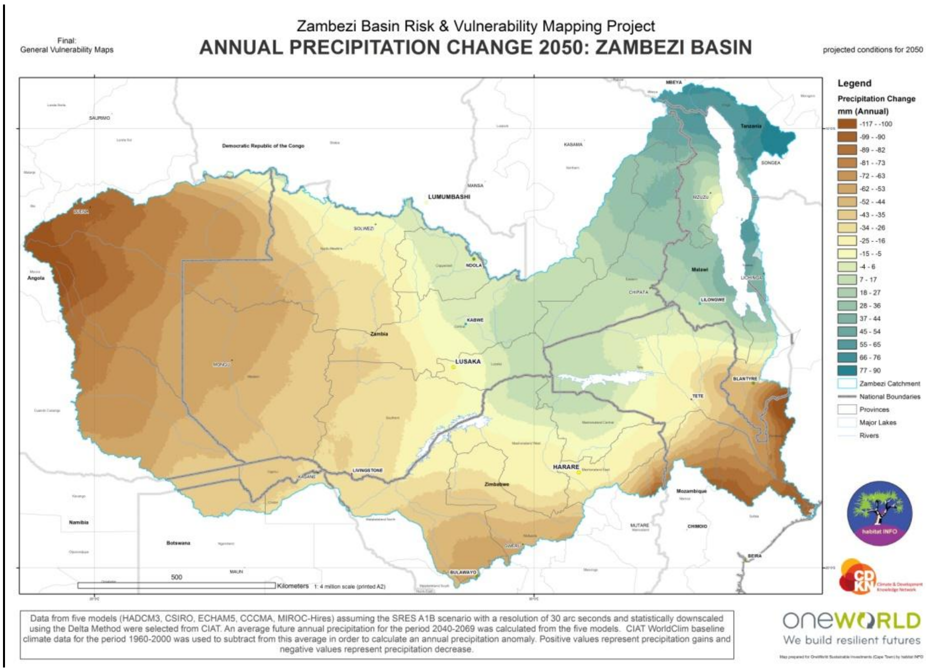

Figure 2. Map of projected annual rainfall changes across the Zambezi River Basin for the period 2040-2069 relative to 1961-2000, using five downscaled GCMs and the SRES A1B scenario. Changes range from decreases in rainfall of up to 117mm per annum in Angola (dark brown), to increases of up to 90mm per annum in Tanzania (dark blue). The circles depict the areas of Case Studies 1-4 below. Davies and Wroblewski, unpublished.

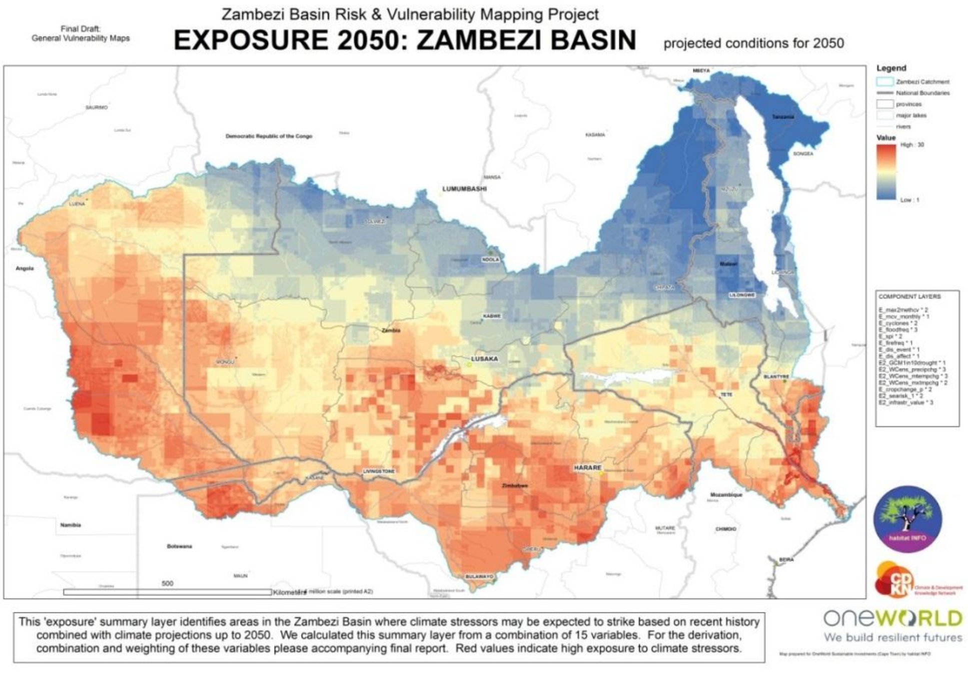

Figure 3. Summary map of projected exposure to climate stressors across the Zambezi River Basin for ca. 2050, based on 16 indicator data layers. Source: Davies and Wroblewski, unpublished.

6 Mapping current and future climate vulnerability

Risk and Vulnerability (R&V) mapping provides a spatial understanding of the impacts of climate change. For example, vulnerable 'hotspots' in the Zambezi River Basin (ZRB) have been identified for present (Fig. 4) and future (Fig. 5) timeframes, using a composite index of vulnerability derived from 64 data layers. These layers, inter alia, map infrastructure poverty, economic wealth, malnutrition amongst children, incidence of disease, gender inequality, soil degradation, people living in water stress, forest loss etc. (Davies and Wroblewski, unpublished; Midgley et al., unpublished), combined in a structured manner with climate exposure (Fig. 3).

Geographically distinct differences in climate risk and vulnerability should inform the nature and prioritization of adaptation responses. Adaptation planning needs to ensure that the focus is trained on parts of the Basin where people are likely to be most vulnerable to the major anticipated difficulties associated with climate variability and change (notably food security, damage to ecosystem services, water shortages, climate disasters and associated health problems).

While the climate R&V maps and analysis do not suggest exact locations of interventions, or propose specific adaptation options, they provide a very useful geographical guide and starting point for Basin-wide dialogue towards building consensus around options and priorities. GIS-based climate change vulnerability maps are a powerful tool in a toolbox of approaches to assist with the process of translating science into strategy, policy, planning and finance readiness in the Basin.

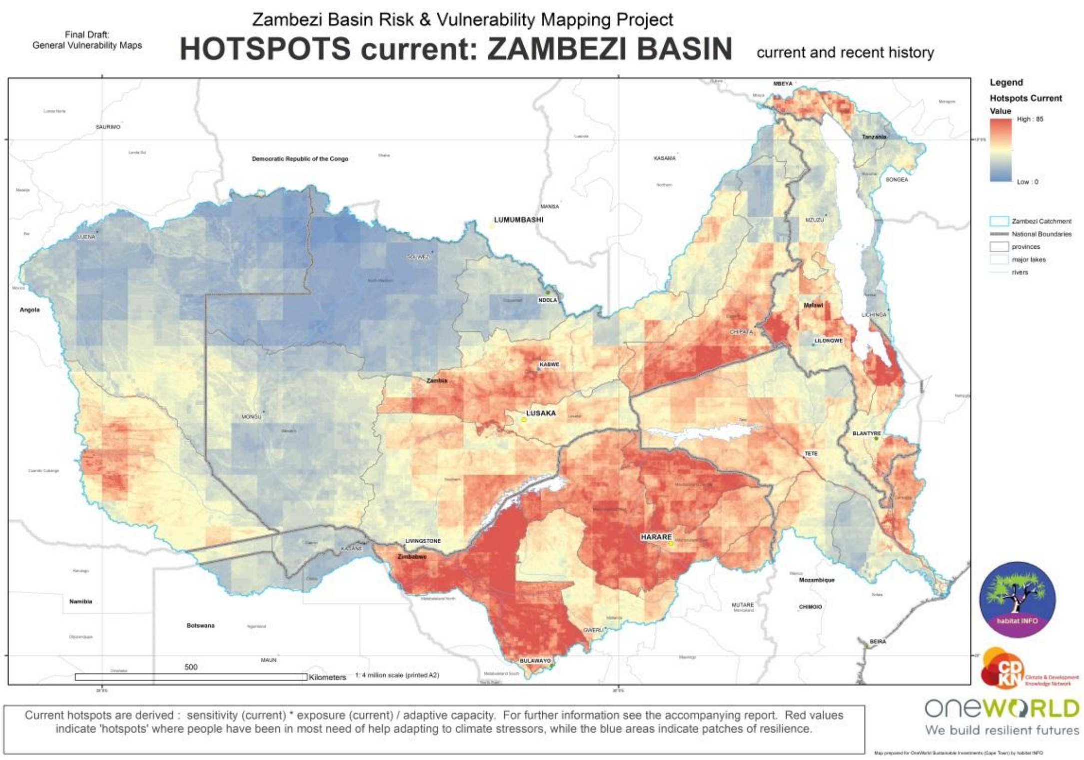

Figure 4. Map of current climate vulnerability hotspots across the Zambezi River Basin. Red areas indicate hotspots where people are most likely to be most in need of help adapting to climate stressors, while the blue areas indicate areas of resilience. Source: Davies and Wroblewski, unpublished.

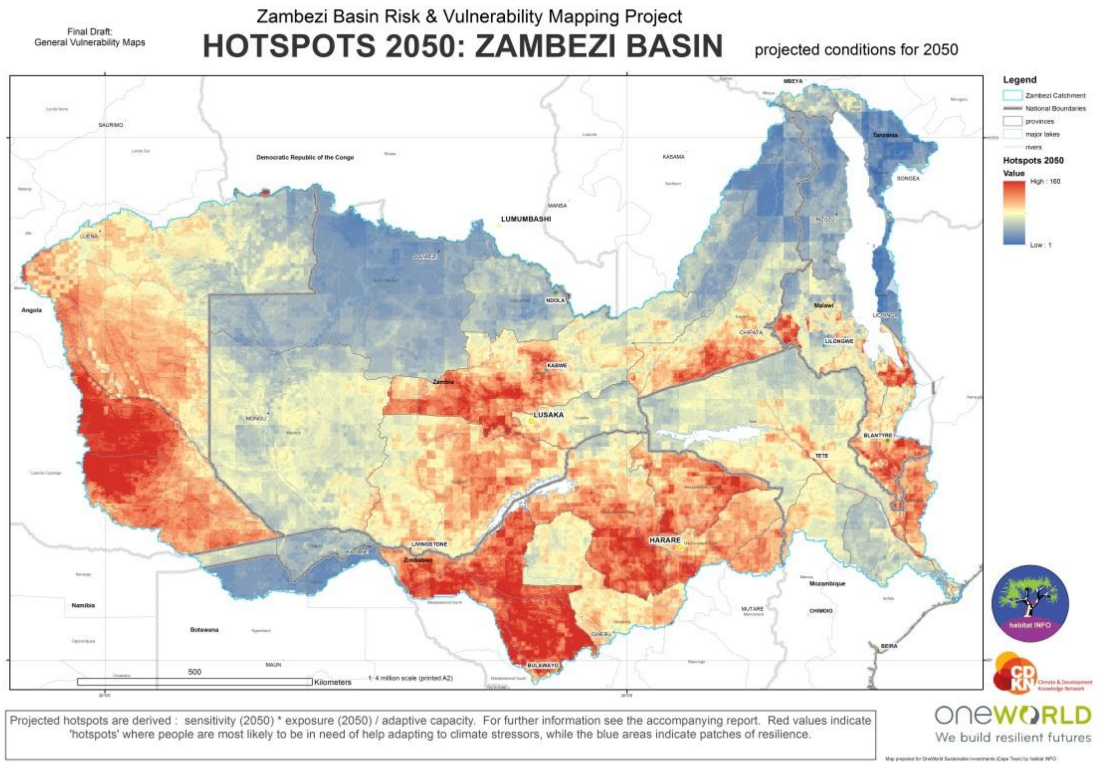

Figure 5. Map of future (ca.2050) climate vulnerability hotspots across the Zambezi River Basin. Red areas indicate hotspots where people are in future most likely to be most in need of help adapting to climate stressors, while the blue areas indicate areas of future resilience. Source: Davies and Wroblewski, unpublished.

7 Key messages from the results

Vulnerability hotspots in the south-central parts of the Basin (south-central Zambia, central and northern Zimbabwe) and the lower Shire/lower Zambezi area are likely to persist and intensify with climate change and continued population growth. Hotspots in north-eastern Basin areas (eastern Zambia, central and northern Malawi) appear likely to benefit from less negative climate futures although areas with high population densities could remain vulnerable. New vulnerability hotspots are projected to arise in the western part of the Basin (south-east Angola, western Zambia) due to rainfall reductions and strong warming.

Spatially explicit economic and land use planning at basin, national and sub-national levels should factor in areas of differing exposure and vulnerability. For example further agricultural and hydropower developments should proceed with great caution in areas of future high risk and vulnerability, such as the Kafue Flats and Southern Province of Zambia, parts of central Zimbabwe, southern Malawi and the lower Zambezi area in Mozambique. Other more resilient areas, such the northern parts of the Angolan basin area, the Copperbelt, adjacent Northwest Province of Zambia, and northern Malawi could, however, support increased development. This will rely on improved infrastructure and accelerated socio-economic development, whilst ensuring sustained flow of ecosystem services. Thus, difficult trade-offs will need to be considered.

Management of the shared water resources of the ZRB under conditions of climate change will become central to basin-wide cooperation and climate change response strategies. Differential climate changes and vulnerabilities within the ZRB should inform integrated water resource management and adaptation planning at all spatial scales, with transboundary and basin-level planning, management, monitoring and data sharing becoming particularly important. Countries containing the more resilient catchments (Angola, Zambia, Malawi) have a basin-wide responsibility to manage these catchments wisely in order to secure the bulk of future basin water resources. Equally, countries containing vulnerable catchments should assess their water-based development planning with great care. Basin-level research, dialogue and agreements at political and technical levels should increasingly factor in spatially explicit future climate scenarios and vulnerability to inform multi-national decision making.

8 Institutional and policy support

Strong adaptive institutions are essential for dealing effectively and flexibly with the expected impacts of climate change and the policy and governance responses which will be required to confer greater resilience to regions with high vulnerability. Africa (and Southern Africa) with its various transboundary river basins has, in many respects, been a world leader in getting to grips with the cooperative and integrated management of shared watercourses (e.g. Revised SADC Protocol on Shared Watercourses, 2003, Table 3), notwithstanding the political difficulties often encountered. The water sector in Southern Africa has also taken the lead in developing a sectoral climate change response strategy (SADC Climate Change Adaptation Strategy for the Water Sector, 2011, Table 3). This progress has been made possible through multi-stakeholder sectoral platforms and dialogue over many years, supported by key institutions such as AMCOW (African Ministerial Conference on Water) and Global Water Partnership Southern Africa (GWP SA), and donors such as GIZ. Most recently, the establishment of the Interim ZAMCOM Secretariat (IZS) and other ZAMCOM organs ensures that a well-positioned and mandated institution is at hand to guide and help implement the climate change response for the Zambezi River Basin.

The acknowledged importance of water resource and benefit sharing and a basin-level approach to Integrated Water Resources Management (IWRM) were key drivers for the development of a River Basin Organisation (RBO) for the Zambezi River Basin, the Zambezi Watercourse Commission (ZAMCOM) (Box 1). The ZAMCOM Operationalisation Plan (ZOP) has as its primary objective “To promote the equitable and reasonable utilisation of the water resources of the Zambezi Watercourse as well as the efficient management and sustainable development thereof”. This will be achieved through the development of the Strategic Plan (ZAMSTRAT) and the implementation of priority projects. The ZAMSTRAT Framework specifies four challenges as the basis of its strategic objectives:

- Integrated and coordinated water resources development;
- Environmental management and sustainable development;
- Adaptation to climate variability and climate change, and;
- Basin-wide cooperation and integration

It is hoped that the Zambezi Basin Risk & Vulnerability maps and analysis will give early impetus to the development of robust science-based information around the impacts of climate variability and climate change in the Basin and required adaptation responses, in support of the ZAMCOM objectives. In addition, they should inform new strategies, policies and programmes currently under development not only for the Basin and SADC region, but also for Africa as a whole, for example the SADC Climate Change Strategy and the AMCOW-led Climate Water and Development Programme for Africa. Lessons learnt in the application of the Zambezi mapping products for policy and programmatic development should be documented to inform similar approaches for other transboundary river basins across Africa and beyond.

Beyond the water sector, the Zambezi climate R&V maps and analysis carry important messages for the following sectors and cross-cutting areas and their institutions: agriculture and food security (e.g. SADC FANR, NEPAD), energy (e.g. SAPP, SADC Energy), health (SADC Health), environment (SADC FANR, AMCEN), infrastructure, development planning, disaster risk reduction (SADC DRR), and gender (key policies shown in Table 3). The development of strategies and policies in these sectors/areas would equally benefit from a spatially explicit analysis and interpretation, leading to stronger policies and more effective interventions and investments under changing climatic conditions. A strong ethic and policy of cooperation between these various stakeholders will be required to ensure coherence in policy objectives.

Box 1: The Zambezi Watercourse Commission (ZAMCOM)

Countries: Angola, Botswana, Malawi, Mozambique, Namibia, Tanzania, Zambia and Zimbabwe

Following a protracted process initiated in 1987, a draft ZAMCOM Agreement was developed by the Riparian States in 1998, but this process was then superceded by a process involving all SADC Member States, which resulted in the Revised SADC Protocol on Shared Watercourses, ratified in 2003. In October 2001, the ZACPRO6 Phase II Project was launched with the aim to establish the national and regional enabling environment for strategic water resource management through ZAMCOM; establish water resources management systems; and develop an integrated water resources management strategy and implementation plan (this was achieved in 2008). The draft ZAMCOM Agreement was revised and signed by seven of the eight riparian countries in July 2004, and finally came into force in June 2011 after six countries had ratified. Since then, the Interim ZAMCOM Secretariat (IZS) has been established and is hosted in Botswana. The SADC Secretariat provides technical support within the ZAMCOM governance structure.

Source: Based on SADC ICP website (www.icp-confluence–sadc.org/rbosummary)

Table 3: Regional and sub-regional (SADC) policies, plans, strategies, protocols and programmes of action with relevance to climate risk and vulnerability based on the vulnerable sectors (water, agriculture, energy, health) and cross-cutting themes (disaster risk reduction and management, gender). 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
New Partnership for Africa's Development (NEPAD)/ Comprehensive Agricultural Development Programme (CAADP) **2003**	Agricultural programme of NEPAD; aims to eliminate hunger and reduce poverty through agriculture. Established by the African Union assembly, CAADP focuses on improving food security, nutrition, and increasing incomes in Africa's largely farming based economies. Implemented at sub-regional and national levels
AUC-NEPAD Agriculture Climate Change Adaptation-Mitigation Framework (AU-NEPAD Agric-CC Framework) **(to be finalised and endorsed)**	Designed as an agriculture-climate change strategic tool to build capacity and address aspects of alignment, coherence and harmonization amongst programs. Will help African countries and RECs define and determine their agendas on agriculture-climate change and build informed and decisive leadership and responsibility.

[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.

SADC Regional Agricultural Policy (RAP) **(to be finalised and endorsed)**	Intended to provide a legally binding instrument to stimulate sustainable agricultural development and food security in the SADC region.
SADC Energy Protocol **2008**	Member states are to 'use energy to support economic growth and development, alleviation of poverty and the improvement of the standard and quality of life throughout the region' and 'ensure that sectoral and sub-sectoral regional energy policies and programmes shall be in harmony with the overall policies and programmes of SADC and with the strategies and programmes of other SADC sectors.' Integration of water, climate change and broader environmental aspects of energy that may impact upon the social and economic development of the region.
SADC Health Protocol **1999**	Promotes co-operation and harmonisation in addressing health problems and challenges facing Member States through effective regional collaboration and mutual support. It includes provisions for the promotion of health education, development of information systems, measures for treatment of HIV/AIDS, epidemic preparedness including communicable and non communicable diseases, utilisation of health personnel and facilities within SADC, work with external partners such as UNICEF, harmonisation of policies, collaboration with other SADC sectors.
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.
SADC Protocol on Gender and Development **2008**	Provides for the empowerment of women, to eliminate discrimination and to achieve gender equality and equity through the development and implementation of gender responsive legislation, policies, programmes and projects; to monitor and evaluate progress made by Member States towards achieving gender equality and equity; to deepen regional integration, attain sustainable development and strengthen community building.
National Adaptation Programmes of Action (NAPAs) under the UNFCCC **various**	Provide a process for Least Developed Countries (LDCs) to identify priority activities that respond to their urgent and immediate needs to adapt to climate change – those for which further delay would increase vulnerability and/or costs at a later stage. Implemented at country level by Least Developed Countries (all Basin countries except Botswana, Namibia, Zimbabwe). NAPAs have been submitted by all Basin LDCs except Zimbabwe.

9 Cooperative risk reduction

Managing the freshwater impacts of climate change is a socio-economic development challenge within a changing climate (Pegram et al., 2011). The key focus will be on development planning and infrastructure operations which optimise resource development (particularly water) for energy, food security, health and ecosystem services under an evolving climate. Regional integration and the leveraging of comparative advantage around these important concerns are central objectives of ZAMCOM (and other basin-relevant institutions), and constantly improving cooperation between the riparian states will provide an important adaptive response to climate change.

Adaptation will firstly be required at different scales, from individual and community scales, through meso-scales of local catchment and provincial institutions that manage local infrastructure, to the macro-scales of institutions that create and operate the policy, legal and strategic frameworks and allocation of resources. Therefore, there will be certain requirements if these objectives are to be met, including adaptation in the face of uncertainty. Adaptations need to be fostered at higher levels in the cooperative governance structures, which are better able to direct institutional and financial support in ways that creates the adaptive natural resources environment, but which includes the important aspect of mitigating risk and reducing vulnerability.

One of the most important problems that need to be addressed will be that of flexible water allocation regimes, given the inherent uncertainties that exist in climate projections and socio-economic developmental pathways, but particularly when it comes to those extreme climatic conditions which require key policy choices. For example, during a severe drought competition for water could arise between the different sectors, between rural and urban water needs, and between countries. Basin-level strategic planning and sufficient institutional capacity will be required for flexible decision making.

The issue of flooding and the exposure of vulnerable people to this hazard is a core concern. Ensuring the safety of people through co-ordinated releases of water from the major hydropower storage dams also impinges on electricity demands, agricultural production, environmental flows and dam safety. The issue of avoiding flood risks is closely tied, and interlinked with, operational issues in other socio-economic sectors. To effect this, the Zambezi system requires short-term forecasts of flows at key points, for example through the 5-day guidance forecasts of extreme weather (regional storms) provided by the Regional Specialist Meteorological Centre (RSMC). Integration and communication between various basin-relevant early warning systems is crucial for reducing disaster risks.

Last but not least, the appropriate financial support will be required at all levels of basin governance. Sufficient funding of what is seen to be a slow-onset problem could prove problematical because funders often demand quick pay-offs. By anticipating certain problems early, and by clearly identifying where there are multiple benefits to a solution, the principles of IWRM will be achieved (Euroconsult Mott MacDonald, 2007) and likelihood of support will be increased. By putting planning and management systems in place that deal more effectively with the impacts of extreme conditions, both flooding and drought, a measure of no-regrets, low regrets investment can be achieved that has a higher chance of stimulating increased accumulated net flows of funding and benefits into the future.

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