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RESILIENT WATERS PROGRAM

Final Report

Cyclone Idai in the BuPuSa transboundary river basins of Mozambique and Zimbabwe:

Impacts, mitigation & community resilience

December 2020

Prepared by the Centre for Applied Research with Hatfield Consultants Africa

for Resilient Waters Program

CENTRE FOR APPLIED RESEARCH

Hatfield

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DISCLAIMER: The authors' views expressed in this publication do not necessarily reflect the views of the United States Agency for International Development or the United States government.

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Abbreviations

ACP	African, Caribbean, and Pacific
AfDB	African Development Bank
ARA	Regional Water Center
BBB	Build Back Better
BRB	Buzi River Basin
BUPUSA	Buzi, Pungwe and Save River Basins
CAMPFIRE	Communal Area Management Program for Indigenous Resources
CAR	Centre for Applied Research
CBNRM	Community Based Natural Resource Management
CCA	Climate Change Adaptation
CENOE	Regional Emergency Operation Centers
CERP	Cyclone Emergency Recovery and Resilience Program
COE	Center for Emergency Operation
CPU	Civil Protection Unit
CRG	Core Response Group
CRIDF	Climate Resilience Infrastructure Development Facility
DCP	Department of Civil Protection
DMF	Disaster Management Fund
DNDRH	Directorate of Water Resources Management
DRM	Disaster Risk Management
DRMC	Disaster Risk Management Committee
DRR	Disaster Risk Reduction
DSS	Decision Support System
DTM	Displaced Tracking Matrix
EBA	Ecosystem Based Adaptation
ECDPC	European Centre for Disease Prevention and Control
EMA	Environmental Management Agency
ERG	Extended Response Group
ESA	European Space Agency
EU	European Union
EWS	Early Warning System
GACOR	Reconstruction Coordination Office
GAR	Global Assessment of Risks
GBV	Gender-Based Violence
GDFRR	Global Facility for Disaster Risk reduction and Recovery
GDP	Gross Domestic Product
GEE	Google Earth Engine (GEE)
GEF	Global Environmental Facility
GIS	Geographical Information System
GNP	Goronso National Park
GoM	Government of Mozambique
GoZ	Government of Zimbabwe
GRI	Global Risk Index
GRD	Ground Range Detection

HCA	Hatfield Consultants Africa
HIV/AIDS	Human Immunodeficiency Virus & Acquired Immune Deficiency Syndrome
ICP	International Cooperating Partners
IDP	Internally Displaced Person
IFRC	International Federation of Red Cross & Red Crescent Societies
INFORM	Index for Risk Management
INAM	National Institute of Meteorology
INGC	National Institute for Disaster Management
IOM	International Organization for Migration
LIMCOM	Limpopo Watercourse Commission
MAR	Mean Annual Runoff
MICOA	Ministry of Environment
MHCC	Ministry of Health and Child Care
MPD	Ministry of Planning and Development
MSIOA	MultiSectoral Investment Opportunity Assessment
MT	Metric Ton
NB(A/S)	Nature-Based (Adaptation/Solution)
NCPC	National Civil Protection Committee
NCPF	National Civil Protection Fund
NGO	Non-Government Organization
NP	National Park
NSA	Non-State Actors
NDWI	Normalised Differential Water Index
OCHA	(United Nations) Office for the Coordination of Humanitarian Affairs
OECD	Organization for Economic Cooperation & Development
OKACOM	Permanent Okavango River Basin Water Commission,
PA	Protected Area
PC	Per Capita
PERC	Post Event Review Capability
PDNA	Post Disaster Needs Assessment
PIERRP	Post Cyclone Idai Emergency Recovery and Resilience project
PIES	Poverty, Income and Expenditure Survey
PRB	Pungwe River Basin
PWD	Persons with Disabilities
RINA	Rapid Impact and Needs Assessment
RLA	Rural Livelihood Assessment
RS	Remote Sensing
SA	Sendai Framework Key Area
SADC	Southern African Development Community
SAP	Strategic Action Plan
SAR	synthetic Aperture Radar
SRB	Save River Basin
SEP	Stakeholder Engagement Plan
SMME	Small, Micro and Medium Enterprise
STD	Sexually Transmitted Diseases
TDA	Transboundary Diagnostic Analysis
TFCA	Trans Frontier Conservation Area

UN	United Nations
UN-ECA	UN-Economic Commission for Africa
UNDP	United Nations Development Program
UNDRR	United Nations Office for Disaster Risk Reduction
UNICEF	United Nation's Children Fund
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNOPS	UN Office for Project Services
USA	United States of America
USAID	United States Agency for International Development
WASH	Water, Sanitation & Hygiene
WHO	World Health Organization
WMO	World Meteorological Organization
WWF	World Wildlife Fund
ZAMCOM	Zambezi Watercourse Commission
ZINWA	Zimbabwe National Water Authority
ZIRP	Zimbabwe Idai Recovery project
ZRRF	Zimbabwe Recovery and Resilience Framework

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Quick reading guide and report structure

This report summarizes the main findings of the project "Impacts of Cyclone Idai in Mozambique and Zimbabwe, the mitigation measures and strengthening community resilience: with the focus on the BuPuSa transboundary river basins".

Readers with little time and those who are particularly interested in the conclusions, recommendation and follow-ups are advised to read chapter 6.

The structure of the report is as follows:

1. Introduction;
2. Buzi, Pungwe and Save River Basins (BuPuSa);
3. Disaster risk management structure and post Idai recovery projects;
4. Idai impacts: geospatial and socio-economic assessments, and consultations;
5. Mitigation, preparedness, and prevention, feedback from consultations; and
6. Summary, recommendations, and follow-ups.

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1 Introduction

Cyclone Idai struck Mozambique, Zimbabwe, and Malawi in March 2019, and caused significant loss of life and livelihoods, injuries as well as extensive damage and destruction of infrastructure, houses, etc. The USAID Resilient Waters Program commissioned the Centre of Applied Research (CAR) to assess the impacts of Cyclone Idai on communities in Mozambique and Zimbabwe[1] and to identify lessons, tools, and strategies for the strengthening of communities' resilience towards cyclones. The project started in December 2019 and is completed in December 2020. It comprised a geospatial assessment, a socio-economic desk top assessment and consultations to understand the cyclone's impact and mitigation measures taken and to develop a plan for follow-up activities, particularly at the community level. The specific project objectives are to:

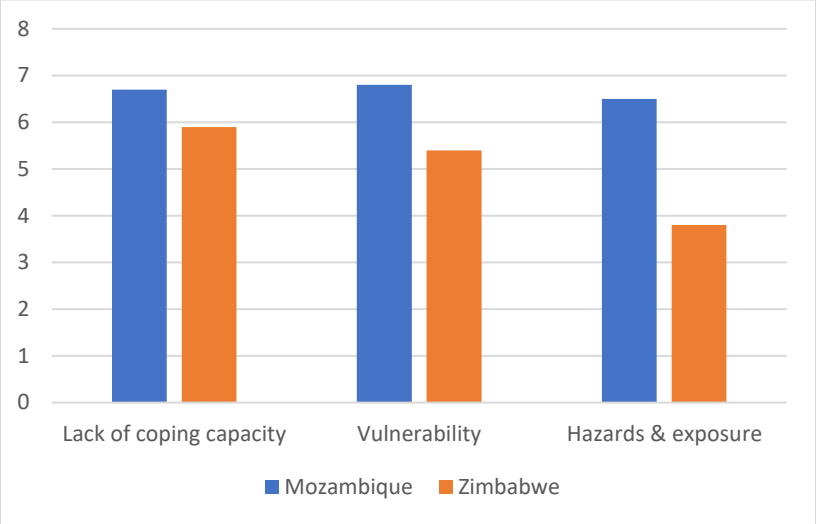
a. Assess the impacts of Cyclone Idai at community level in Mozambique and Zimbabwe; and
b. Identify lessons for strengthening of community resilience against cyclones.

The project focused on three shared river basins between Mozambique and Zimbabwe, i.e., the Buzi, Pungwe and Save river basins (BuPuSa). CAR carried out the socio-economic assessment and consultations; Hatfield Consultants Africa (HCA) conducted the geospatial assessment. CAR was responsible for the overall project coordination and integration of the results.

The EU developed a global risk index (GRI) showing the vulnerability of countries to disasters. Generally, the higher the risks are, the greater the vulnerability and the more limited countries' potential to mitigate impacts is. The GRI shows that Mozambique and Zimbabwe are in the high-risk category for disasters with high disaster exposure and vulnerability, and with a limited coping capacity (Figure 1 below). Mozambique is ranked 19th highest risk country out of 190 countries with an overall score of 6.2 (on a scale of 0 to 10; 10 being the highest risk) and Zimbabwe is ranked 47th (overall score 5.1). In terms of natural risks, droughts pose the highest risk in both countries, while floods, tsunami (Mozambique) and epidemics are also common natural risks. The risk of tropical cyclones is high in Mozambique, but low in Zimbabwe.

[1] Malawi is not covered.

Figure 1: Global Risk Index (INFORM[2]) for Mozambique and Zimbabwe (2020).



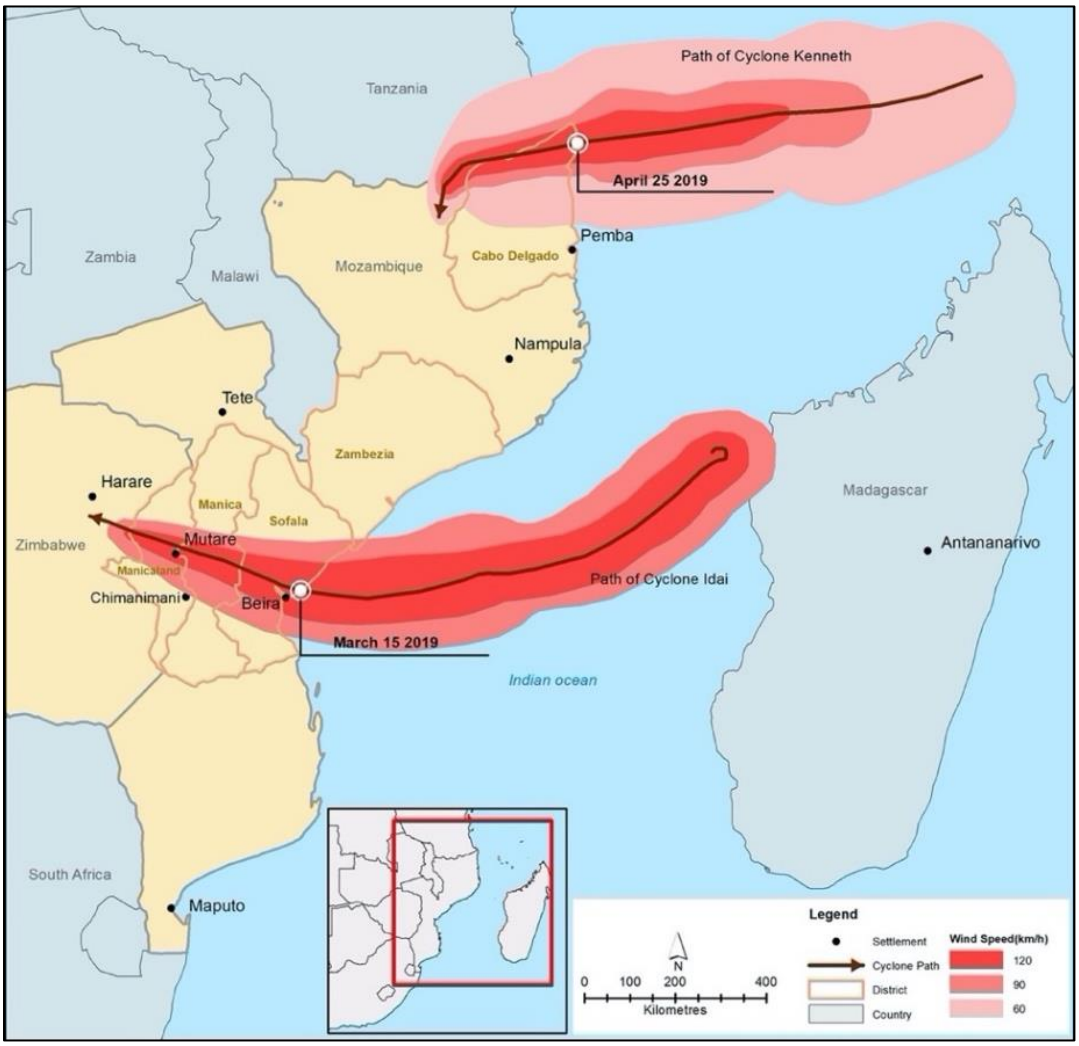
Source: INFORM data on https://ec.europa.eu/jrc/en/publication/index-risk-management-inform.

During mid-March 2019, Idai brought high winds and intense rainfall devastating parts of Mozambique and Zimbabwe; the BuPuSa basins were hard hit. The path and point of landfall for Cyclone Idai is shown in Figure 2. Another cyclone (Kenneth) followed a month later, striking Mozambique, Malawi, and Tanzania. Needs Assessments were quickly conducted in Mozambique (Post Disaster Needs Assessment or PDNA; GoM, 2019) and Zimbabwe (Rapid Integrated Needs Assessment or RINA; GoZ *et.al.,* 2019) soon after Idai, establishing the main impacts and required relief, recovery, and reconstruction efforts. The assessments showed that substantial relief efforts were needed together with investments in reconstruction and planning to improve the resilience of the impacted sectors and communities. It must be noted that cyclones are not a new phenomenon in southern Africa, as Eline in 2000 and Dineo in 2016 demonstrated. Therefore, building resilience to such extreme events is an integral part of sustainable development.

The assessment methodologies are described in CAR & HCA (2019). The core components are the geospatial and socio-economic assessment, complemented by limited stakeholder consultations. This report synthesizes and expands earlier project reports on the Cyclone Idai impacts and mitigation measures (CAR and HCA, 2020a & b). The earlier reports are not continuously referenced here. Readers will find more details in these reports.

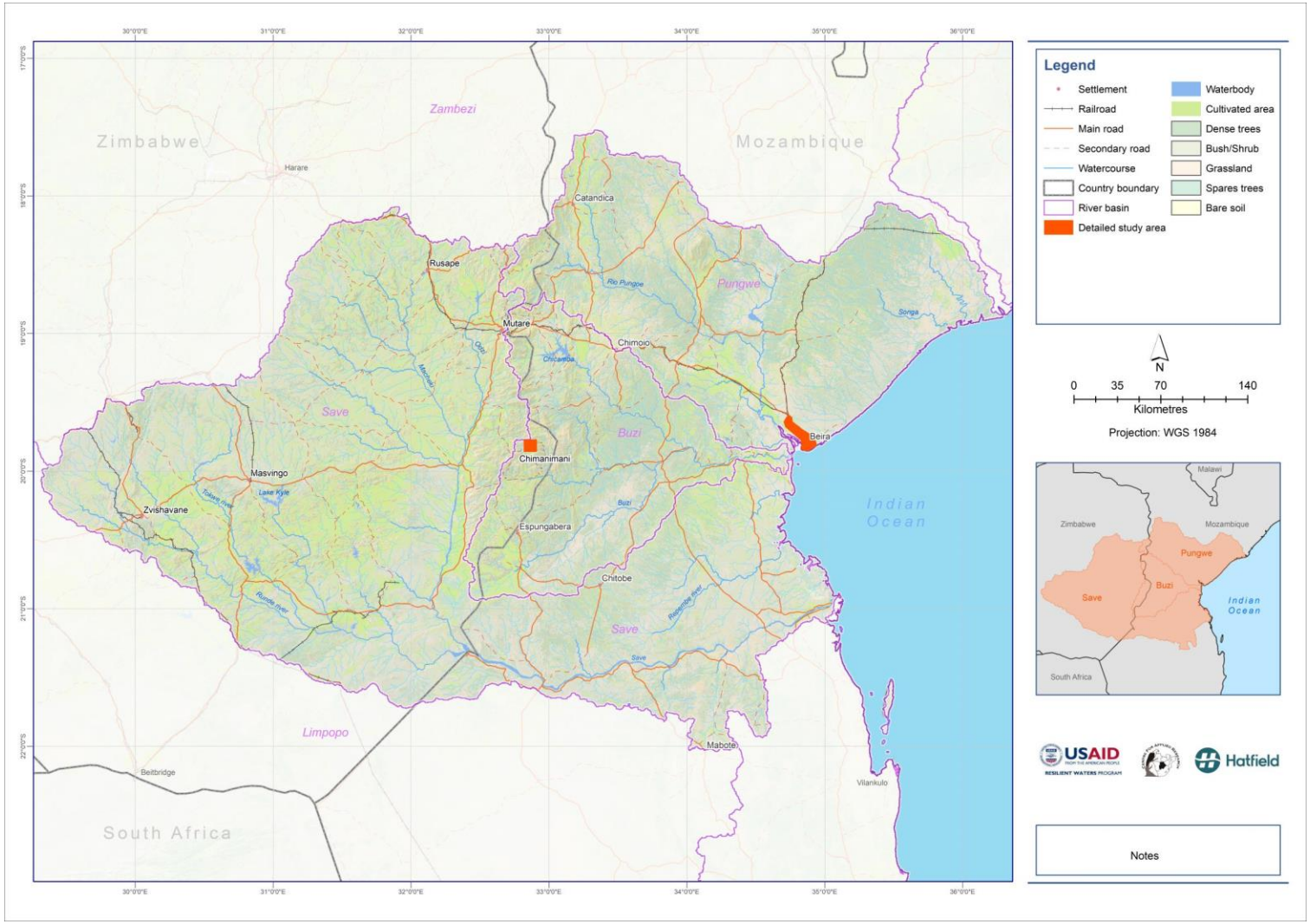
[2] INFORM is Index for Risk Management.

Figure 2: Paths of cyclones Idai and Kenneth.



Source: Adapted from GoM, 2019.

Figure 3: BuPuSa river basins.



2 BuPuSa river basins

2.1 Introduction to the basins

The Buzi, Pungwe and Save River (BuPuSa) basins are shared by Mozambique and Zimbabwe. Separate transboundary agreements between the countries exist for the Buzi (GoM & GoZ, 2019) and Pungwe (GoM & GoZ, 2016); the countries are currently developing a three-basin agreement for co-management of water resources. The three rivers all originate in Zimbabwe and end in the Indian ocean in Mozambique.

The basins have seven ecosystems, as defined by the World Wildlife Fund (WWF) Terrestrial Ecoregions with several Protected Areas or PAs (Figure 4). The coastal area consists of East African mangroves, Southern Zanzibar-Inhambane coastal forest mosaic and Zambezian coastal flooded savanna. Inland ecosystems shift to the Southern Miombo woodlands, Zambezian and Mopane woodlands, and Eastern Zimbabwe montane forest-grassland mosaic, with Southern Africa bushveld further inland covering the western-most portion of the basins.

Figure 4: WWF ecoregions present within the BuPuSa basins.

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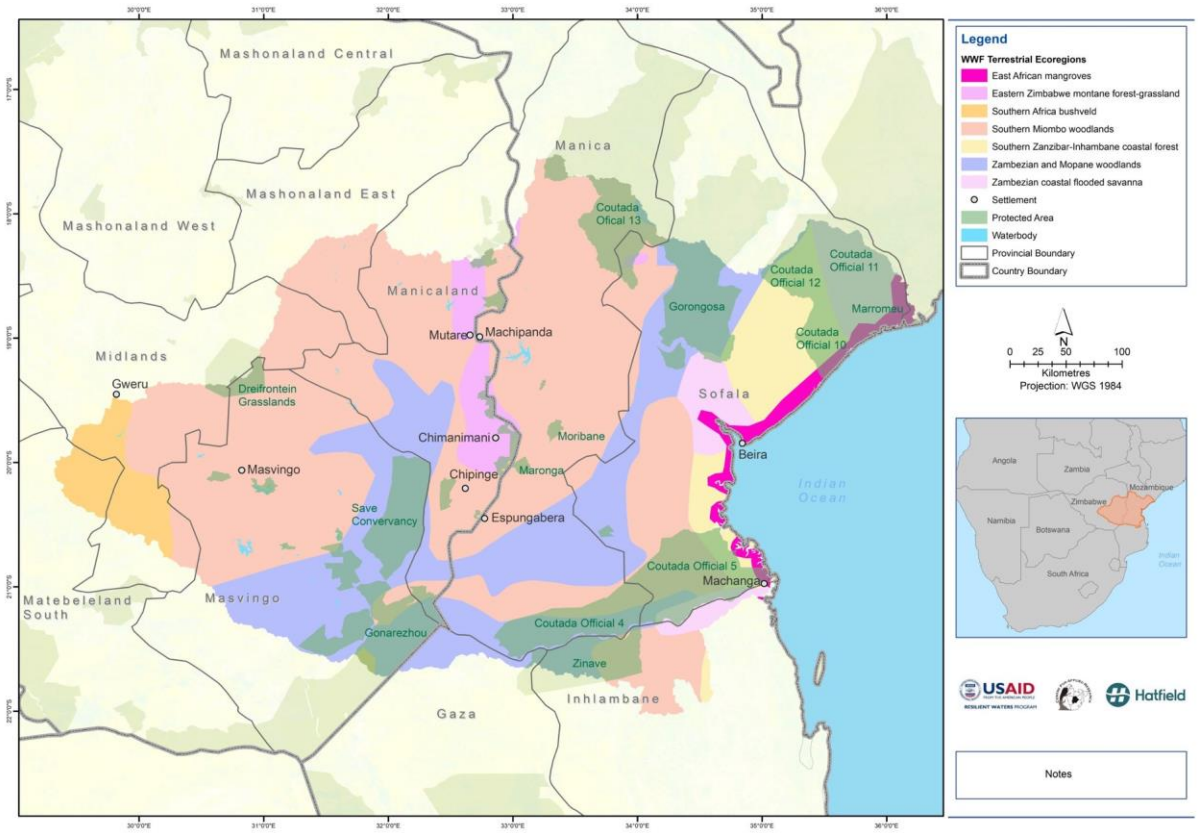


Table 1 provides brief profiles of each basin. An estimated 5.7 million people live in the BuPuSa basins, which together cover 166,400 km^2. The average population density is 34.2 persons/km^2, with the highest density in the Buzi River basin (41.6 persons/km^2). The Save is the longest river with the largest basin and the highest mean annual run-off (MAR). The Save River is said to dry up in parts of the basin

due to heavy development and abstractions upstream. The largest part of the Buzi and Pungwe Rivers are in Mozambique. The Pungwe River has the potential for further development in Mozambique.

Table 1: Key parameters of the BuPuSa River basins.

River Basin	Area (km^2)	Length (km)	MAR (Mm^3/ annum	MAR (m^3/s)	Human Population	Population density
Buzi	28,870	250	250-288 at lower Buzi	79.1	1,200,000	41.6
Pungwe	31,150	400		120-133	1,200,000	38.5
Save	106,420	640	7,000	221	3,300,000	31.0
BuPuSa	166,440[3]	1,290		0	5,700,000	34.2

Sources: Climate Resilient Infrastructure Development Facility CRIDF, Wikipedia and 2018 Global Environmental Facility (GEF) project proposal.

2.2 The Buzi River Basin (BRB)

The Buzi River originates in the eastern highlands of Zimbabwe south of Mutare town. Only 20 km of the river is in Zimbabwe. The basin has three large towns in Mozambique (Buzi, Manica, and Chimoio).

The basin's population is rapidly growing, but poverty is widespread. In Zimbabwe alone, rural poverty increased from 40% to 60% of the population between 1995 and 2003 (SWECO *et.al,* 2011). Agriculture is the main activity in the basin. Maize is the most common staple crop; cash crops are also grown, mostly commercially. Two large dams generate hydropower on the upper Revue River tributary; many small dams have been constructed for irrigation (SWECO *et.al*., 2011). Agriculture contributes most to the livelihoods of 68 % of the active population, followed by commerce (21%) and other services (10%). Alluvial gold mining is an additional informal source of livelihood. The situation is similar in Mozambique: 85 % in agriculture, 10 % in commerce and services and 5 % in industry.

The basin is flood prone, and floods are particularly damaging where the Buzi estuary joins the flood plain of the Pungwe. In terms of management, water planning is done by the Zimbabwe National Water Authority (ZINWA) on the Zimbabwe side, and in Mozambique by ARA-Centro as the regional water administrator (also for the Pungwe and Save).

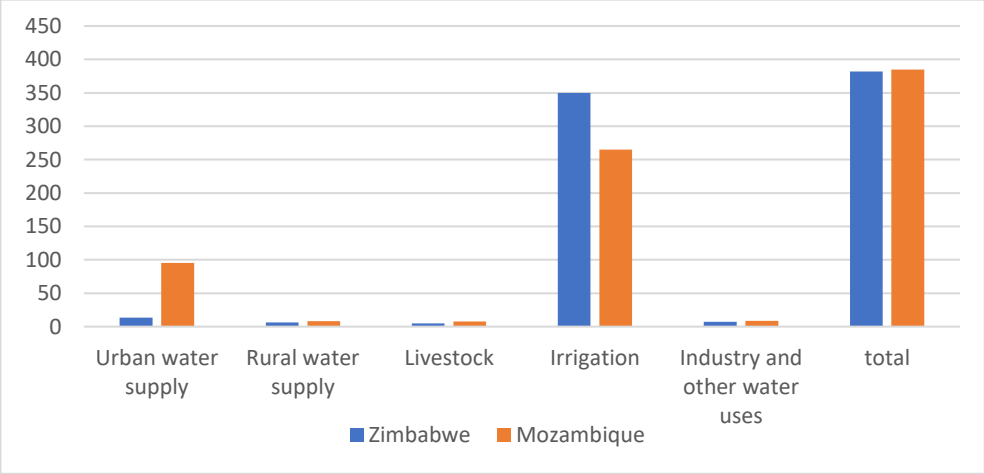
The Basin Agreement (GoM & GoZ, 2019) specifies the agreed water abstractions by country and sector (GoM & GoZ, 2019). Total agreed water abstractions are 766.7 Mm^3 per annum, mostly for irrigation (615 Mm^3) followed by urban water supply (109 Mm^3; Figure 5). Reservations for other uses are small; countries may shift allocations between sectors within the overall allocated amount. The actual annual water abstractions are not known. The agreed annual water abstractions are almost the same for each country, most of it for irrigation and urban water supply. Figure 6 shows that Mozambique contributes around 80 % of the MAR and basin area.

[3] The project's geospatial analysis estimates the total BuPuSa area at 196,728 km^2: 54 % in Mozambique and 46 % in Zimbabwe.

2.3 The Pungwe River Basin (PRB)

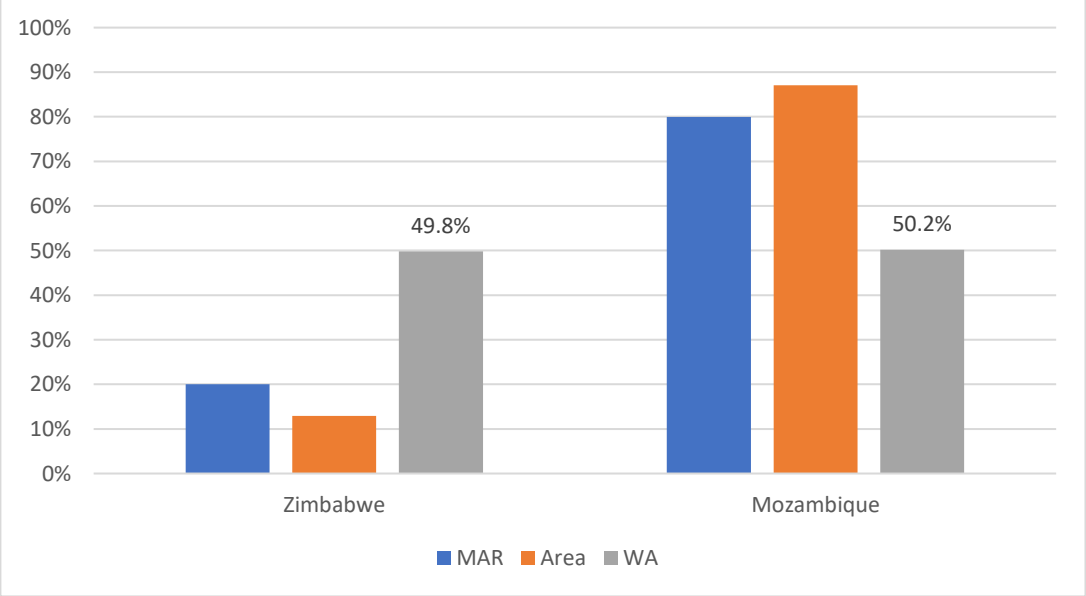
The Pungwe River originates in the Eastern Highlands of Zimbabwe and ends in the Indian Ocean in the Mozambique Channel at Beira. It forms a large estuary there, where it is joined by the Urema River; both rivers have large seasonal wetlands or flood plains. The river has one major dam in Zimbabwe and 19 small dams in Mozambique.

Figure 5: Agreed water abstractions by sector and country in the Buzi River Basin (Mm^3).



Source: GoM & GoZ, 2019.

Figure 6: Agreed water abstraction, contribution to MAR and basin area by country in the Buzi River Basin (as % of total).



Source: GoM and GoZ, 2019.

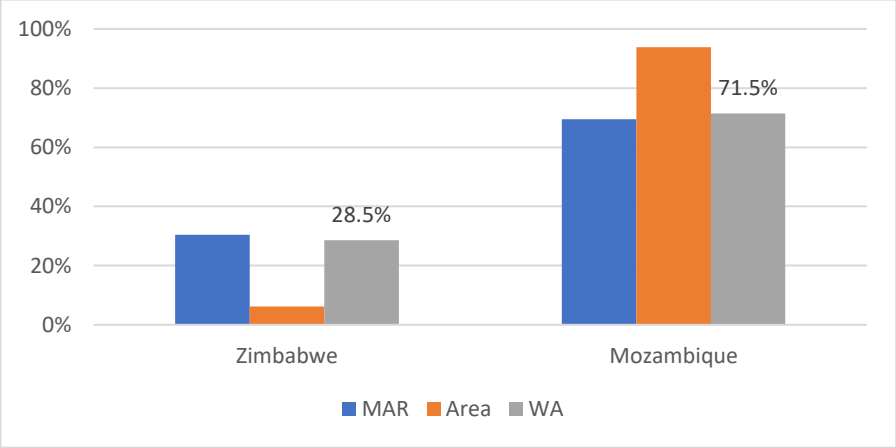
The Pungwe River Basin (PRB) covers a large part of Mutasa District in Zimbabwe and parts of Sofala and Manica Provinces in Mozambique. In terms of land use, the Zimbabwe portion of the PRB comprises a National Park, forest plantations, and mixed agriculture in the lower parts, along with some alluvial gold mining. In Mozambique, land is mostly used for mixed subsistence farming; the lower parts of the basin are flood prone. Over half of the rural population live in poverty, with the

most important economic activity being farming; both subsistence dryland farming and irrigated crop farming.

Less than 20 % of the available water resources are utilized (GoM & GoZ, 2006). Future development could be based on the fertile soils, ecotourism in the Gorongosa National Park (GNP) and dam developments for water supply systems (GoM & GoZ, 2006).

The agreed maximum annual water abstraction is 810 Mm^3, mostly for Mozambique[4]. Figure 7 shows the countries' shares in MAR, basin area and water abstractions. Mozambique has been allocated 72 % of the annual water abstractions.

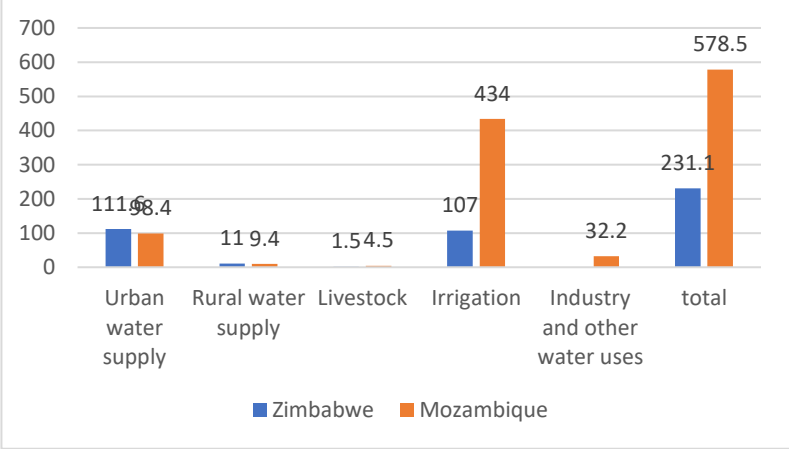
Figure 7: Agreed water abstraction, contribution to MAR and basin area by country in the Pungwe River Basin (as % of total).



Source: GoM & GoZ, 2016.

Figure 8 shows the agreed allocations by sector in the BRB. The irrigation sector is allocated the largest share, mostly in Mozambique, followed by urban water supplies (201 Mm^3). Countries may shift sectoral allocations within their total allocation; the actual annual water abstractions are unknown.

Figure 8: Agreed annual water allocations by sector in the Pungwe River Basin (Mm^3).



Source: GoM & GoZ, 2016.

[4] This excludes an expected water flow reduction of 257 Mm^3, associated with large scale afforestation plans 18,000 ha in Zimbabwe and 80,000 ha in Mozambique (GoM & GoZ, 2016).

2.4 The Save River Basin (SRB)

The Save River originates around 80 km south of Harare and ends in the Indian Ocean south of Beira. The Save River Basin (SRB) is mostly located in Zimbabwe. The Save Delta in Mozambique has mangrove forests along 100 km of coastline. Due to upstream water resource development schemes, the river is almost permanently dry in the lower parts except during periods of seasonally high flows.

Poverty in the basin is among the highest in Zimbabwe; most households depend on mixed subsistence farming, which is prone to regular crop failures. The basin is vulnerable to climate change, which is expected to lead to lower rainfall and longer dry periods. The largest water use is irrigation in the Rundu area with a system of large dams and distribution canals. There are many dams on the Save River and its development potential has almost been reached (CRIDF, 2019). The SRB Water Resource Management Strategy (GoM & GoZ, 2013) envisages the construction of more dams in combination with dam operation guidelines (CRIDF, 2019), environmental flow requirement assessment, and climate resilience strategy as well as community-based irrigation projects. The draft dam operating rules aim to ensure fairly and equitable access to river water and efficient allocation of the available water resources during wet and dry periods.

3 Disaster risk management structures and post Idai projects in Mozambique and Zimbabwe

To understand the impacts of and recovery and mitigation interventions for Cyclone Idai, it is important to describe the disaster risk management (DRM) and reduction (DRR) structures that exist in both countries. In recent years, Mozambique and to a lesser extent Zimbabwe have improved their DRR and DRM structures. Below, we first describe the situation in Mozambique together with Cyclone Idai relief and recovery projects (3.1), followed by Zimbabwe (3.2). International DRM support institutions that offer affected countries support are briefly discussed in section 3.3.

3.1 Mozambique

Mozambique has well developed DRR and DRM institutions, led by the National Institute for Disaster Management (INGC; see Figure 9 below). INGC's mandate has three areas, covering the entire DRM cycle:

a. Emergency actions and relief;
b. Disaster prevention and mitigation actions; and
c. Post-disaster reconstruction actions through the Reconstruction Coordination Office GACOR.

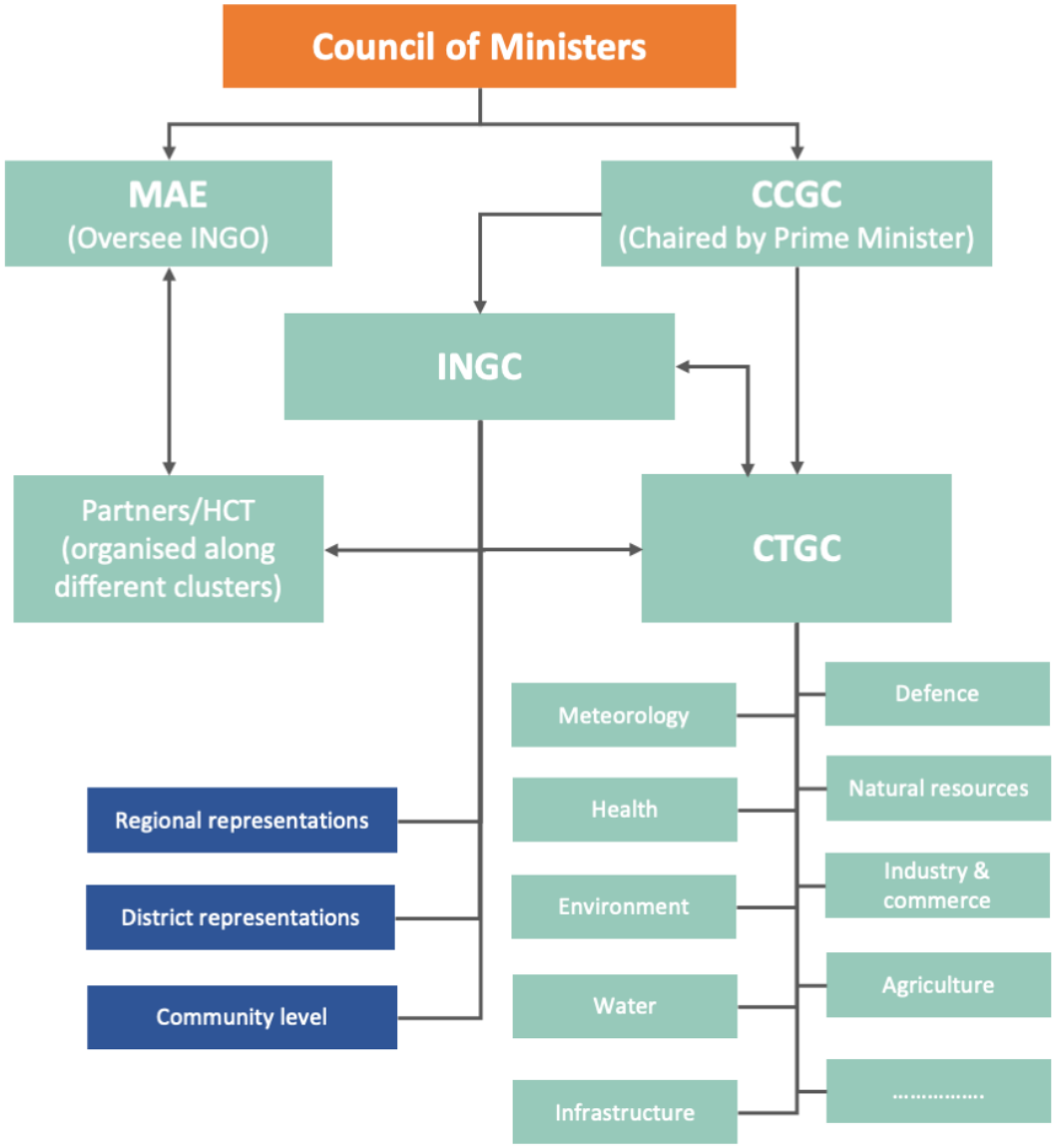
The INGC is decentralized and has four regional emergency operation centers (CENOE) as well as local disaster risk management committees (DRMC). DRM is financed from a special Disaster Management Fund (DMF) and from ministerial DRR budgets.

Each sector and district integrate DRR and climate change adaptation (CCA) in their planning and budgeting (UN-ECA, 2015). Funds and capacities for DRR and CCA are however limited, particularly at the district and local levels. The Ministry of Environment (MICOA) is responsible for CCA[5] and the Ministry of Planning and Development (MPD) also plays a key role in DRM (UN-ECA, 2015). The country has a National Strategy for Climate Change Adaptation and Mitigation (2013-2025; GoM, 2012). The National Institute of Meteorology (INAM) is responsible for weather forecasts and has an early warning system (EWS) in place. Water resource management is led by the Directorate of Water Resources Management (DNDRH), which has regional offices (Ara Centros). The Ara Centro in Beira is responsible for the BuPuSa basins[6]. The DNDRH also has a Department of International Rivers for transboundary water resource management.

Mozambique's early warning system (EWS) extends to and involves communities. Village DRMCs were established at least ten years ago.

[5] Key areas identified with respect to climate change are coastal protection, EWS and preparedness, prepared cities, resilience in the private sector, water demand management and efficiency, food security, preparing people, dealing with extremes, and DRR strategy (UN-ECA, 2015).
[6] It merged recently with the Ara Centro Zambezi under the new name Ara Centro.

Figure 9: DRM Institutional structure in Mozambique.



Source: UN-ECA, 2015.

3.2 Zimbabwe

The Department of Civil Protection (DCP) leads the DRR/DRM efforts in Zimbabwe (Figure 10). It is backed by out-of-date legislation (Civil Protection Act, Chapter 10:06 of 1989[7]) and manages the National Civil Protection Fund (NCPF), which finances its DRR activities. The DCP operates at the national, provincial and district level through Civil Protection Units (CPU).There are no local DRMCs. The National Civil Protection Committee (NCPC) has stakeholders from government and outside

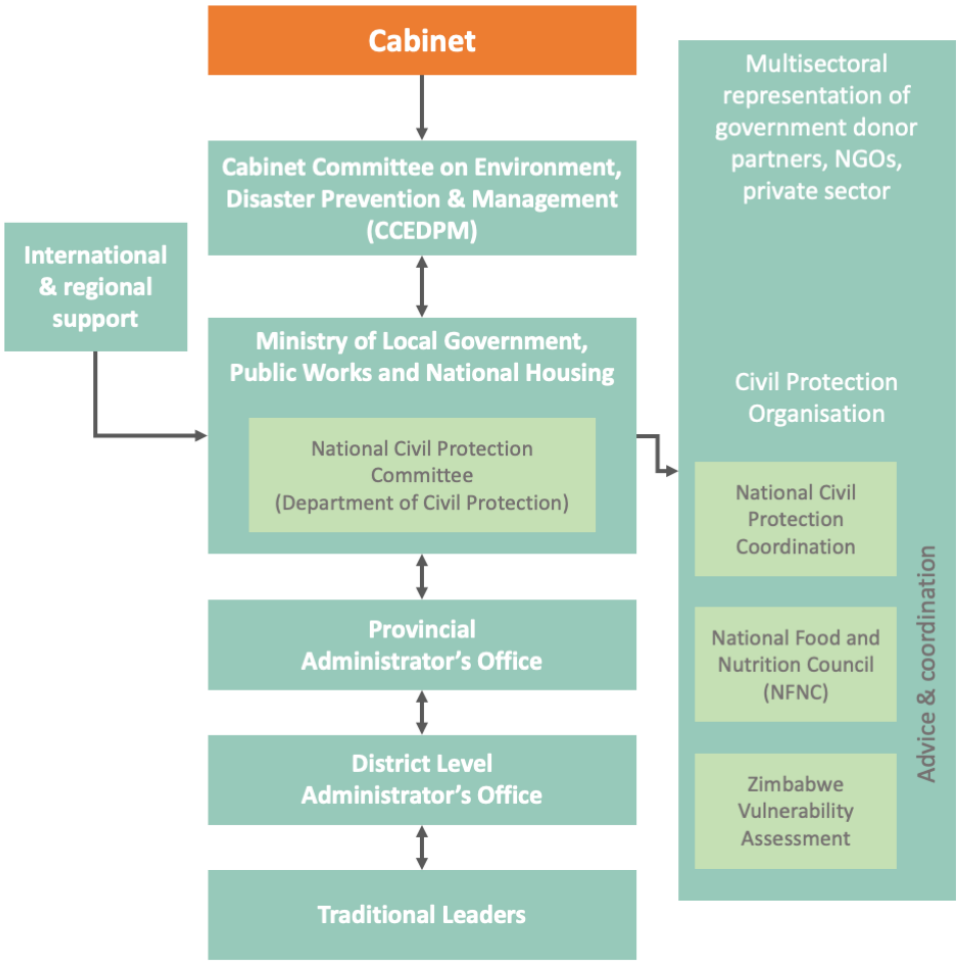
[7] The draft 2015 DRM bill is yet to be finalized.

government. One percent of the national government budget is meant to be available for DRR activities through the NCPF[8].

DRR efforts are guided by the 2012 National DRM Strategy and the National Climate Change Response[9] (GoZ, 2014; GoZ & UN, 2017). For Cyclone Idai, the Provincial Administrator of Manicaland led relief efforts, supported by District coordinators. Thirteen technical subcommittees were established at provincial level.

In terms of water resources, the Department of Water Resources, the Zimbabwe National Water Authority (ZINWA) and catchment councils are key institutions. The ZINWA is the key institution for BuPuSa. Communities, the private sector, and non-government organizations (NGO) as well as International Cooperating Partners (ICP) are key partners in DRR and are represented in the Civil Protection Platform. Every citizen is obliged to be involved in efforts to avoid disasters.

Figure 10: DRM institutional structure in Zimbabwe.



Source: Chatiza, 2019.

[8] This would be US$77.7 million in 2019. Over the period 2012-2018, the DCP received on average only 0.6% of its ministerial budget (Chatiza, 2019).

[9] A good practice is to integrate DRR and CCA (OECD, 2020). Namibia has done so by adopting "The National Strategy for Mainstreaming Disaster Risk Reduction and Climate Change Adaptation into Development Planning in Namibia 2017-2021" (UNDRR, 2019).

3.3 International DRM support

Many bilateral and multilateral organizations offer support for disaster relief efforts. International efforts are often coordinated through the United Nations (UN) Office for Disaster Risk Reduction (UNDRR) and the UN Office for Project Services (UNOPS). Many other multilateral organizations are actively involved in DRM including the United Nations Educational, Scientific and Cultural Organization (UNESCO), the United Nation's Children Fund (UNICEF), the International Organization for Migration (IOM) and the World Bank. Bilateral organizations (e.g., United States Agency for International Development or USAID) and Non-Government Organizations (e.g., faith-based organizations and humanitarian organizations such as the International Federation of Red Cross & Red Crescent Societies or IFRC). Country relief efforts of international collaborating partners (ICP) are coordinated through a cluster approach, comprising the following cluster:

a. Food security and livelihoods;
b. Water, sanitation, and hygiene (WASH);
c. Health
d. Social protection
e. Nutrition; and
f. Shelter.

The UNOPS maintains a database for humanitarian aid, which provides details of the amount of aid provided, the funding sources, and the beneficiary clusters (www.fts.unocha.org). This data base shows that Mozambique received on average US$57 million per year of international funding in the period 2010-2020. Zimbabwe received on average US$153 million per annum over the same period, mostly for food aid. Numerous ICPs were involved in Idai relief efforts.

4 The Impacts of Cyclone

This chapter discusses the impacts of Cyclone Idai through a geospatial assessment (4.1) and a socio-economic assessment (4.2). Stakeholder views regarding the impacts are summarized in section 4.3.

4.1 Geospatial assessment

The geospatial assessment provides independent analysis and augments the socio-economic assessment (section 4.2). The geospatial assessment is fully reported in CAR and HCA (2020a). The assessment included a basin-wide assessment and a focused area assessment. The basin wide analysis assessed landcover changes that resulted from the cyclone at provincial and country level to determine impacts on forest, agriculture, settlements, and protected areas. High-resolution imagery was used for geospatial analysis of two focus areas (most affected: Chimanimani and Beira), which included infrastructure damage assessment and flood/landslide analysis. These provided insights in the concentration of damage within the area of interest in these two settlements. Table 2 below provides a summary of the geospatial analysis that were conducted during the project. Details of the methodology can be found in CAR & HCA (2019).

The geospatial assessment took cues from RS analysis conducted for RINA (GoZ *et.al*., 2019) and other independent assessment by the European Space Agency (ESA), but included additional analysis, such as landcover mapping across the entire basin. The damage assessment conducted at building-level in both settlements, provided a unique detailed assessment of the impact of the cyclone. With respect to landcover mapping, entirely new landcover data were developed before and after the event, rather than relying on aged existing data.

Table 2: Summary of geospatial assessment and list of cartographic products.

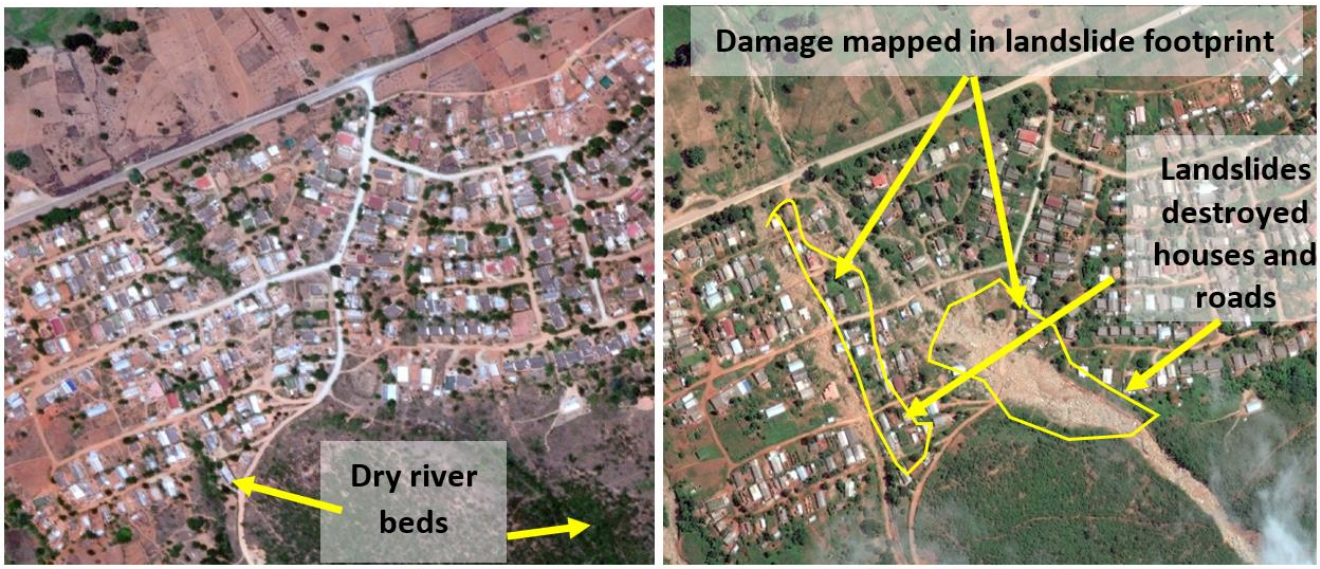
Image Resolution	High (50 cm Worldview-2)	Medium (10 m Sentinel-2)
Geospatial analysis	• Damage assessment • Landslide analysis • Flood analysis • Landcover change	• Landcover change • Forest cover loss • Impact on agriculture • Impact on protected areas • Impact on settlements • Vulnerability assessment
Map products	• Damage density map • Chimanimani landslide and flood analysis map • Detailed topographic maps (before and after the event)	• Forest loss map • Cyclone impact assessment (per province) • Change analysis (per province) • Areas vulnerable to flooding • Areas vulnerable to cyclones

4.1.1 High resolution - Damage assessment

The damage assessment utilized a combination of on-screen, heads-up digitizing data capture from high-resolution satellite imagery, and the geostatistical analysis to develop damage density heat-maps. First, GIS operators placed a point feature on all buildings in the defined focused study areas in the before high-resolution satellite image. Each point was classified by use as either residential,

commercial, or public. Then using the *after* imagery, each point was assessed and the intensity of damage was catalogued, utilizing the following classes (no damage, possible damage, moderate damage, severe damage removed and new building). An example of *before* and *after* imagery for Chimanimani, Zimbabwe is shown in Figure 11.

Figure 11: Before (left) and after (right) images for Chimanimani, Zimbabwe.



The damage assessment yielded two sets of results for the focused study area:

a. Tabulated statistics from the building count and visual assessment; and
b. Infrastructure damage density map from the geospatial analysis of the clustering of visible damage to infrastructure.

In Chimanimani, it was observed that most of the damage was to residential buildings as summarized in Table 3 below and localized in lower lying clusters of buildings, close to stream channels running down from the ridges where landslides moved rapidly downslope, destroying buildings and infrastructure in their paths, and shown in Figure 11. From the imagery, it was deduced that most damage to infrastructure observed in Chimanimani resulted from landslides, subsequent mass slope failures and mudslides as shown in Inset A and Inset B of Figure 12.

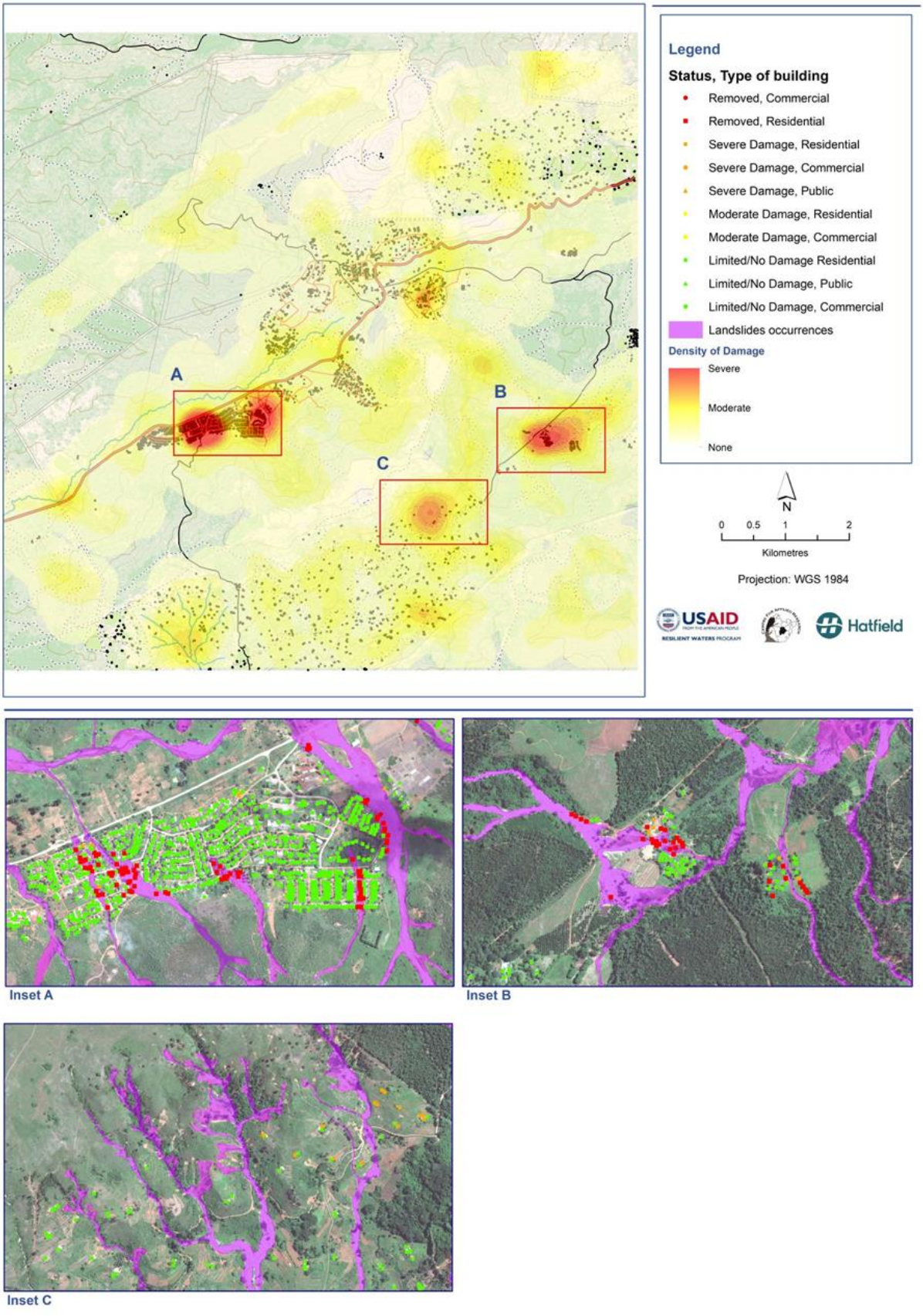
Table 3: Chimanimani building damage assessment (numbers and as %).

	Residential		Commercial		Public		Total
Limited/no damage	3,098	92%	97	92%	26	96%	3,221
Moderate damage	10	0%	1	1%		0%	11
Severe damage	58	2%	1	1%	1	4%	60
Removed	199	6%	7	7%		0%	206
Total	**3,365**		**106**		**27**		**3,498**

Note: The limited/no damage class is presented as a single category, as it was found that change between two images was subjective. Limited damage was difficult to discern from no damage, especially in Chimanimani where the image was captured a significant amount of time after the event.

Source: this project.

Figure 12: Building and road infrastructure damage density, Chimanimani.



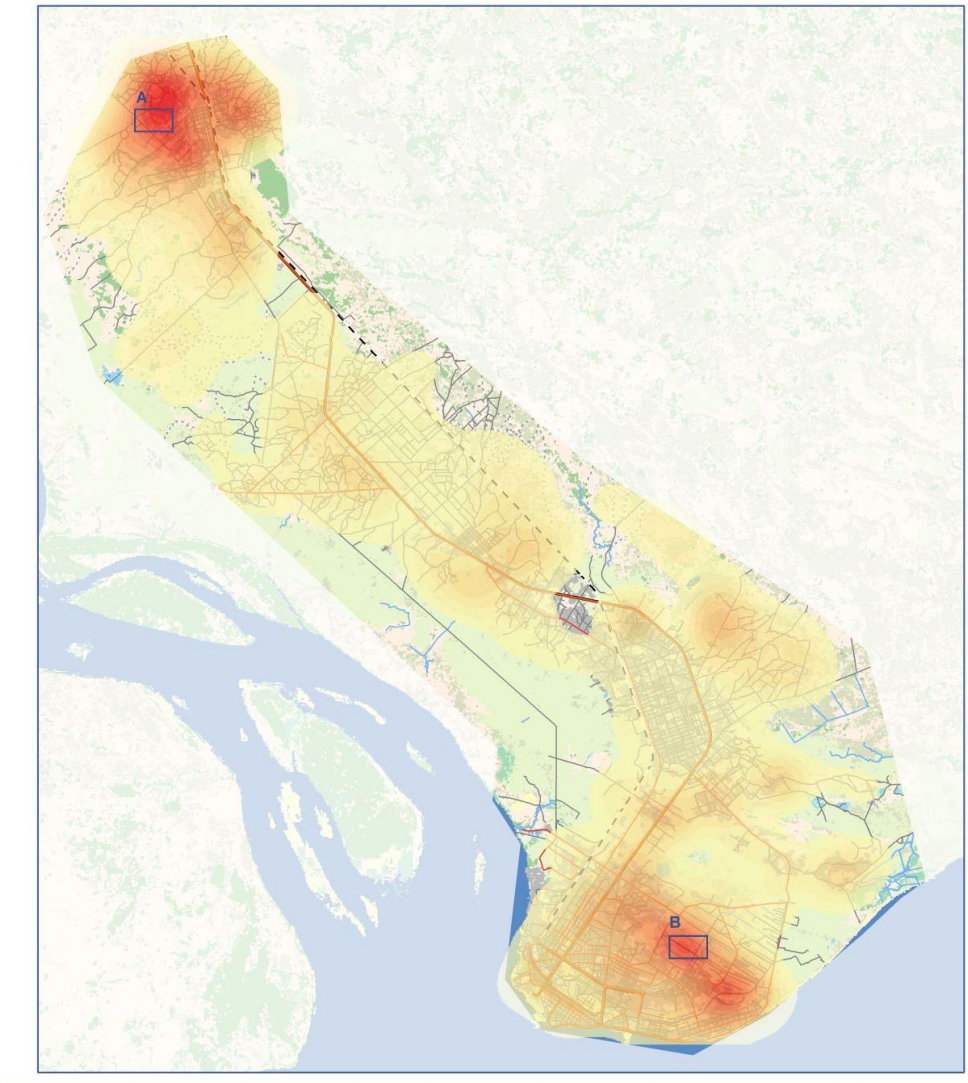
In Beira, there was a higher concentration of damage to public/civic buildings as summarized in (Table 4). The damage density heat map of Beira in Figure 13 shows the distribution of damage caused by high winds and heavy rainfall on coastal dwellings. Damage is clustered in two main locations, with A in the north, in-land section, and B in the town of Beira itself, at the river mouth.

Table 4: Beira building damage assessment (numbers and %).

	Residential		Commercial		Public		Total
Limited/no damage	110,606	85%	8,641	81%	1,050	73%	120,297
Moderate damage	6041	5%	899	8%	144	10%	7,084
Severe damage	8053	6%	853	8%	221	15%	9,127
Removed	5345	4%	211	2%	24	2%	5,580
Total	**130,045**		**10,604**		**1,439**		**142,088**

Source: this project

Figure 13: Building damage density, Beira.



The comparison of the damage assessments in both areas shows that the damage patterns are substantially different. Damage in Chimanimani was localized around the devastating landslide paths, and to a lesser extent flooding in low-lying areas and general damage to small-holdings likely due to heavy rain and associated winds. The impacts in Beira were more widely distributed, likely driven by factors such as exposure to the elements, exacerbated by removal of sheltering trees, building density, and building materials.

4.1.2 Flood and landslide analysis

Flooded area extent estimates were extracted from Sentinel-1 SAR[10] Ground Range Detection (GRD) imagery using a change detection approach comparing GRD imagery products for the before (2019-03-01/2019-03-10) and after the flood event (2019-03-10/2019-03-25). The *before* flood time frame was set to images collected between 1st and 10th March 2019, and the *after* flood time frame was set to images collected between 10th and 26th March 2019. VH (vertical/horizontal) polarisation was selected with a descending mode overpass direction. This multi-polarisation SAR analysis differentiated between existing water and water bodies (farm dams, reservoirs, river channels, etc) and standing water following the extreme rainfall events that caused flooding events.

In Beira, results from the SAR-based flood analysis generated from Sentinel-1A data collected in March 2019, shows that most of the flooding took place in the unpopulated area of the north of the main coastal coastal residential district, to the east and further north-east, with limited flooding occurring in the main settlement itself as shown in Figure 14.

As for Chimanimani, landslide occurrences were extracted from the high-resolution image classification, with this analysis only performed for the Chimanimani focused study area as no landslides were recorded in Beira. The landslides generally followed stream channels from higher ground, often merging to form larger landslides, moving large amounts of sediment, soil, and uprooted vegetation downslope. In many cases the landslides in Chimanimani terminated in flooded river areas. Flooding in Chimanimani was localized on river flood plains and in low-lying areas (Figure 15).

[10] Synthetic Aperture Radar.

Figure 14: Flooded area analysis – Beira, Mozambique.

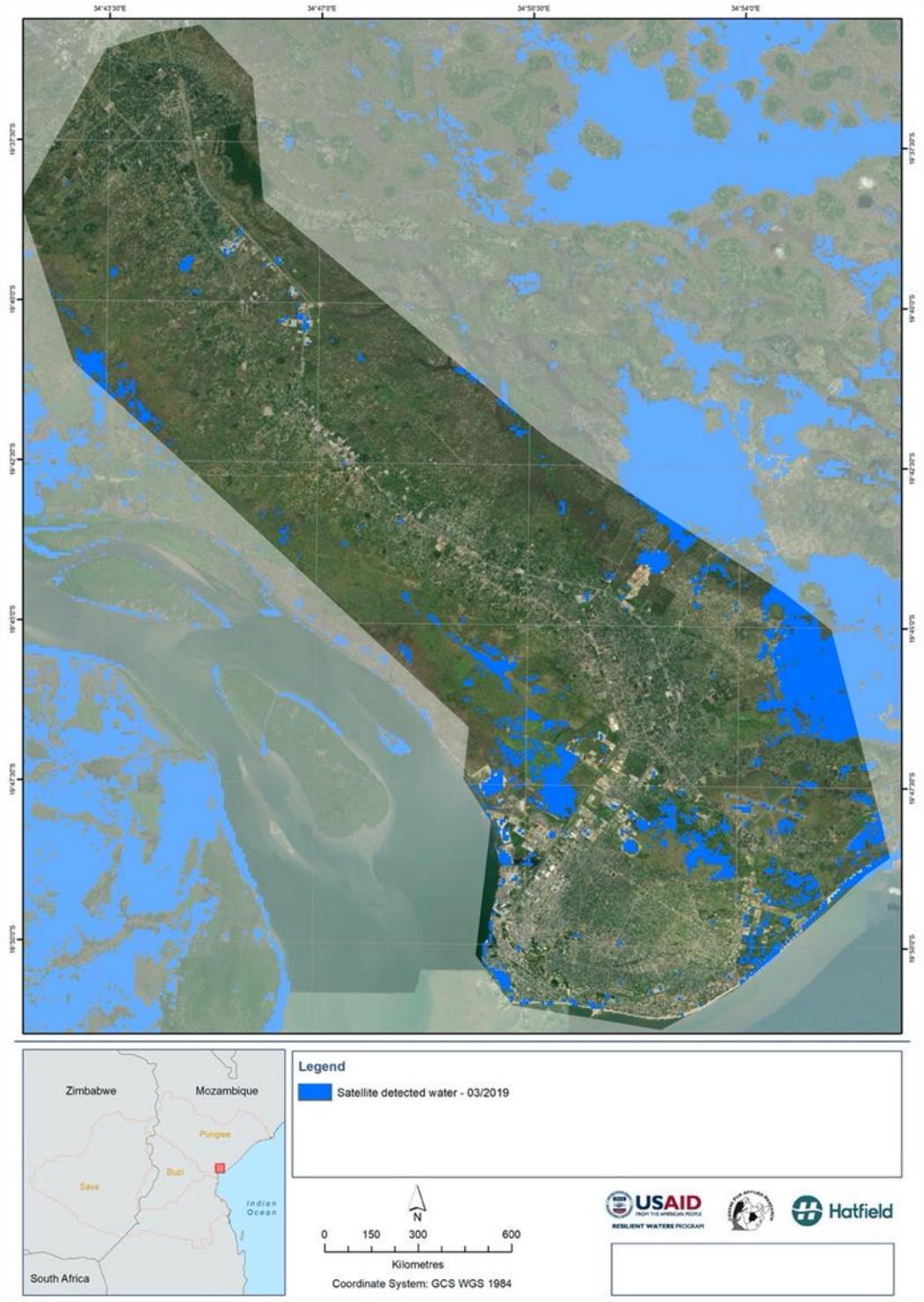
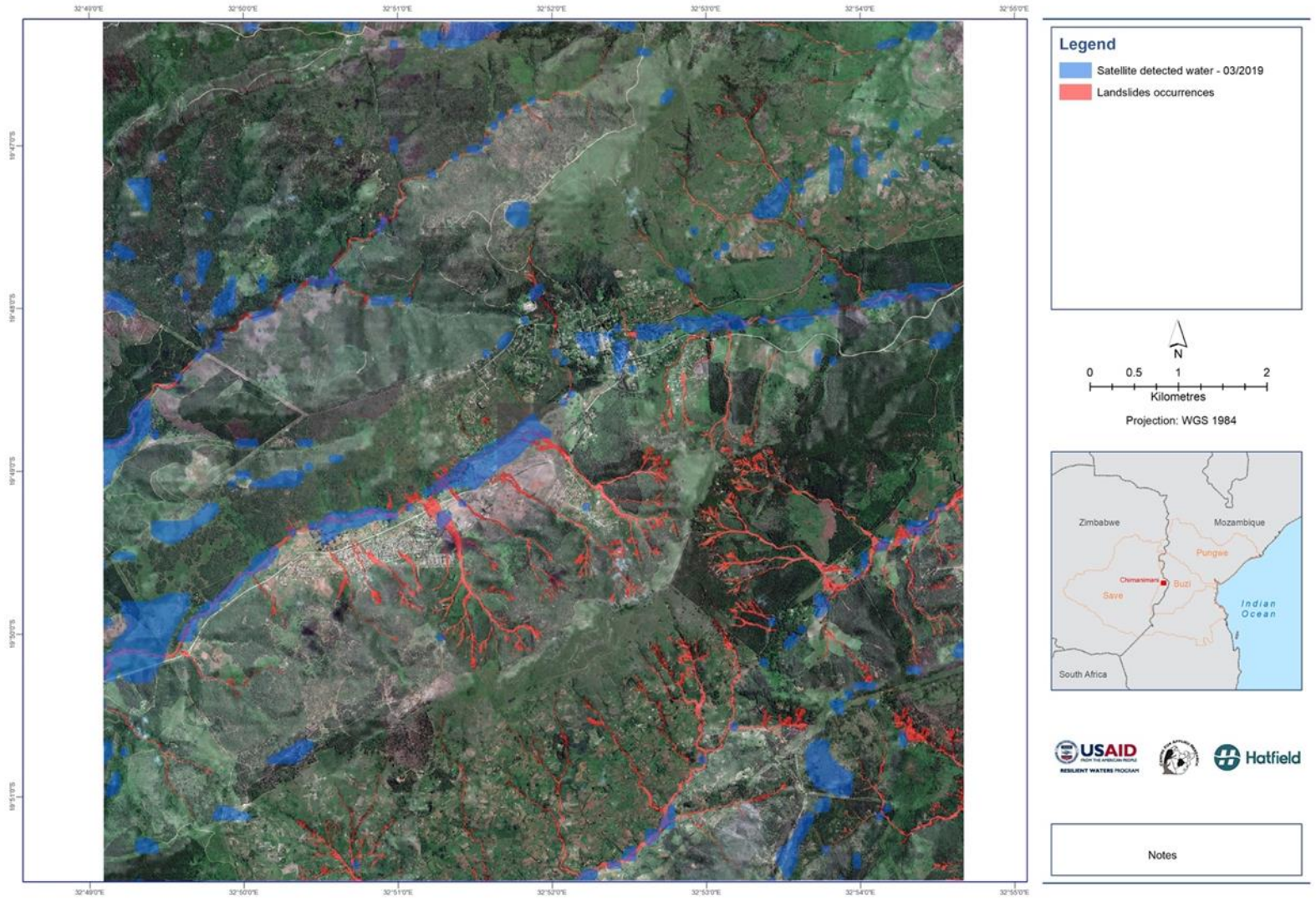


Figure 15: Flooded area and landslide analysis – Chimanimani, Zimbabwe.



4.1.3 Landcover mapping analysis

Unsupervised landcover classification was conducted in Google Earth Engine (GEE), using two Sentinel 2A medium-resolution imagery mosaics collected *before* the 20th of February 2019 and *after* the 20th of March 2019. Image analysis was restricted to parts of each province that fall within the BuPuSa basin. The imagery was classified into the following classes:

a. Dense vegetation: forest, woodland and dense thicket, and bush;
b. Grassland/pasture: savanna, grassland landscapes and bare soil;
c. Sparse vegetation: sparsely vegetated bush and scrubland, including senescent bush and thicket;
d. Agriculture: irrigated and dryland cultivation; and
e. Water: open water bodies, standing water, lagoons, dams, reservoirs, and estuaries.

The results of the landcover mapping demonstrate landcover status at a basin-scale *before* and *after* the cyclone events, and inform landcover change, which provides an assessment of landscape level change during and immediately after the cyclone, focusing on primary landcover classes. It is important to note that changes in landcover may not be linked to direct 'negative' impacts of the cyclone, such as physical damage or removal due to the adverse meteorological conditions, but also due to indirect effects such as substantial increase of available surface water and groundwater, and subsequent large-scale regeneration of vegetation communities and revitalisation of ecosystems.

Furthermore, as the BuPuSa basins are home to widespread agricultural activity it is not possible without field validation data to ascertain damage to agricultural crops with RS techniques alone. Hence, the cyclone exposure footprint was used to establish the portion of the study area where the effects of the storm were felt. This therefore presents an estimate of *exposure of agriculture.*

The first product from the landcover mapping was a post classification comparison conducted on the *before* and *after* landcover data, which provided a "from" and "to" class change description over the window of October 2018/February 2019 (before) and March/August 2019 (after). This enabled a high-level assessment of the amount of landcover change per province (Table 4). Except for Gaza Province in Mozambique, all provinces experienced increases in dense vegetation, and reduction in sparse vegetation, and four of the nine provinces experienced increases in grassland/pasture. The land cover category 'water" increased by over 27,000 ha, mostly in Sofala Province (25,618 ha) and to a lesser extent in Inhambane Province (2,232 ha), and Manicaland Province (44 ha). Most of these landcover changes in landcover are characterized by the seasonal regeneration and densification of senescent vegetation driven by increased moisture availability across the basins.

The second product was the baseline exposure maps, which summarized the areas of each province that were exposed to the cyclone, with particular attention to irrigated and rainfed agriculture that was exposed to the cyclone (Table 5). Figure 16 provides an example of landcover, and agriculture baseline exposure for Masvingo province in Zimbabwe. It must be emphasized that exposure does not equate to damage, but rather exposure to increased rainfall, higher winds, and the associated physical damage these factors may cause.

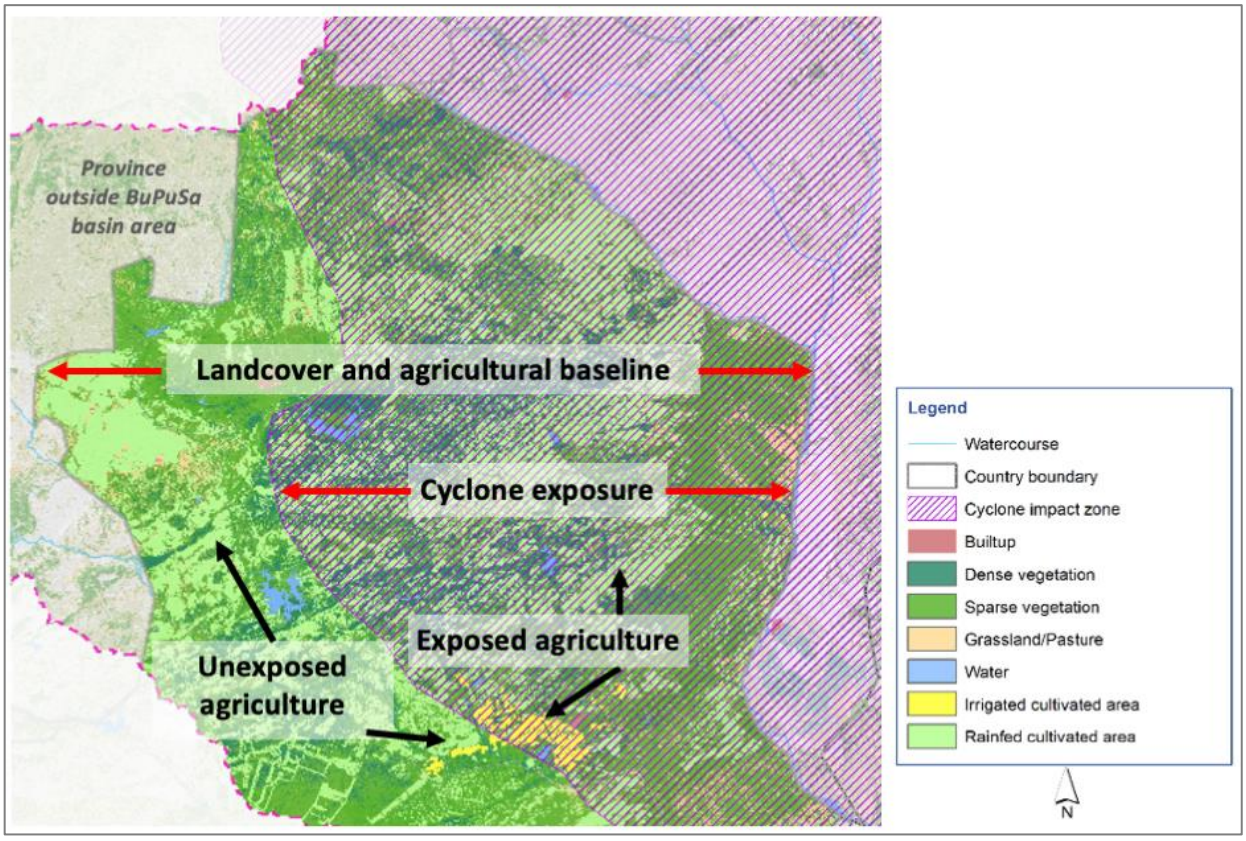
Table 4: Landcover change assessment results (ha)

		BEFORE					AFTER				CHANGE			
Country	Province	Dense Vegetation	Sparse Vegetation	Grassland/ Pasture	Water	Total area	Dense Vegetation	Sparse Vegetation	Grassland/ Pasture	Water	Dense Vegetation	Sparse Vegetation	Grassland/ Pasture	Water
Zimbabwe	Manicaland	496,126	706,291	232,370	27,961	1,462,748	667,635	586,255	180,854	28,005	171,509	-120,036	-51,516	44
	Mashonaland East	72,050	225,846	43,562	3,395	344,853	100,149	172,461	68,848	3,395	28,099	-53,385	25,286	0
	Masvingo	623,557	1,939,287	265,608	23,616	2,852,068	761,331	1,906,957	160,633	23,147	137,774	-32,330	-104,975	-469
	Matebeleland South	40,198	123,903	31,923	1,590	197,614	41,002	74,775	80,275	1,563	804	-49,128	48,352	-27
	Midlands	296,978	603,860	69,697	6,490	977,025	375,141	501,939	93,454	6,490	78,163	-101,921	23,757	0
Mozambique	Gaza	53,919	130,702	2,527	4,773	191,921	48,689	135,454	3,008	4,771	-5,230	4,752	481	-2
	Inhambane	255,371	436,629	32,760	12,605	737,365	260,368	428,482	33,678	14,837	4,997	-8,147	918	2,232
	Manica	989,346	2,332,683	278,795	58,781	3,659,605	1,436,481	1,973,283	191,059	58,781	447,135	-359,400	-87,736	0
	Sofala	1,345,690	2,752,435	474,109	55,377	4,627,611	2,286,020	1,963,359	297,236	80,995	940,330	-789,076	-176,873	25,618

Table 5: Satellite-based estimates of exposed agricultural land in the BuPuSa area.

Country	Province	Irrigated	Exposed Irrigated Agriculture	Dryland Agriculture	Exposed Dryland Agriculture	Total Agricultural Area	Total Agriculture in exposed area	% Agriculture Exposed	Total Area	% Agriculture	Total Exposed Area	Total Exposed Agriculture	Total Exposed Area in BuPuSa
Zimbabwe	Manicaland	46,298	46,298	1,252,445	1,252,445	1,298,743	1,298,743	100%	3,575,425	36%	3,575,425	36.3%	2,760,897
	Mashonaland East	11,771	11,771	121,376	120,992	133,147	132,763	100%	2,818,859	5%	1,703,271	7.8%	467,540
	Masvingo	35,644	31,178	1,230,688	830,782	1,266,332	861,960	68%	5,535,209	23%	2,594,654	33.2%	2,590,976
	Matebeleland South	13	0	29,460	0	29,473	0	0%	5,440,018	1%	0	0.0%	0
	Midlands	104	0	447,649	115,015	447,753	115,015	26%	5,617,081	8%	489,084	23.5%	334,662
Mozambique	Gaza	0	0	742	742	742	742	100%	7,551,163	0%	219,765	0.3%	150,675
	Inhambane	3,397	3,397	25,639	12,107	29,036	15,504	53%	6,887,945	0%	1,183,201	1.3%	598,213
	Manica	41,531	41,531	894,399	894,399	935,930	935,930	100%	6,280,823	15%	6,280,823	14.9%	4,594,768
	Sofala	21,359	21,359	466,993	466,993	488,352	488,352	100%	6,761,923	7%	6,761,865	7.2%	5,115,113

Figure 16: Visual explanation of the agriculture baseline and cyclone exposure concept.



4.2 Socio-economic assessment

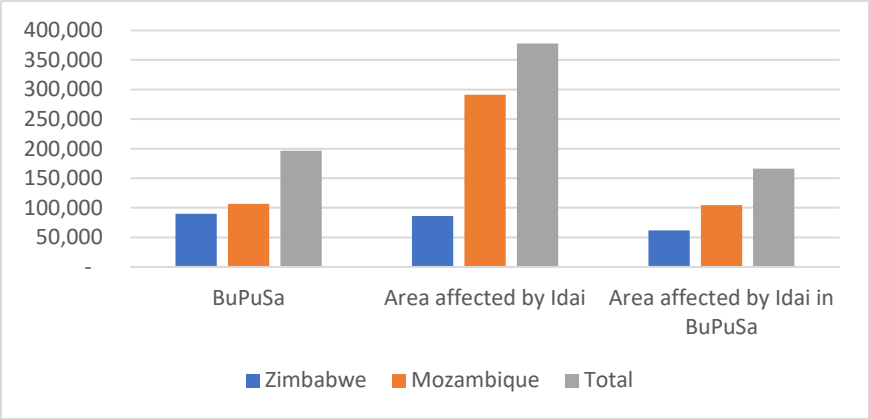
Cyclone Idai has had major impacts on people's lives and livelihoods, the private sector, local and national economies, and infrastructure. The impacts have been most widespread and largest in Mozambique; in Zimbabwe, Chimanimani and Chipinge Districts were hardest hit. Soon after the disaster, impact assessments were made in each country: The Post Disaster Needs Assessment (PDNA; GoM, 2019) in Mozambique, covering Sofala, Manica, Zambezia and Tete[11] Provinces, and the Rapid Integrated Needs Assessment (RINA) in Zimbabwe (Manicaland, Masvingo East, Mashonaland and Midlands; GoZ *et.al*., 2019).

An estimated 84 % of the BuPuSa area (166,128 km^2) was affected by the cyclone; 63 % of this in Mozambique and 37 % in Zimbabwe. Almost the entire Mozambican portion of the three basins (98 %) was affected compared to 84 % in Zimbabwe. It is important to realize that Cyclone Idai affected an even larger area outside BuPuSa region: 211,550 km^2, mostly in Mozambique (Figure 17). Outside the BuPuSa area, Zambezia and to a lesser extent Tete Provinces were heavily affected. Inside the BuPuSa area, the

[11] A quick assessment of Inhambane Province was done in Annex 3 of the PDNA report (GoM, 2019). Only 110 households were affected in this province.

most heavily affected provinces were Sofala and Manica Provinces in Mozambique and Manicaland and Masvingo Provinces in Zimbabwe.

Figure 17: BuPuSa and Idai affected areas in Mozambique and Zimbabwe (km^2).



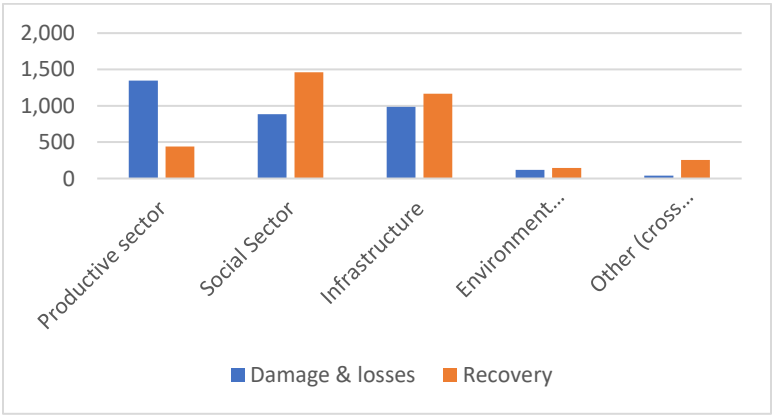
Source: this project.

The total damages and losses in the two countries are estimated at US$3.4 billion (GoM, 2019 and GoZ, *et.al.,* 2019). The damages and losses are highest in Mozambique:

a. Mozambique: US$2.8 billion or 18.9 % of the gross domestic product (GDP); and
b. Zimbabwe: US$0.6 billion or 3.6 % of GDP.

The estimated recovery costs are in the same order of magnitude as the damages and losses: US$3.5 billion in total (GoM, 2019; GoZ *et.al*., 2019), for Mozambique US$3 billion and for Zimbabwe US$0.5 billion. Details of the distribution of the costs of damages and losses as well as recovery by sector are provided in the project's "Idai impact report" (CAR and HCA, 2020a). The damage and losses are highest in the productive sectors, in particular agriculture, infrastructure, and the social sector, in particular housing (Figure 18).

Figure 18: Estimated damage and losses due to Cyclone Idai (US$ million).



Sources: based on GoM, 2019 and GoZ *et.al*., 2019.

4.2.1 Impact on people's lives

People's lives were seriously affected in multiple ways. Lives were lost and people injured or displaced. Moreover, people's health was affected as well as their access to water and sanitary facilities.

Overall, 1.8 million people were directly affected or around 354,000 households (GoM, 2019: GoZ *et.al*., 2019). The same reports mention that almost 140,000 people were displaced, 3,200 injured and around 1,000 people lost their lives. In Zimbabwe 270,000 people were affected (54,000 households), mostly in Chimanimani and Chipinge districts. Some displaced persons were housed in temporary camps, but most stayed with other families. The International Organization for Migration (IOM[12]) estimated that more than half a year after Idai, over 43,000 people were still displaced (IOM-DTM, 2020); this is 72 % of the people initially displaced persons by the cyclone (60,000). In Mozambique, over 1.5 million people were affected (around 300,000 households), mostly in Sofala Province (1.2 million) and Manica Province (262,000). Some 79,000 people were displaced; 73,000 lived in accommodation centers in Manica, Sofala and a few in Tete and Zambezia. The most seriously affected population lived in the high rainfall area in Mozambique (Sofala), in flooded areas (Sofala) and in areas with landslides (Chimanimani). In Sofala Province, 53 % of the population was affected (GoM, 2019).

Following Cyclone Idai, outbreaks of cholera and malaria occurred in Mozambique involving 6,000 and 15,000 cases, respectively. In Zimbabwe, some cases of malaria, dysentery and diarrhea were reported but no cases of cholera, typhoid, measles, and rubella (per end of April 2019).

Figure 19 provides details of the affected population in relation to rainfall amounts. It also shows the settlements that received the heaviest rainfall.

Figure 19: Estimated affected BuPuSa population by heavy rainfall

Based on the geospatial assessment, it is estimated that 74 % of the population in the BuPuSa region lived in areas that received more than 200 mm of rainfall. Of these, 58 % lived in Mozambique and 42 % in Zimbabwe. Roughly a quarter of the population lived in areas that received up to 200 mm and 201—400 mm each; 47 % received more than 400 mm (of which 6 % over 600 mm).

Almost half of the BuPuSa population lived in areas that received more than 400 mm of rainfall; 67% of the BuPuSa population in Mozambique and 19% of the BuPuSa population in Zimbabwe. People were typically affected in Manicaland, Manica and Sofala.

In terms of settlements, 45 settlements received more than 200 mm of rainfall (5 in Zimbabwe); 28 settlements 400 to 600 mm (2 in Zimbabwe: Chimanimani and Chipinge). Three settlements received over 600 mm: Tica around 68,500 inhabitants), Inchope (36,500) and Nhamatanda (140,000).

Source: project.

4.2.2 Livelihood impacts

The livelihood impacts of Idai have been dramatic. These impacts were aggravated by the fact that most (rural) households depend on agriculture, the most heavily affected economic sector, and many already experienced livelihood stresses prior to Idai. Generally, agriculture dominates rural livelihood strategies

[12] Using its Displaced Tracking Matrix (DTM).

while households in urban areas have more diverse strategies based on different livelihood options, including employment and trading.

In rural Mozambique, households lost multiple livelihood sources: food, income from crops, fruits and vegetables, lost income and consumption from livestock and chicken sales, fish for fishing communities, alluvial gold mining, and lost limited (informal) employment opportunities. Moreover, multiple household assets were damaged or destroyed (e.g., water points, seeds, equipment/ machinery, animals, sanitary facilities, and opportunities to engage in informal business from home). As a result, poverty increased, and livelihoods became even less secure. Pre-Idai poverty levels were already above the national average of 46% (GoM, 2019) and poverty level was expected to increase steeply from 64% before to 79% after Idai (GoM, 2019). Consumption of staple food decreased by over 50 % and 1.4 million people required emergency food assistance.

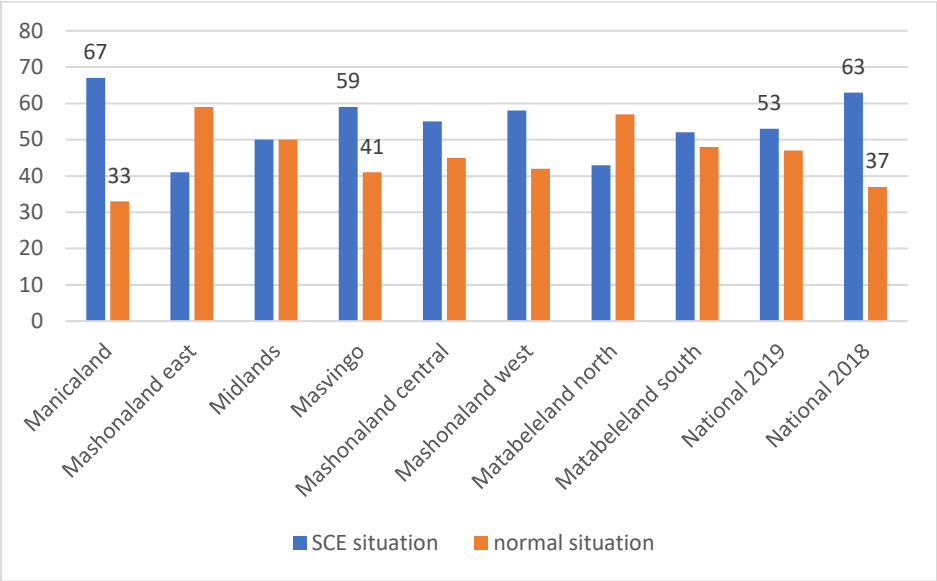
In urban areas of Mozambique, self-employment is the main source of livelihood of 40% of the urban households (GoM, 2019). In Beira, Chimoio, Tete and the district capitals formal employment in the public and private sectors is important too. Self- employment in agriculture and the informal sector, and formal employment in the private sector were seriously affected, while public servants' salaries were maintained (GoM, 2019). The self-employed and private sector workers were thus most adversely affected.

Subsistence agriculture is also the dominant livelihood source in rural Zimbabwe too. Secondary livelihood sources include employment (formal & informal), gold panning, vending and SMMEs. In urban areas, employment, and trading/small micro & medium enterprises (SMMEs) are important livelihood sources. Over half of the country's rural households experienced serious livelihood constraints in 2018 before Idai struck, i.e., they were under stress, in crisis or under emergency conditions (Figure 20). Households had to reduce their expenditures on agriculture and education in favor of food and health (ZIMVAC, 2020). Almost two-thirds of the rural households could not adopt any other coping strategy and were thus vulnerable to events like Idai. Households that managed to adopt coping strategies did this at great current and future costs as follows:

1. Stress measures: Borrowing, reducing savings, and selling of assets;
2. Crisis measures: Selling of productive assets, withdrawing children from school, and cutting non-food expenditures; and
3. Emergency measures: Selling land and breeding stock as well as begging.

Households sold animals and reduced their cereal stock and became dependent on external support from government, relatives/remittances, NGOs, UN, and churches.

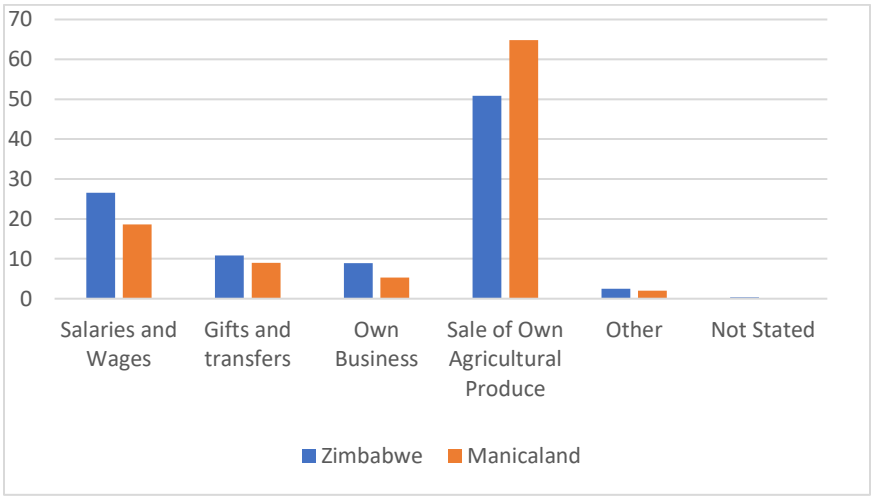
Figure 20: Rural livelihood conditions (as % of households).



Note: SCE = stress, crisis, and emergency livelihood situation.
Source: ZIMVAC, 2020.

The 2017 Zimbabwe Poverty, Income and Expenditure Survey (PIES) also showed that households already drew down on their assets prior to Idai (ZimStats, 2019). The survey found that an income gap of a factor three exists between rural and urban areas, and that in-kind income are important in rural (34 % of rural income) and urban areas (17 %). Rural households are highly dependent on the sales of agricultural produce (Figure 21) and thus the agricultural damage caused by the cyclone has had a profound negative impact on livelihoods, particularly in Manicaland.

Figure 21: Household main income sources (adults 18+; as %).



Source: Zimstats, 2019.

An attempt was made to estimate the impact of Idai on household income in Zimbabwe. Assuming the low range of housing damage costs, and further assuming that 75 % of the agricultural production losses are incurred by households, this together would amount to a loss of US$4,592 per household. This exceeds the average annual household income in 2017 and is more than double the average rural household income in 2017. This shows that livelihood losses have been huge and livelihood stress and emergencies must have worsened due to a decrease in household assets (cereal stock, some loss of livestock and damaged houses; see sections below). Most households became more dependent on external assistance.

The severity of the impact of Cyclone Idai on livelihoods can be seen from the comparison of the per capita (p.c.) private damage and losses and the average per capita income. P.c. damage and losses in Mozambique are estimated to be around US$ 840[13], as compared to the average p.c. income of US$ 590. Unfortunately, the RINA report does not distinguish private and public sector damage[14]. Assuming that only the damages in the productive and social sectors are private, the p.c. costs would be US$ 1,275 compared to a p.c. income of US$ 860, also more than the average p.c. annual income.

4.2.3 Impact on private assets

Houses

It is estimated that 250,000 to 300,000 houses were destroyed or damaged affecting 1.3 to 1.5 million people. In Mozambique, 110,000 houses were completely destroyed; 130,000 houses were partly destroyed. Sixty percent of these were in urban areas and in low-lying areas close to rivers. Small businesses run from home were also negatively affected (GoM, 2019). In Zimbabwe, at least 10,000 houses were destroyed and 17,715 were damaged, mostly in Chimanimani and Chipinge Districts (GoZ *et.al*., 2019). A RS assessment for RINA puts the figure lower at 10,730, two-thirds of which are in Chimanimani[15].

Business buildings

In Zimbabwe, Cyclone Idai damaged irrigation infrastructure, plantations of tea, sugar cane, fruit trees and forest plantations.

In Mozambique, Idai affected an estimated 429 private companies that employed 15,517 people[16]. The estimated damage was US$119.3 million (e.g., damaged warehouses and production interruptions[17]). In terms of numbers, the service & commerce sector was most affected; in terms of losses, industry and agribusiness suffered the highest losses, mostly large businesses with more than 100 employees (GoM, 2019).

The private sector also incurred some damage to private educational and health facilities. The private sector incurred around 3 % of the damage to educational facilities.

[13] This excludes the private costs and damage to the commerce and industry sector.
[14] RINA does not differentiate between damage costs and costs of losses.
[15] A recent IOM-DTM estimate puts the number of damage houses at close to 50,000: partial damaged 37,483 and destroyed 10,097. Only 3,047 households have received assistance as per December 2019.
[16] Excluding backyard informal businesses. Assuming each employee was a breadwinner, around 100,000 households may be affected.
[17] Six days in Sofala Province.

4.2.4 Impact on the agricultural sector

The cyclone's impact on crop production has been most serious, among the agricultural impacts. Livestock production, fisheries and forestry were affected to a smaller extent.

Dryland crop production

Cyclone Idai led to significant flooding of drylands. The floods were most widespread in Mozambique (GoM, 2019): an estimated 715,378 ha of cultivated land were flooded, affecting over 433,000 households. Sofala Province was worst affected: over 400,000 ha and close to 60 % of the province's households. Production losses were estimated at 2.2 million metric tons (MT), roughly a quarter of which was corn and cassava. Assuming all households cultivate corn and cassava, each household lost 2,472 kg of corn and cassava. Losses of fruits, vegetables and rice were also high. In addition to production losses, support infrastructure was damaged and or destroyed.

In Zimbabwe out of the total 1.4 million ha of dryland farming land, 46 % had possible flooding damage (GoZ *et.al.,* 2019, p.19). Maize and millet were the most affected food crops; both are staple crops for rural livelihoods, with production losses estimated around 580,000 MT. Considerable losses of fruit trees also occurred. Fruits trees are grown mostly for commercial but also for subsistence/ livelihood purposes.

Figure 22 shows the estimated impact of rainfall on cultivated land.

Figure 22: Estimated affected cultivated area by heavy rainfall

Based on the geospatial assessment, it is estimated that 61 % of the cultivated land in the BuPuSa region received 200+ mm of rainfall; this is around 38,000 km^2. In Mozambique, 85% of the cultivated land received more than 200 mm of rainfall compared to 49% in Zimbabwe.

The heaviest rainfall was in Mozambique: Most very heavy rain (over 400 mm) fell in Manica, Manicaland and Sofala Provinces. Manica and Sofala in Mozambique received over 600 mm of rainfall. Almost 45% of the rainfall affected areas received over 400 mm of rain in Mozambique compared to 3% in Zimbabwe.

Source: project.

Irrigation

The impact on the irrigation sector has been smaller than that on dryland farming. In Mozambique, over 4,300 ha of irrigated land and associated infrastructure were damaged or destroyed, mostly small and medium farms (almost 3,400 farms in total). The production losses are not known. The impact on the irrigation sector has been larger in Zimbabwe. Over 1,500 irrigation schemes may have washed away or were damaged (GoZ *et.al*., 2019). Detailed information is only available for 18 schemes in Chimanimani and Chipinge, which shows that some 2,300 ha of irrigated land was damaged affecting over 5,000 farmers. The schemes vary significantly in size and number of farmers. The total affected irrigated area is probably much bigger but could not be estimated.

Livestock

Livestock losses have been relatively low. In Mozambique, around 6,000 cattle, 2,000 goats and sheep and over 3,000 pigs died (GoM, 2019); in addition, around 400,000 chickens died. Most livestock losses in Mozambique occurred in Sofala Province (8,696, excl. chicken) and to a lesser extent Manica Province

(1,302). In Zimbabwe, around 1,400 cattle died, around 500 sheep, 50 goats and 13,443 chicken, mostly due to landslides (GoZ *et.al*., 2019).

A significantly larger number of livestock may have been affected by Idai because of poorer forage conditions, limited access to water and increased disease risks; possibly up to 500,000 animals in Mozambique, excl. chicken (GoM, 2019).

Fisheries

The fisheries sector in Mozambique was hard hit by the cyclone, especially in Sofala Province. Over 2,100 boats were damaged affecting 10,000 to 15,000 people. Lost fish production in Sofala Province was estimated at 5,210 MT; no figures are available for other provinces (GoM, 2019). Aquaculture was also hard hit. Almost 600 aqua ponds were affected with estimated production loss of 375 MT. Most of the sector's support infrastructure in Sofala Province was damaged.

Forestry

Detailed impacts on the forestry sector are not documented. Forestry is important for commercial production (timber) and for subsistence livelihoods (timber, firewood, and other non-timber products).

In Mozambique, forest resources are important for rural livelihoods and communities. In addition, there are 177 privately managed forest concessions for timber production. The impact of the cyclone on these plantations is, however, not documented.

The basin-wide geospatial assessment filled estimated the areas of tree losses at a provincial and national level at close to 14,000 km^2 (Table 6)[18].

Table 6: Satellite-based estimated tree cover loss (in km^2).

Country	Province	Estimated loss (km^2)
Mozambique	Gaza	236
	Inhambane	1,129
	Manica	3,103
	Sofala	3,520
Mozambique Total		**7,988**
Zimbabwe	Manicaland	1,307
	Mashonaland East	500
	Masvingo	2,550
	Midlands	975
	Matebeleland South	578
Zimbabwe Total		**5,910**
Grand total		**13,898**

Source: this project.

[18] Based a change detection: movement from dense vegetation to sparse vegetation; dense vegetation to grassland or sparse vegetation to grassland. The combination of these three changes is what is recorded as tree loss. .

Losses were most extensive in Mozambique, with a total tree cover loss estimate of 7,988 km^2, with lower losses seen in Zimbabwe (5,910 km^2), possibly due to reduced windspeeds as the cyclone moved further inland and weakened. Sofala and Manica Provinces in Mozambique were hardest hit. In Zimbabwe, the cyclone's impact on forests was most severe in Chipinge and Chimanimani Districts.

The total affected forest area is estimated at around 12,000 km^2 or 4 % of the affected provinces. The RINA report does not quantify the forest damage, but it assumes that the damage increases with the amount of rainfall. The report estimates the forest area at 11,724 km^2. Over 40% of the forests experienced high rainfall. Chimanimani and Chipinge Districts accounted for over a third of the rainfall affected forests and for almost two third of the high rainfall affected forest (GoZ *et.al*., 2019).

The project's geospatial assessment showed that close to 31,000 km^2 of forest received more than 200 mm of rainfall (Figure 23).

Figure 23: Estimated affected forest area by heavy rainfall.

Based on the geospatial assessment, it is estimated that 76 % of the forests in the BuPuSa region received 200+ mm of rainfall; this is around 31,600 km^2. In Mozambique, 89 % of the forests land received more than 200 mm of rainfall compared to 45% in Zimbabwe.

The heaviest rainfall was in Mozambique: most very heavy rain (over 400 mm) fell in Masvingo, Manica, Manicaland and Sofala Provinces. Manica and Sofala in Mozambique received over 600 mm of rainfall. Almost 40 % of the rainfall affected forest areas received over 400 mm of rain in Mozambique compared to 16 % in Zimbabwe.

Source: project.

4.2.5 Impact on public infrastructure

Educational facilities

Close to 1,900 educational facilities were damaged by Idai, most of these in Mozambique. In that country, 1,380 educational facilities were damaged or destroyed, ranging from preschools to universities and teacher training institutes. Between 3,500 and 4,200 classrooms were damaged, affecting more than 330,000 students[19] and 9,616 teachers. Sofala Province was most affected. Public schools accrued 97 % of the damage; private school had limited damage. The RINA report (GoZ *et.al*., 2019) does not provide figures for affected educational facilities in Zimbabwe. The IOM-DTM (2020) assessment estimated that 460 schools were still damaged in December 2019 in Manicaland and Masvingo province; 85 in Chipinge and 38 in Chimanimani.

Health facilities

Between 200 and 300 health facilities were damaged by Cyclone Idai. In Mozambique, 94 health units were affected, representing 14% of the health facilities. Reduced access to health services led to outbreaks of communicable diseases (cholera, diarrhea, fever, and malaria). OCHA (2019) reports that cholera cases remained relatively low, but over 30,000 malaria cases were reported. Overall, the cholera

[19] The number of educational facilities in these provinces is unknown. However, it is calculated that 6.4% of the total enrolled students in the four provinces have been affected (based on GoM, 2019, p. 104). It is possible that around 5-10 % of the educational facilities have been damaged.

outbreak involved 6,727 cases and 8 fatalities[20]; the risk of malnutrition rose significantly. In Zimbabwe over half of the 315 health facilities in the affected areas, had 'possible flood damage' (24th March 2019) and 145 'moderate or probable rainfall damage' (GoZ *et.al*., 2019, p.37). Hospitals (131) and rural health centers (27) were most affected. Later assessments by the World Health Organization (WHO, 30th of April 2019) and the Ministry of Health and Child Care (MHCC) are much lower: 12 and 28 affected hospitals and health centers, respectively. The IOM-DTM assessment (2020) showed that in December 2019 70 clinics were still damaged, 19 of which were in Chipinge, 16 in Masvingo and 3 in Chimanimani. The damage to the buildings also affected the stored drugs and drug shortages were further aggravated by the transport disruptions due to damaged road infrastructure.

Road infrastructure

Road infrastructure was seriously affected, hampering relief and reconstruction efforts. Over 5,000 km of roads were affected: in Zimbabwe mostly regional and local roads but in Mozambique also national roads. In Mozambique, 4,613 km of roads became impassable. Beira harbor and airport were damaged disrupting cargo and personal travels for some days. In Zimbabwe, 865 km of roads were damaged, mostly tertiary roads, making local travel difficult or impossible. The damage was concentrated in Chimanimani and Chipinge Districts. Access to Mutare by road was seriously affected. The project's in-depth geospatial assessment showed that in Chimanimani the main road remained relatively intact, but many minor side roads were severely damaged, especially those in the paths of landslides.

Water and Sanitation (WASH)

The water and sanitation infrastructure were damaged or temporarily unable to operate because of energy supply interruptions. Urban water supply systems were mostly affected by energy supply interruptions. For example, the Beira/Dondo system was disrupted for ten days, affecting some 340,000 people. In rural areas households had to buy bottled water after their waterpoints were affected. In Mozambique, the water supply of almost 1.5 million people was affected, and almost one million people had their sanitary facilities affected. Virtually all rural latrines were destroyed, and open defecation increased from 23 % to 46 % of the households in the 14 hardest hit districts (GoM, 2019).

In Zimbabwe, households use a variety of water points, of which boreholes, deep wells and springs were most affected. Based on RINA data, over 70,000 households and over 300,000 people had their water sources affected. The damage to springs had the largest impact on households and people. The IOM-DTM assessment (2019) indicates that in December 2019 299 boreholes and 44 water springs were still damaged. Over one third of the rural households have no sanitary facility. Around 7,400 pit latrines were damaged and 32 toilets at schools and health facilities (GoZ *et.al*., 2019). Almost 80 % of the damaged pit latrines were in communities; the balance at schools and health facilities. Just over 10 % of the affected households had their sanitary facilities damaged, necessitating use of neighbors' facilities, or open defecation with its associated health risks.

Electricity infrastructure

Mozambique's electricity infrastructure was seriously damaged in Beira and several other settlements (GoM, 2019). In Zimbabwe, power generation infrastructure was not severely affected; damage was

[20] Earlier figures are lower (ECDCP, 2019). OCHA is quoted to report 3 577 cholera cases. Among these cases, six deaths were reported. The main affected areas in Mozambique are Beira, Nhamatanda, and Dondo (8th April 2019).

confined to some transmission and distribution facilities (GoZ *et.al*., 2019). The number of households with power outages due to Idai is not known, but it is safe to assume that the cyclone had an adverse impact on households with electricity as well as public services and the private sector. Furthermore, the fuel pipeline from Beira to Harare was damaged and temporarily closed in Zimbabwe but fuel transport by road avoided severe fuel shortages in other parts of the country.

4.2.6 Social impacts

No dedicated social impact assessment of the cyclone has been carried out. It is known, however, that Cyclone Idai caused a wide range of social impacts, including disruption of community and family relationships, displacement of persons and families, resettlements, losses of breadwinners and jobs and increased hardships due to livelihood losses. This may have led to gender-based violence (GBV) and conflicts between and within families. In the worst affected areas, people also suffered post-traumatic disorders. Vulnerable groups were disproportionally affected as their adaptive capability is low: they live in high-risk areas, have poor houses and/or live in informal settlements with limited access to public services

In Mozambique, the PDNA (GoM, 2019) discussed the plight of six vulnerable groups: children, the elderly, people with disabilities (PWD), people living with HIV, internally displaced persons (IDP) and women. Assuming that the population affected by the cyclone has the same percentages of vulnerable groups as the entire country:

a. Around 750,000 children have been affected by the cyclone;
b. Around 100,000 orphans and vulnerable children are affected. Child labor and abuse of children is likely to have increased;
c. Around 75 % of the elderly needed urgent assistance after the cyclone;
d. Around 110,000 PWDs were directly affected by the cyclone. They are at greater risk of violence, exploitation, and abuse;
e. Disrupted access to health facilities led to a drop in HIV/AIDS consultations and possible increased infection rates. Livelihood losses may have increased sex work and associated risks of sexually transmitted diseases (STDs) and HIV/AIDS;
f. Around 161,000 IDPs were accommodated in 164 temporary shelters in April 2019; and
g. Increased gender-based violence (GBV). OCHA Situation Report 22 mentions 44 GBV cases from mid-March to mid-May 2019. At least 7,000 women were at higher risk of being raped (GoM, 2019a). Delivery risks of pregnant women increased due to limited access to safe maternity services.

In Zimbabwe, social impacts of the cyclone mostly occurred in Chimanimani and Chipinge Districts due to the high number of affected households (OCHA, 2019b). As in Mozambique, vulnerable groups were most seriously affected, including the poor, children, PWDs[21], IDPs and women. Some GBV cases and rape were reported, some 710 children were orphaned, and over 50,000 people were displaced. IDPs are concentrated in Chimanimani and Chipinge Provinces, most living with host communities and families. Tensions may have arising between IDPs and host communities, particularly where the recovery process was slow and IDPs received more humanitarian assistance than the local population.

[21] Around 9 % in Manicaland and Zimbabwe at large.

4.2.7 Environmental impacts

No dedicated environmental impact assessment of Cyclone Idai has been conducted; however, both country Idai impact assessments (PDNA and RINA) contain some qualitative environmental assessments. The BuPuSa region is relatively rich in terrestrial[22] and aquatic biodiversity. In Zimbabwe, it includes mountainous terrain stretching into Mozambique where it ends at the coast with estuaries and mangrove forests. Protected areas (PAs) accounted for around 5 % of the area affected by the cyclone.

In Mozambique, the Idai affected area has six Protected Areas (PAs) covering 27,779 km^2, including Chimanimani Nature Reserve which is part of the Trans Frontier Conservation Area (TFCA) with Zimbabwe, and Gorongosa National Park (GNP) in Mozambique, which has been restored after the country's civil war. PAs are important for biodiversity protection, but they also generate income and contribute to local livelihoods. For example, GNP is the largest non-government employer in Sofala province (GoM, 2019). The BuPuSa area has mangrove forests which provide important ecosystem services. These forests were damaged, but the damage has not been quantified or costed. The damage has adversely affected local livelihoods (e.g., lost timber, fuel, and food).

In Zimbabwe, the heavy rainfall associated with Idai caused landslides, soil erosion and serious land degradation. Riverbeds were destroyed by boulders coming down from the mountains. Some boulders remain unstable, risking more landslides. Inadequate waste management and dumpsites also contributed to landslides. Some 39 PAs were affected by Idai with a total size of 4,711 km^2 or 1.6 % of the area of the affected provinces (GoZ *et.al*., 2019). The damage in the PAs has not been quantified but -similar to the estimated forest damage- the RINA (GoZ *et.al*., 2019) assumed that the damage is correlated to rainfall amounts. Almost half of the PAs got over 50 mm of rainfall and almost a quarter of the PAs got more than 100 mm, mostly Chipinge and Chimanimani Districts (GoZ *et.al.*, 2019).

The project's geospatial assessment estimated that over 30,000 km^2 of PAs[23] received more than 200 mm of rainfall (Figure 24); 79% of this in Mozambique, mostly in Sofala Province. More than 40,000 km^2 had experienced another cyclone prior to Idai, mostly in Mozambique's Manica and Sofala Provinces.

Figure 24: Estimated affected forest area by heavy rainfall.

Based on the geospatial assessment, it is estimated that 81 % of the Protected Areas in the BuPuSa region received 200+ mm of rainfall; this is around 31,700 km^2. In Mozambique, 88 % of the forests land received more than 200 mm of rainfall compared to 53 % in Zimbabwe.

The heaviest rainfall was in Mozambique: Most very heavy rain (over 400 mm) fell in Manica and especially Sofala Provinces of Mozambique. Only Protected Areas in Sofala received over 600 mm of rainfall. Over 35 % of the PAs in Mozambique received over 400 mm of rain in Mozambique compared to none in Zimbabwe.

Source: project.

Cyclone Idai destroyed all hydrological stations in the Buzi River, depriving Zimbabwe, and Mozambique of vital data regarding river flows and early warning options for future floods. This adversely impacts on the water resource management and flood predictions in the BuPuSa region.

[22] The area comprises seven WWF Terrestrial Ecoregions (see Figure 4).

[23] The RINA estimate for PAs is much lower at 4,710 km^2 (GoZ *et.al.,* 2019, p.60). This may be due to different data base. RINA is based on http://pubs.usgs.gov/ds/832/. The project's geospatial assessment used https://www.protectedplanet.net/en.

4.3 Consultation views

A wide range of stakeholders in and outside governments in Mozambique and Zimbabwe were consulted through a survey (extended response group), interviews and virtual focus group discussions (core response group)[24]. Consultations were concluded with a virtual regional workshop (19th November 2020). The findings in this section refer to the perceived impacts of Cyclone Idai.

Asked about the three severest, national level impacts of Cyclone Idai, loss of livelihoods and life, diversion of scarce financial and human resources from other sectors for Idai relief, destruction of /damage to infrastructure, and negative impacts on the national economies of both countries were most frequently mentioned (Table 7). However, several other impacts were mentioned, such as loss of infrastructure, deepening food crisis, communication disruptions and other loss of properties. Challenges of relief co-ordination were mentioned in Mozambique. Government officials in both countries highlighted the damages to critical infrastructure and economic losses as key national level impacts.

Table 7: Perceived national impacts of Cyclone Idai.

MOZAMBIQUE (10 responses)	#	ZIMBABWE (12 response)	#
Human and financial resources were diverted from other sectors to meet Idai demands.	7	Loss of livelihoods	6
Destruction of social and economic infrastructure	5	Negative impact on economy of the country	6
Loss of life	3	Diversion of scarce financial resources to the relief efforts	6
The downturn in economic activities in the central part of the country affected the national economy.	3	Diversion of human capacity and attention for coordination, relief efforts etc.	5
Intense shock to a challenged socio-economic and political climate.	3	Displacement from homes	4
Disruption of livelihoods, increased food insecurity	3	Loss of lives of citizens	3
		Loss of strategic infrastructure such as roads, bridges, and government buildings	3

Note: only impacts listed by at least 3 respondents.
Source: project consultation.

Destruction of the social and economic infrastructure were most frequently mentioned as severe provincial impacts in Mozambique and Zimbabwe (Table 8). e loss of human life was ranked as severe in Mozambique while in Zimbabwe the diversion of human capacity was more frequently listed than loss of life. The diversion of human and financial resources as well as the strong focus on the Idai response were common responses in both countries. Through the examples provided, we can infer that the impacts of the cyclone highlighted the deficiencies in existing DRM structures and processes. In Mozambique, this perception was demonstrated in the alleged absence of clearly laid-out, well-known disaster response

[24] Stakeholder categories included relevant institutions and organizations across government, International Co-operating Partners (ICPs), Non-Governmental and Community Based Organizations (NGOs and CBOs) and Private Sector organizations involved in the Cyclone Idai response. A separate consultation report was prepared (CAR, 2020).

plans and late, inaccurate information. In both countries, co-ordination challenges between the national, district and provincial levels were raised. Government officials in Mozambique and Zimbabwe highlighted the socio-economic impacts of loss of lives, injured and missing persons and the adverse impacts on livelihoods. Critical infrastructure was lost in both countries, ranging from housing/shelter, schools, hospitals, sanitation facilities, farms, dams, communication infrastructure, airstrips, and roads. In Mozambique, environmental impacts included soil erosion that adversely effected river levels and most river basins experienced by salination by seawater intrusion. The cyclone disrupted WASH sector services, through contamination of and damage to water sources as well as sanitation infrastructure.

Table 8: Perceived main provincial and district impacts of Cyclone Idai.

MOZAMBIQUE (10 responses)	#	ZIMBABWE (11 responses)	#
Destruction of social and economic infrastructure	6	Destruction of infrastructure such as roads, schools, health centers etc.	8
Loss of human life	4	Diversion of human capacity	5
Lack of access routes and communications channels	3		
Downturn of the regional economy	3		

Note: only impacts listed by at least 3 respondents.
Source: project consultations.

Table 9 shows the most frequently mentioned three most severe impacts of Cyclone Idai at community level. The most frequently mentioned impacts were loss of lives, destruction/loss of livelihoods, home and other properties/ means of production, displacement, and increased poverty. Injuries, trauma, loss of crops/ hunger, and family disruptions were also mentioned. The loss of market access also emerged as an impact.

Table 9: Perceived main community impacts of Cyclone Idai.

MOZAMBIQUE (10 responses)	#	ZIMBABWE (12 responses)	#
Houses were destroyed and people displaced from their homes.	8	Destroyed livelihoods especially in the crops and animal lost - cattle, goats, and sheep	10
The cyclone left poverty in communities having lost almost everything	7	Loss of lives	7
Loss of property and assets	5	Loss of homes and property	5
Loss of access to safe drinking water	4	Destruction of infrastructure leading to challenges having access to critical needs-food, water, shelter, health, education, and roads.	3
Loss of lives	4	Trauma/community distress	3
Destruction of means of production (e.g., fields, tools, animals)	3	Poverty, hunger, and homelessness are the major problems because victims lost everything including animals	3

Note: only impacts mentioned by at least 3 respondents.
Source Project consultations.

The Mozambique core response group (CRG) underlined the damage caused by the cyclone to farms and other community livelihood assets along the river basin. The Zimbabwe CRG highlighted the damage to

road networks, schools, health facilities, the business infrastructure, loss of business and revenues as well as the psycho-social and mental challenges that came with the disaster. Hydrological impacts include damage to 16 hydro stations while many were completely washed away. Chimanimani and Chipinge were the most affected districts. The Zimbabwe National Water Authority (ZINWA) now fails to retrieve hydrological data for early warning. This highlights the importance of regular maintenance of critical infrastructure. The irrigation sector was also reported to have been severely affected with adverse impacts on rural livelihoods as many households depend on small scale irrigation. Three of ZINWA's irrigation schemes were damaged.

4.4 Impact 'worsening' and 'softening' factors

The impacts of Cyclone have been described in this chapter. These impacts have 'worsened' or 'softened' by pre-existing factors in each country. The dominance of aggravating factors tends to make the impacts worse while in contrast 'softening factors reduce the scope and magnitude of impacts. These factors are summarized below based on available literature and the project consultations.

The consultations showed that the impact aggravating and ameliorating factors were numerous, divergent and in some instances, contradictory. In both countries the limited capacity of disaster preparedness and response mechanisms as well as insufficient human and financial resources emerged as aggravating factors. That such capacity although insufficient was available, however, saw respondents viewing capacity, experience, and humanitarian support also as ameliorating factors. Unfavorable pre-Idai economic conditions and poor land-use planning were in both countries viewed as other aggravating factors. Another similarity is that in both countries, local knowledge, experiences, and lessons learned from previous disasters were mentioned as softeners.

A key difference in ameliorating factors in the two countries is that in Mozambique, the role and contribution of government through the National Disaster Management Institute (INGC) was highly acknowledged while in Zimbabwe the roles of ICPs and Non-State Actors (NSAs) were seemingly affirmed more.

During consultations in Mozambique many worsening and softening factors were mentioned, but few factors were frequently mentioned as compared to the impacts. These factors are summarized in Tables 10 and 11 below. The country's low-income status was mentioned, together poor communications with the disaster affected population as well as the logistical capacity challenges associated with community poverty and settlements in high-risk areas as aggravating factors. Other worsening factors mentioned included the lack of search and rescue means, non-flood and cyclone resistant infrastructure. Softening factors included many community engagement and participation related aspects such as the community notices put out by DRM institutions, existence of local DRMCs and evacuation plans. Local knowledge about the area, experiences with earlier disasters and the lessons learned contributed to strengthening community resilience to the Cyclone Idai disaster. The leadership and good co-ordination of the INGC working closely with the Technical Council for Disaster Management, the COE and over 400 humanitarian relief organizations softened the impacts.

In the consultations in Zimbabwe, lack of disaster preparedness at the national and local levels, low adaptive capacity by communities, ineffective early warning and early action systems were frequently mentioned as impact worsening factors. Drought conditions that prevailed in Zimbabwe when the cyclone hit also stood out in terms of the frequency of the worsening factors stated. The capacity and experience of ICPs as well as the swiftness of interventions by NSAs were the most frequently mentioned ameliorating factors, stated by respondents.

Table 10: Idai impact softening factors (Mozambique)

	Impact softening factors	Consequence for impact
	Physical environment	
	No springtide during Idai landfall	Flooding would have been far worse in Beira, Sofala and Zambezia
	Presence of trees in residential areas	Trees worked as wind breakers and reduced damage to houses and buildings in Beira
	Improved weather information	Improved and more detailed forecasting, predictions, and warnings
	Infrastructure	
	Partial rehabilitation of Beira's drainage system	Flooding was limited in the parts of Beira with a rehabilitated drainage system; maintenance of critical infrastructure is essential.
	Existence of pre-existing WASH and food aid infrastructure facilities & programs (at provincial level)	Rapid mobilization and upscaling of WASH and food aid efforts.
	Some DRR equipment and facilities at the local level through the local DRMCs in Mozambique (e.g., shelters)	Rapid local response and relief efforts. Some equipment was poorly maintained, limiting the benefits. Local DRMCs need to be expanded , trained, equipped and equipment maintained
	Social capital	
	Self-help spirit; Solidarity and cooperation within communities and sharing of resources, knowledge, experiences, and ideas	Essential to bridge the gap of government responses and support government and ICP relief.
	Oneness & co-operation as communities at the provincial & district levels	Aided rapid responses and relief.
	Co-operation between non-state actors and the government (Zimbabwe) also in the DRM Platform	Aided rapid response and partnerships
	Local & private sector willingness to assist the affected communities.	Increased capacity, aided rapid responses & partnerships
	DRM structures & processes	
	Both countries have existing DRR structures and procedures. Mozambique local DRMCs with evacuation plans and designated shelters	useful for immediate relief and limiting casualties and injuries; Timely evacuation of communities in risk zones
	INGC and DCP leadership. Good coordination, institutional co-operation, and a spirit of solidarity in prevention and mitigation activities	Quick mobilization of 400 ICPs in Mozambique for relief & response.

	Both countries have early warning systems.	Helped rapid responses. EWS down to the community level is essential but not enough. There is evidence that households do not necessarily use EWS information.
	Community notices issued by natural DRM entities in Mozambique	Timely evacuation of communities in risk zones
	Quick response from NSAs in terms of funding and technical assistance	Faster and bigger response & relief efforts

Table 11: Idai Impact worsening factors Mozmabique).

	Worsening factors	Consequence for impact
	Socio-economic conditions	
	Pre- existing food insecurity due to droughts in both countries	This increased the household vulnerability and made many dependent on food aid
	Pre-Idai refugees and asylum seekers (Zimbabwe)	Put extra pressure on humanitarian relief, including shelters and camps
	High incidence and severity of poverty, especially in Zimbabwe	Increased the size of vulnerable groups and limited their coping options; No buffers and coping mechanisms; dependency on external support
	Rural livelihood dependency on agriculture and lack of diversification	Increase livelihood vulnerability to droughts and cyclones *The poor performance of the economy and devastating effects of Cyclone Idai negatively affected the livelihoods of both rural and urban households*". (RLA, 2020, p.15)
	Difficult macro-economic conditions: government budget constraints; hyper-inflation, forex shortages.	Underfunding of DRM Funds and dependency on foreign assistance; may have slowed down the immediate relief response. ICPs support mostly through non-government institutions in Zimbabwe.
	High incidence of HIV-AIDS	Increased vulnerability & dependency in health care infrastructure; High opportunity costs for government and households
	Unequal distribution of support and people seeking to profit	Unbalanced relief & responses; reduced aid efficiency
	International sanctions (Zimbabwe) and no access to IMF loans (Mozambique)	Increased macro-economic problems and limiting growth opportunities as well as Idai recovery.
	Physical environment	
	Climate change aggravates intensity of cyclone and causes sea level rise; conflicting thoughts about frequency of cyclones	Intensifies the impacts of the cyclone. The frequency and intensity of cyclones is expected to increase in Mozambique. Mozambique and Zimbabwe are expected to experience more frequent and severe droughts (already the most important natural hazard)
	Cyclone Kenneth came soon after Idai. and made things even worse. Displacement	Worsened impacts in Mozambique and challenged Idai relief and responses.
	Infrastructure	
	Vulnerable, non-cyclone-resistant and flooded infrastructure.	Large damage to infrastructure; disruption of relief and reconstruction interventions
	Poor development and maintenance of public infrastructure	Poorly maintained coastal defense structure worsened the cyclone's impacts in Beira. Increased damage to public facilities and infrastructure Too much pressure on local services
	Insufficient local search and rescue means	Limits local relief and preparedness capacity

	Worsening factors	Consequence for impact
	Break down of communication	Restricts options to coordinate and implement relief and recovery efforts
	Inadequate building standards & regulations	Increased vulnerability of buildings and infrastructure
	DRR/DRM	
	High risk exposure to multiple types of natural disasters; drought is the most common disaster in both countries (INFORM)	Limited capacity to manage natural hazards; need to be prepared for diverse natural disasters.
	Lack of effective national and local cyclone preparedness in Zimbabwe	Non-state actors had to come to the rescue
	Lack of details and action-orientation of early warning; information about the strong winds was inadequate	Limited the benefits of EWS
	Limited DRR & DRM capacities; inadequate integration of CCA and DRM putting more capacity constraints	Delays in coordinated responses
	Limited understanding of and awareness about cyclone's intensity risk at an institutional and individual level	Underestimation of cyclone impacts.
	Limited implementation capacity of DRR structures implementation in national and community-based development organisations	Slows down and limits relief & recovery efforts
	Lack of DRR preparedness, especially at local level (Zimbabwe) Mostly reactive DRR orientation (both countries)	Future impacts of a cyclone could be similar or worse. This aggravates the impacts rather preventing them from happening.
	Development & land use planning	
	People living in high-risk areas, low areas, and informal settlements	This worsened the impacts of on people and households. This factor is linked to poverty and vulnerable groups. Larger adverse impacts; need for resettlement etc.
	Water Resource Management	
	Absence of a transboundary DRM approach. This does not yet exist	National DRM approach is limited in scope. Surprises, inefficiencies etc.

5 Recovery, mitigation, and prevention assessment

The cyclone's impacts and the impact 'softeners" and 'worsening" factors have been discussed in chapter 4. This chapter focuses on how the impacts have been handled in terms of reconstruction, mitigation, and preparedness for the next cyclone. DRR and DRM are essential to mitigate impacts and prevent or be prepared for impacts of future disasters. DRR and DRM can be captured in the "DRM cycle" that aims to offer relief, reconstruction, mitigation, and prevention associated with preparedness for future disasters. The DRM cycle commonly distinguishes four phases:

a. **Response and relief**. Responses are "a*ctions taken directly before, during or immediately after a disaster in order to save lives, reduce health impacts, ensure public safety and meet the basic subsistence needs of the people affected*" (www.undrr.org). Response and relief are short term interventions (up to 1 to 2 years);
b. Recovery and rebuilding; Recovery aims at "*restoring or improving of livelihoods and health, as well as economic, physical, social, cultural and environmental assets, systems and activities, of a disaster-affected community or society, aligning with the principles of sustainable development and "build back better", to avoid or reduce future disaster risk*" (www.undrr.org). Recovery and rebuilding are typically short- and medium-term interventions (e.g., up to 5 years);
c. **Mitigation and prevention**. Mitigation of a disaster is defined as "*the lessening of the potential adverse impacts of a hazardous event or physical hazards'* (source: www.undrr.org). Prevention refers to "a*ctivities and measures to avoid existing and new disaster risks"* (www.undrr.org). No timelines exist for mitigation and prevention interventions as these should be continuous efforts; and
d. **Preparedness.** Preparedness refers to the "*knowledge and capacities developed by governments, response and recovery organizations, communities and individuals to effectively anticipate, respond to and recover from the impacts of likely, imminent or current disasters*" (www.undrr.org). Ideally countries and communities should always be fully prepared.

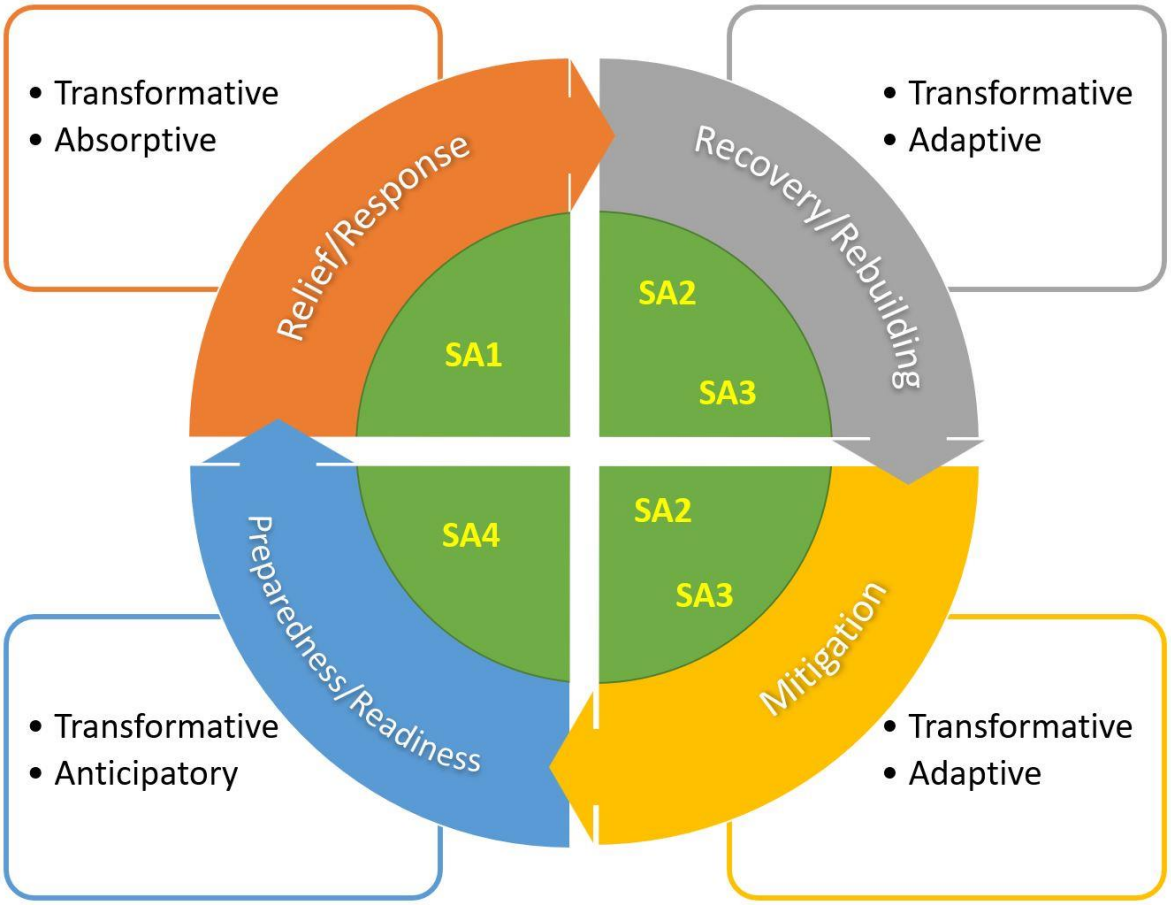
This chapter focuses on measures that **have been taken** and measures that **could be taken in future** to mitigate and prevent impacts and be prepared for the next disaster. "*As we know, after the event is before the next event"* (Norton *et.al.*, 2020).

Increasingly, mitigation measures are incorporated in recovery and rebuilding interventions as the above terms show. For example, recovery and rebuilding efforts in the PDNA and RINA assessments (GoM, 2019 & GoZ *et.al.*, 2019) include Building-Back-Better (BBB), resilient building designs, building codes, resettlement plans and livelihood diversification. Mitigation is also linked to preparedness as preparedness contribute to **actual** impact reduction. Therefore, this chapter will also include preparedness measures.

Figure 25 shows the DRM cycle with linkages to the four Sendai key areas (UN, 2015) and the four abilities of the SADC Resilience Framework (SADC, 2019). The figure shows the DRR cycle, starting with relief/response interventions on the upper left side, moving towards recovery/ reconstruction, mitigation, and preparedness/ readiness for the next disaster, and where the Sendai key areas and the abilities of the SADC Resilience Strategy Framework fit in. The absorptive ability determines that nature and intensity of impacts, while adaptive ability determines that recovery/rebuilding process as well as mitigation.

Anticipatory ability determines the preparedness for the next disaster, e.g., based on improved data and modeling, better EWS and implementation of lessons learned.

Figure 25: The DRM cycle with Sendai key areas and SADC resilience strategy abilities.

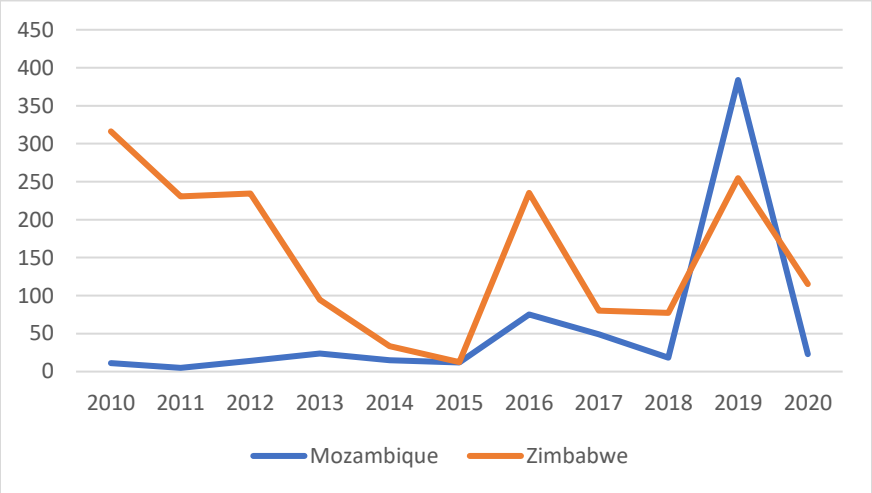


Notes: transformative ability applied to the entire DRM cycle; SA are Sendai key areas. SA1 = understanding the disaster; SA2= strengthening DRM structures; SA3 = Investment in DRR and SA4 = disaster preparedness. the diagram can be used at different spatial levels (e.g., community, district, province, country and BuPuSa.

Given their vulnerability, both countries depended on external assistance for relief and reconstruction efforts. International financial support for Mozambique and Zimbabwe is mostly destined for relief efforts (e.g., droughts and floods). Only a small part is earmarked for recovery projects, rebuilding and mitigation. A multitude of bilateral and multilateral agencies as well as NGOs offered humanitarian assistance, causing capacity and coordination challenges in recipient countries.

Figure 26 shows the international humanitarian relief for Mozambique and Zimbabwe since 2010. The increase of 2019 funding for Idai relief efforts is clearly visible, probably amounting to around US$ 500 million. Zimbabwe received almost three times the amount of Mozambique, i.e., on average US$153 million per annum, mostly for food aid. Over the period 2010-2020 to-date, financial assistance to Zimbabwe totaled US$1.7 billion while Mozambique received US$629 million.

Figure 26: Humanitarian relief funding for Mozambique and Zimbabwe (2010- June 2020; US$ million).



Note: 2020 figure is for the period January-June.

Source: www.fts.unocha.org.

5.1 Response and relief

Response and relief efforts comprised saving of lives (e.g., evacuation), movement of affected people to safety (e.g., shelters, family, or friends), emergency supplies of water, sanitation and hygiene kits and food aid. The response and relief efforts have been rapid and substantial in both countries. Within a few months, countries and ICPs carried out comprehensive need assessments (PDNA in Mozambique and RINA in Zimbabwe) and governments, led by INGC in Mozambique and the DCP in Zimbabwe led domestic relief efforts. Given the countries' vulnerabilities prior to Idai, both countries depended on external support from a wide range of ICPs (UN agencies, World Bank, IMO, and international NGOs). Significant support programs (WASH and food aid) were already in place and were quickly expanded to Idai affected areas.

Relief and response efforts are not yet completed in November 2020, among others, because of insufficient funding and capacity constraints. However, international relief efforts are being scale down as other disasters, including Covid-19, have occurred and compete for limited urgent relief funds. Figure 27 shows the outstanding Idai relief needs in Zimbabwe.

Figure 27: Outstanding Idai relief needs in Zimbabwe's Humanitarian Response plan 2020.

A year after Cyclone Idai hit Zimbabwe, 128,270 people remain in need of humanitarian assistance across the 12 affected districts in Manicaland and Masvingo provinces, particularly in the districts of Chimanimani (14,839 individuals), Chipinge (63,245 individuals) and Buhera (8,565 individuals). Almost all (97 %) of the IDPs reside with host communities; only 3% shelter in 4 established IDP camps, accommodating 224 households (953 individuals) in Chimanimani.

Out of the 25,160 households in need of shelter support, only 3,000 are currently receiving it, and a significant number of households in host communities is still in need of transitional shelters.

At least 87 % of the IDPs in Chimanimani, Chipinge and Buhera districts have returned to their original homes which were not properly repaired. In January 2020, Manicaland province received fresh violent windstorms, significantly increasing damage to houses already impacted caused by Cyclone Idai.

Emergency shelter (tarpaulins) are now uninhabitable, while others are staying in makeshift structures. Relocation of IDPs is not feasible in the short term and it is anticipated that IDPs will remain in the camps for the next 6 to 12 months.

Source: GoZ and UN, 2020.

The Zurich Flood Resilience Alliance[25] conducted a Post Event Review Capability (PERC) study for Cyclone Idai (Norton *et.al.,* 2020)[26]. Based on earlier PERC experiences, a PERC manual was developed (Venkateswaran *et.al*., 2020) as well as a community flood resilience measurement tool (Keating *et.al*., 2017). While damage assessments such as PDNA or RINA are normally done as soon as possible after the event to identify relief and reconstruction priorities and mobilize resources, PERC studies are best applied longer after the event (e.g., a year) to review the progress with relief, mitigation, and recovery interventions and identify lessons learned for next disasters. It would be useful to repeat the PERC after another year or two to review progress with medium and long-term recovery and preparedness. Figure 28 summarizes the key findings of the Idai PERC covering the entire DRM cycle.

Figure 28: Key findings from the Idai PERC.

The Idai PERC focuses on **opportunities** for better handling of future cyclones, particularly at the community level, and **lessons learned**. The Idai PERC study identifies three key opportunities to reduce vulnerability (Norton *et.al*., 2020):

a. **Strengthening of EWS and climate services** together with capacity building (preventive);
b. Supporting the **rebuilding of resilient houses, WASH infrastructure and DRR efforts** (mitigation and prevention); and
c. Supporting **agricultural and livelihood diversification** to improve livelihood resilience (absorption).

The efficiency and effectiveness of humanitarian assistance efforts should be enhanced through collaboration. Furthermore, while external assistance focuses mostly on the short and medium-term, more long-term support is necessary to build resilience, mitigate and prepare for the next event. More local materials and resources should be used, and maintenance must improve. Donors tend to avail equipment and material from their own countries, which cannot easily be maintained or operated efficiently. Wise use of local know-how and materials could improve the resilience of buildings in safer places.

Critical infrastructure: Critical infrastructure was severely damaged, hampering relief efforts. Local rescue material was inadequate or absent and there were other essential local reserves (e.g., water purification, long life food etc.), The PERC report identifies roads, communication, rescue equipment, hospitals, clinics as key critical infrastructure.

Early Warning Systems: the intensity and scale of Idai surprised the population and the inadequate protective infrastructure hampered rapid action. End-to-end EWS requires active community participation in EWS

[25] The alliance is a consortium of the private and public sectors as well as NGOs, academia: Institute for Social and Environmental Transition and the International Federation of Red Cross & Red Crescent Societies, Practical Action and Zurich Insurance Group. The PERC study included the impacts of Kenneth and covered Malawi.

[26] The Idai PERC is based on a literature review and interviews with over 100 stakeholders from government, UN agencies, donors, NGOs, communities, and academia (Norton *et.al.*, 2020).

development and the resulting actions to be taken, e.g., through hazard mapping, evacuation and safe shelter identification and development and hazard resistant construction.

Resettlement is a significant and sensitive challenge. Community consultations are essential but do not sufficiently happen (e.g., in Zimbabwe). Safer sites need to be identified while social community and family structures need to be maintained and basic infrastructure needs to be provided; households need to be able to make a living and diversify their livelihoods. Resettlement planning and implementation is still on-going and as it takes a long time, some people move back to their old, risky areas, exposing them to the same risks as before Cyclone Idai.

The study further concluded that:

i. The creation of DRM institutions and structures in both countries has helped coordinated responses, allocation of resources and post disaster assessments (PDNA and RINA);
ii. Increased forecasting accuracy has improved EWS and both countries disseminated warnings several days before the cyclone struck;
iii. The WASH support programs assisted to contain cholera and other flood related diseases;
iv. As shown in Beira, well-maintained urban drainage systems can reduce flood damage;
v. Significant financing gaps delayed the relief and recovery efforts. Investments in CCA and DRR do not sufficiently reach communities; and
vi. Most interventions focus is on short-term humanitarian aid which reduces the chances of a more resilient recovery. Investments are still mostly re-active and need to become more pro-active.

Consultations identified the following main challenges for DRM and DRR:

i. Strengthening of disaster risk awareness;
ii. Improving EWS to make the warnings actionable, identification;
iii. Protection of critical infrastructure, developing and scaling up of disaster-resistant housing;
iv. Integration of DRR and CCA in recovery and development programs.

Source: Norton *et.al.,* 2020.

5.3 Recovery and rebuilding

Both Governments together with ICPs developed recovery and rebuilding programs. The common view expressed during project consultations in Mozambique was that communities will take at least two to ten years to recover. In the worst-case, communities would never recover given the levels of poverty and the likelihood of other future disasters to happen. The views expressed during consultations in Zimbabwe were slightly more optimistic. Relief efforts were also judged insufficient, but the immediate needs were addressed. Recovery could take years for communities, primarily because of the 'worsening' factors that cripple the country. It will take continued support to communities by GoZ and partners to fully recover.

In Mozambique, recovering and reconstruction project activities have focused on the following:

a. Repair and reconstruction of houses:
    a. of the most vulnerable groups; and
    b. in rural and peri-urban areas targeting the most affected vulnerable people and Building-Back-Better (BBB).
b. Repair and reconstruction of:
    i. Critical infrastructure;
    ii. Construction of key public infrastructure at the local level; and
    iii. Construction of key community infrastructure at the local level.

c. Private sector support:
    i. Recovery of the private sector and economic production; and
    ii. Support for micro, small and medium enterprises.
d. Livelihood, income, and employment support:
    i. Identification of early economic recovery and income generation needs; and
    ii. Emergency employment for disaster affected people, driven by communities and gender focused.

Stakeholder engagement plans are in place to ensure that people contribute to the identification, design, implementation and monitoring of project activities. The support also includes a contingency emergency response component to be used in the event of another disaster. Finally, the reconstruction activities included support for Government's Reconstruction Cabinet to lead and coordinate recovery and rebuilding efforts.

In Zimbabwe, recovery and reconstruction focused on the following main activities:

a. Livelihood restoration through cash transfers to provide food assistance and unconditional cash transfers for vulnerable groups;
b. Restoration of agricultural production, including distribution of agricultural inputs for small farmer households and the restocking & treatment of livestock & poultry;
c. Revitalization of basic health services, including combating GBV and child protection;
d. Repair of three hydrological stations; and
e. Support for the rehabilitation of critical community infrastructure.

During the consultations, the impact of the Covid-19 pandemic on Idai relief and recovery efforts was discussed. The common view is that Covid-19 has disrupted relief and recovery efforts; worsened the already precarious socio-economic situation of the affected population; raised the costs of relief and recovery efforts as well as diverted Idai human and financial resources to Covid-19 related activities. The detailed responses are provided below:

i. Covid-19 has worsened the social and economic situation of the communities affected by Cyclone Idai;
ii. The pandemic affects recovery activities negatively and is slowing down the implementation of activities;
iii. Covid-19 complicates relief efforts and raises the DRM costs; resources earmarked for Idai relief and recovery efforts are diverted to the Covid-19 related emergencies and needs;
iv. Covid-19 in addition to the drought experienced prior to Idai is leaving already vulnerable households worse off;
v. The pandemic deems PWDs as the most affected and most at risk; for PWDs, social distancing is difficult as they need someone to assist them all the time. Some need to touch things or people to carry on with their life, increasing their Covid-19 exposure. Sanitization and hygiene are challenge for PWDs. Stress levels are currently high and psycho-social support through phone calls is necessary to properly support PWD; and
vi. Covid-19 delays service provision and increases inequalities, particularly for those already poor.

5.4 Mitigation & prevention

Some mitigation and prevention efforts have been built in the recovery programs in Mozambique and Zimbabwe. In Mozambique, building resilience for climate change activities are concentrated in the Beira area, and has two main components:

a. Repairing and significantly strengthening coastal protection; no details are given how this will be done but there is scope to apply nature-based solutions (Norton *et al*., 2020); and
b. Expanding the rehabilitated drainage system to reduce flooding in vulnerable parts of the city.

In addition, the capacity of relevant units within the city administration to strengthen operation and maintenance is being strengthened.

In Zimbabwe, mitigation and prevention measures include:

i. Support rehabilitation of critical community infrastructure; and
ii. Support community level structural risk reduction and mitigation efforts.

In addition to the above, both countries aspire to resettle affected population from high-risk to lower-risk areas. It is unclear how much progress has been made with resettlement. While the potential benefits are widely recognized, resettlement is a sensitive and challenging issue. Progress has been too little for some households who decided to move back to their old homes, exposing them to the same risks as before. New settlements need to be identified, carefully planned, and have basic infrastructure as well as income generating opportunities to improve livelihoods. Stakeholder consultations showed that sound resettlement needs to meet several requirements (Table 12).

Table 12: Requirements for sound resettlement.

MOZAMBIQUE (5 responses)	#	ZIMBABWE (11 responses)	#
Socio-economic and environmental studies should be carried out before or during the resettlement process.	3	Stakeholder analyses and communications are also critical. A stakeholder analysis will also be essential to determine the positive/ negative issues that may favor/ hinder the resettlements	3
The potential socio-economic and environmental impacts of resettlement need to be understood prior to resettling people. Better planning and management of resettlement is important	2	Environmental Impact assessments are necessary for sound resettlement.	2

Note: only view by more than 1 person listed.
Source: project consultations.

Mitigation and preventative measures generally require land use and settlement planning that integrate disaster risk management concerns. In addition, there is need for improved building regulations as well as construction of more resilient critical infrastructure, houses, buildings, and WASH facilities. This requires additional financing but should reduce damage and loss costs. "*We already know that every US$1 invested in prevention saves on average US$5 in future losses".* (https://www.zurich.com/en/sustainability/our-role-in-society/flood-resilience).

Asked how countries could mitigate future impacts of cyclones, stakeholders also indicated that EWS need to be further improved and that the capacities of technical personnel involved in DRR and DRM and communities need to be strengthened (Table 13).

Table 13: Measures to mitigate future impacts.

Mozambique (8 responses)	#	Zimbabwe (11 responses)	#
There is need for strengthened infrastructure reinforcements and urban planning.	3	Better land-use planning and improved building regulations.	7
Strengthen the capacity of hydro-meteorological observations in the country and region.	3	The Government together with the local councils must establish new settlement areas and these areas must not be disaster prone.	4
Empower technicians and communities to learn how to respond to this type of disaster by positioning human and financial resources in a timely manner and providing alternative means of communication.	2	Investment in early warning systems that make use of real-time data.	3
Building back better in safe areas that are not disaster prone	2	Abiding by the different frameworks that aims towards disaster preparedness such as the Sendai Framework.	2
		Adequate disaster financing	2

Note: includes only responses by at least 2 persons.

Source: Project consultations.

5.5 Preparedness

Preparedness requires activities after the event to prepare for the next event. Generally, support efforts still emphasize relief and reconstruction and pay insufficient attention to long-term strengthening of prevention and preparedness.

Countries' preparedness has improved over time due to better meteorological and hydrological data and models, better DRM institutional structures and early warning systems. The consultations showed that a major preparedness issue related to Idai was its extent and intensity that surprised people and had not been witnessed before. Existing food and WASH programs in both countries allowed rapid responses and, in a way, 'prepared' the countries.

Institutional structures

Both countries have established DRM structures and institutions, led by the INGC in Mozambique and the DCP in Zimbabwe as well as funding mechanisms. In Zimbabwe, the National Civil Protection Committee (NCPC) has stakeholders from government and outside government. In Mozambique, local DRMCs exist with volunteers. Assisted by the EWS, these committees succeeded in reducing the impacts of Idai through preparation and relief efforts (Figure 29). The operations of the committees can, however, be improved by focusing more on disaster prevention, readiness, and adaptation for disasters (UN-ECA, 2015; IOM &

INGC, 2019). Generally, the EWS information has been useful, but it needs to be more detailed and more action oriented.

Figure 29: Local DRMCs and community based EWS.

Out of the 498 villages in the Idai affected area, 70% had a local DRMC and evacuation plan (UN-ECA, 2015; and IOM-DTM survey); 82% of the villages have public buildings as emergency shelters (2,394 in total with capacity of 601,224 people).

Community-based EWS has 4 key components: 1. knowledge of risks; 2. monitoring, analysis and forecasting of hazards; 3. communication/alerts/ warnings; and 4. local response capabilities. Community-based EWS requires strong community ownership, basic equipment (e.g., transport, emergency supplies and communication), and training.

Countrywide, 855 communities have local DRMCs. Communities with DRMCs have had less adverse impacts than those without (UN-ECA, 2015, p.26). However, the committees' challenges include high turn-over among members/ volunteers, lack of incentives and inadequate information flows from national to local level. The focus on the committees remains with disaster response and relief rather than preparedness. Strengthening of community engagement and resilience would recognize communities as key players, use indigenous knowledge raise awareness raising and assist with e.g. evacuation drills).

Sources: UN-ECA, 2015; IOM & INGC, 2019.

A number of NGOs are active in DRR and DRM in both countries. Both countries have dedicated DRM Funds and ministerial DRR/DRM budget allocations; they experience funding and capacity constraints. Capacity, funding, and equipment constraints remain prominent particularly at the district and local levels, hampering rapid responses, recovery, mitigation, and preparedness. Consequently, both countries rely heavily on external financial and technical support. As indicated earlier, this poses coordination challenges and puts pressure on the countries' limited institutional capacities.

Bi-directional communication between national, district and local levels is vital for effective DRM. When Cyclone Idai struck, communication systems broke down, hampering rapid coordinated actions and information sharing. Communication channels are an important component of the critical infrastructure; backup channels are necessary when a particular communication mode fails (e.g., mobile networks in Beira).

Policy environment

The DRR enabling environment needs further improvement, particularly in Zimbabwe for example through the finalization and adoption of the new draft DRR Act. It is also important to coordinate and integrate DRM and climate change adaptation (CCA) in development planning as disaster and climate change are intricately linked, have huge development implications, and countries have limited implementation capacities (UN-ECA, 2015; OECD, 2020). CCA and DRM integration requires synthesizing the policies and strategies and close cooperation between the implementing institutions.

Both countries and ICPs principally acted at the national level. However, Cyclone Idai has shown that disaster drivers and impacts transcend national boundaries, and that preparedness requires DRR/DRM collaboration and coordination at the transboundary level. BuPuSa needs to be actively involved in DRM in its basins, for example through the development of a BuPuSa DRM plan, including rebuilding/ establishment of a network of hydrological stations, regular basin wide data collection and sharing as well as basin wide weather, hydro, and flood risk forecasting.

Community preparedness and support

It is widely agreed that communities are the key to effective DRR, requiring that communities be prepared for disasters at any time. Institutional DRM structures reach out to the community level, either directly through local DRMCs in Mozambique or through community support from central and district government and other support groups (Zimbabwe). In Mozambique, local DRMCs contributed to early relief and responses, and assisted through preparatory measures (e.g., evacuation plans, shelters, essential local supplies). There is, however, need to strengthen community level preparedness and to expand the number of local DRMCs (Figure 10).

The project consultations generated several suggestions to support communities.

a. Increased support from the DRM lead institutions (DCP and INGC);
b. The use of the UN-adopted cluster approach to coordinate ICP and national support efforts to communities; the clusters cover education, food security and livelihoods, shelter/ housing, management of relief camps, health, nutrition, logistics, WASH and people's safety and protection (e.g., child protection and protection against GBV);
c. The use of local languages to support communities;
d. NGOs and CBOs need to be trained to develop and implement long-term sustainability strategies;
e. In Zimbabwe, the development of a data base on key DRR institutions is seen as way to increase the effectiveness of support to communities.

Project consultations identified the following main strengthen and weaknesses of communities (Table 14). Support should address the weaknesses and build on exploit the strengths.

Table 14: Perceived community strengths and weaknesses.

COMMUNITY STRENGTHS	#	COMMUNITY WEAKNESSES	#
Mozambique (10 responses)		Mozambique (10 responses)	
Communities have learned a lot from this cyclone because now they can easily comply with guidelines provided during emergencies and disasters. From Cyclone Idai they learned a lot about how to deal with similar phenomena in the future.	3	Receiving communication late or receiving wrong information.	3
Mozambican people are very resilient as they deal with many 'disasters' during their lives.	2	Engaging communities in DRR has been slow due to the economic hardships and inadequate communication infrastructure. There is need to strengthen community DRR structures to develop plans to reduce and prepare better for disasters.	3
The first responders were at the community level. Community structures are a major strength – ward, village, provincial and district level. Traditional leadership is also a strength in DRM/DRR	4	The EWS are not strong to pick disasters before they strike. There has been an over-reliance on the aviation sector and international community in terms of EWS. Emirate flights for example, assisted Zimbabwe in predicting the cyclone but its strength would be unknown. Cyclone Idai's expected landfall in Zimbabwe was expected to have been weakened by the time it made landfall.	2

The skills and experience of communities are a significant strength	2	Inadequate donor support for NGOs/CBOs to support community engagement, participation, and livelihood improvement programs	2

Note: only strengths and weakness by more than 1 respondent listed.

Source: Project consultations.

EWS

Early warning systems are critical components of preparedness. EWS starts with the collection and analysis of climatic and hydrological data, leading to detailed forecasts, warnings, and recommended actions to minimize damages and losses of the disaster. The EWS stretches from the national down to the local, village level as the first responders. EWS in both countries have significantly improved due to better meteorological data and weather forecasts. These led to early warnings and notifications, but further improvements need to be made. The following shortcomings emerged during consultations:

a. Early warnings reached the local level (too) late;
b. Early warnings did not sufficiently prepare people for the severity of the cyclone. Local awareness was limited;
c. Early warnings were not sufficiently action-oriented; and
d. Local DRMCs were inadequately equipped to take the required actions.

Community involvement in monitoring and EWS activities will improve community awareness about DRM and offers opportunities to integrate the community's local knowledge in monitoring.

Consultations in Zimbabwe revealed that ZINWA and the meteorological department are improving forecasting and the early warning systems. A flash flood monitoring system has been developed and there are observers in areas where floods normally occur. Near real time data was received using cell phone messages and emails and used to alert communities. Table 15 shows suggestions how community based EWS can be strengthened.

Table 15: Strengthening community based EWS.

MOZAMBIQUE (9 responses)	#	ZIMBABWE (11 responses)	#
Improve the quality of forecasts and improve communication (e.g., increase the number of radios in communities, increased circulation of forecasts, create more risk management committees and information experts	3	EWS should be established from village level, then to the ward level, developing into the district, provinces, and the nation at large.	3
Community level structures and EWS are required in disaster prone areas. On-going training to strengthen community capacities in EWS is important.	2	Linking the community structures to the relevant government line ministry/ department at the district level	2

Note: includes only responses by at least 2 persons

Source: Project consultations.

5.6 Sendai focus areas

Two Sendai strategic areas ("strengthening of DRM" and "enhancing disaster preparedness") have been discussed above in section 5.5 and will not be repeated here. Below, we briefly review the other strategic areas of "understanding disaster risks" and "investing in DRR for resilience".

5.6.1 Understanding disaster risks

The understanding of cyclones, particularly at the national level has generally improved due to better data, forecasting models and experiences from previous cyclones. However, further enhancement of the understanding is necessary, particularly in view of the changing nature of cyclones due to climate change. The scale and intensity of Idai were not understood prior to its landfall. This project focuses on cyclones, but it should be realized that other types of disasters also occur, which may require a different DRM approach. In fact, droughts are the most common disasters in both countries. The multitude of types of disasters is challenging for DRR/DRM institutions.

Cyclone Idai demonstrated the transboundary nature and impacts of disaster, while the needs assessment and responses, relief and recovery measures were implemented at the country level. Idai shows that disaster risks also need to be understood and acted upon at the basin level. For example, high rainfall in upstream Zimbabwe contributed to additional floods in downstream Mozambique. Furthermore, disruptions of transport and communication networks in Mozambique made relief efforts in Zimbabwe more difficult.

Each cyclone has unique characteristics and consequently, each needs general but also cyclone specific responses. For example, Cyclone Idai made landfall twice, and the second landfall was more destructive. Another example, Cyclone Idai differed from Cyclone Kenneth in windspeeds and location, but the occurrence of both cyclones within a short time spell was new in southern Africa. Local communities perceived the intensity of Idai as unique. This highlights the importance of detailed forecasts and informed EWS as well as building a cyclone data base with details of past cyclones, their risks, and impacts[27].

5.6.2 Investing in DRR for resilience

While national DRM Funds exist in Mozambique and Zimbabwe, national funds were insufficient, and both countries relied on international funding. International funding was rapidly mobilized and significant, but it fell short of the needs as assessed in the PDNA and RINA and focused on relief and recovery. The relatively low level of DRM funding towards mitigation, prevention and preparedness hampers resilience building for future cyclones. And yet, resilience building at the national and community level is critical for effecting changes and long-term sustainability. It is also more cost-effective on the long term.

As DRR and CCA are intricately linked, investments in CCA and DRR/DRM should be integrated in the development planning process. This already happens to a limited extent, but it should become standard

[27] Currently, cyclones are largely treated on a case-by-case base, missing the history of cyclones.

practice and part of the development planning and funding processes and mechanisms (Norton *et.al*., 2020).

Investments require that the basic critical infrastructure be in place and well maintained, and that alternatives are in place when some infrastructure components fail (e.g., a road). Critical infrastructure should include 'hardcore or engineering" infrastructure and green infrastructure. The former refers to constructed infrastructure (roads, buildings, communication networks, dams). Cyclone Idai has shown the importance of properly maintained drainage systems in Beira. The latter refers to investments in biodiversity and ecosystem services to help people adapt to the adverse effects of climate change and disasters. It covers nature-based solutions such as mangrove rehabilitation, rehabilitation of coastal ecosystems, urban greening and generally land rehabilitation.

At the local level, Idai has shown that communities need shelters, evacuation plans, transport/boats, and communication equipment to be prepared and respond effectively to disasters (Norton *et.al.,* 2020). Moreover, local storage facilities are needed for emergency supplies (e.g., food, basic medicines, water purification) to facilitate rapid availability and access.

5.7 SADC DRR Resilience abilities

5.7.1 Anticipatory ability

Anticipative ability refers to being well **prepared** prior to a disaster and that tends to reduce adverse impacts. The anticipatory ability of social systems is to **foresee and reduce** the impact after a disturbance through preparedness and planning (Bahadur *et al*. 2015 quoted in SADC, 2019). It is thus linked to the Sendai key area of "Preparedness" (see 5.1.4). The greater the anticipative ability is, the better the preparedness can be, but it needs to be translated into action through effective EWS.

Prior to the land fall of Cyclone Idai, weather forecasts were prepared with details of the possible land fall date, the location, and the intensity of the cyclone. In Mozambique, this information was transferred to institutions and communities by INAM through EWS for community action and by INGC to institutions for DRR readiness. INAM and INGC used different coding schemes, apparently causing some confusion, which may have delayed action (WMO, 2019). The communities with active DRMCs were able to prepare and implement their evacuation plan and use their shelters. However, key equipment was often inadequate or poorly maintained, causing operational problems.

The impacts of Idai were much more severe than expected, indicative of inadequate anticipation, with some believing that the cyclone could have positive impacts by breaking the existing drought conditions. The local DRMCs are more reactive than pro-active and anticipative (Norton *et al.,* 2020). Cyclone Idai showed that the anticipative ability and preparedness need to be further enhanced at the community level by e.g., training and awareness raising campaign, storage of local emergency supplies, maintenance of basic DRR and relief equipment and action oriented EWS messages.

Community anticipation existed to some extent, particularly in Mozambique through the local DRMC and EWS. However, gaps existed in:

a. Appreciation and anticipation of the intensity of the disaster;
b. Action-orientation nature of the EWS; and
c. Conditions of local DRR relief facilities and equipment.

5.7.2 Absorptive ability

Absorptive ability or persistence refers to various (coping) strategies by which a system **moderate or buffer the impacts** of shocks on their livelihoods and basic needs (Béné *et al*., 2012 quoted in SADC, 2019). The more resilient for example a community is, the better and the faster it can cope with the impacts of shocks. Greater absorptive ability reduces the magnitude of the required response or relief efforts.

Clearly, Governments and communities were unable to absorb Idai's impacts due to the scale and intensity of the disaster and significant external funding and technical assistance that was needed to cope with the impacts. Pre-Idai assistance with WASH and food aid helped to quickly absorb and limit impacts and contribute to reconstruction. Pre-Idai existing widespread poverty in both countries had already eroded people's absorptive ability. In Zimbabwe, most rural households lived under stress prior to Idai and had no or little savings left.

Livelihood diversification, rebuilding of assets (Building-Back-Better or BBB) and savings would strengthen people's absorptive ability. At the basin level, ecosystem-based adaptation (EBA[28]) could increase the absorptive ability of the basin together with well-maintained critical infrastructure such as dams. Operational guidelines for dam management such as those developed for the Save River could reduce the disaster risks and diversify livelihoods (CRIDF, 2019). Rehabilitated and expanded mangrove ecosystems would form buffers for storm surges, and in the case of Idai, rehabilitation of part of Beira's drainage system resulted in less flooding in these areas.

Reviews of earlier cyclones in Mozambique suggest that cash hand-outs, assistance to small, micro, and medium enterprises (SMMEs) and supply of farming implements for the next agricultural season were successful in rebuilding livelihoods (Wiles *et.al*., 2005). Cash payments and emergency employment generation are part of the post Idai recovery programs in both countries. The same World Bank review (Wiles *et.al*., 2005) concluded that recovery efforts usually benefit from large scale international publicity and the resulting additional funding that the publicity generated. While Cyclone Idai drew significant global publicity, funding gaps remain. As a result, recovery is incomplete, and for example many people still live-in temporary shelters (e.g., Norton *et.al*., 2020 and project consultations).

The absorptive ability of governments was low as reflected in the global risk ranking (INFORM). Communities' absorptive abilities were limited prior to Idai due to:

a. Widespread poverty;
b. Food insecurity and dependency on food aid; and
c. Dependency on subsistence agriculture and lack of economic diversification.

[28] EBA and natural based solutions (NBS) are used interchangeably.

Cyclone Idai has further limited the absorptive ability due to losses of livelihood sources and assets. Dependency on external support has increased.

5.7.3 Adaptive ability

Adaptive ability is the capacity to **learn, combine experience and knowledge**, **adjust responses** to changing external drivers and internal processes, and continue operating (Berkes *et al.,* 2003 quoted in SADC, 2019). **Adaptive ability supports recovery and mitigation measures.** The adaptive ability in both countries has improved with the development of DRR and CCA structures, improved data, and experiences from earlier cyclones. However, it is still limited due to several factors, including:

i. Unfavorable and unstable macro-economic conditions;
ii. Financial and human resource constraints;
iii. Limited baseline and monitoring data; and
iv. Limited DRR capacities particularly at district level.

The Idai recovery projects reflect some adaptive ability with clear focal areas such as agricultural support, livelihood support, coastal zone protection, expansion of the Beira drainage rehabilitation system and resettlement programs and restoration of critical infrastructure and housing.

Resettlement is an interesting case of adaptive ability. While it is widely accepted that it is "good" to move households and communities from high-risk to lower-risk areas, resettlement is hard and slow to implement in practice. This is due to the complexity of the required preparation (e.g., identification and mapping of suitable resettlement areas as well as service provision), the need for full participation and cooperation of communities and the need to create a conducive environment for livelihood diversification and improvement. A variety of cultural and social factors also play a key role. The progress of resettlement programs could not be verified, nor their performance.

Other examples of adaptive ability emanating from Idai are the perceived need to adapt building regulations, to build-back-better, and to strengthen integrated land use planning.

Communities adapted by social networking and mutual support, hosting of IDPs etc. However, communities' adaptive abilities, particularly for long-term interventions are constrained because of:

a. Local financial and human resources constraints for DRR;
b. Lack of local DRR equipment and strategic reserves;
c. Lack of upscaling of BBB design and construction;
d. Difficulties in relocating to low-risk areas from high-risk areas (i.e., resettlement).

Covid-19 has led to diversion of human and financial resources and reduced the countries' and communities' adaptive ability.

5.7.4 Transformative ability

Transformability ability seeks "*to create a fundamentally new system when ecological, economic or social structures make the existing system untenable"* (Walker *et al*., 2004, p.5 quoted in SADC, 2019) so that shocks will no longer have major impacts. It is the ability to transform systems and structures to better handle disasters. It covers all stages of the DRR cycle, all other abilities and refers to communities as well as governments (as shown in Figure 29).

Several transformative abilities are important. Firstly, the ability to switching from the focus on short-term relief and response to a more balanced short and long-term approach of DRR. This shift has long been talked about, but its realization is slow, indicative of transformative ability constraints of countries and ICPs. Secondly, empowerment and greater participation of communities in DRR and DRM is desired by many; this transformative process is on-going in Mozambique but needs to progress further and be established in Zimbabwe, where possible linked to community-based programs such as CAMPFIRE[29]. Thirdly, countries should seek to integrate DRR and CCA planning governance structures to better handle disasters and climate change (OECD, 2020). This has not formally happened and requires that CCA and DRR are integrated in development and land use planning and management. Fourthly, DRR needs to be upscaled to the transboundary level, which requires direct BuPuSa involvement as well as involvement of other transboundary basins, in which Mozambique and Zimbabwe participate (e.g., Limpopo and Zambezi). This transformation is just starting and needs to be developed.

Transformation is not the prerogative of government as it refers to society at large, and includes the private sector, communities, faith-based organizations, and NGOs. Idai relief and recovery have seen good examples of partnerships. Collaboration between governments and ICPs has been effective for relief and response interventions. However, ICPs need to support longer term recovery and countries' and communities' opportunities to grow and diversify, become more resilient and to develop their own abilities rather than relying on external funding and technical assistance.

Idai demonstrated the benefits of collaboration between government, communities, and the private sector. This became apparent in Chimanimani when the town was completely cut off. Communities and private sector joined hands in rapid relief efforts. Public-private-community partnerships are important to overcome resource scarcity and develop social capital, the benefits of which extend beyond DRR. Communities need to actively participate and implement to make DRR benefit from local knowledge as well as their (self-) interest in mitigation and prevention. This requires further awareness raising, training, funding, and equipment. The involvement of communities in weather and hydro monitoring, EWS, mapping, strengthening of the community DRMCs (Mozambique) and expansion of CBNRM are possible examples.

As argued earlier, ICPs are currently indispensable for humanitarian relief, recovery, and mitigation. To optimize long-term results, ICPs need to be flexible in addressing local needs, to sourcing local material, equipment, and human resources/ companies and to make it a longer-term commitment to develop better and build resilience (Norton *et.al*., 2020).

[29] CAMPFIRE: Communal Area Management Program for Indigenous Resources.

Generally, the ability to adapt, absorb, anticipate, and transform grows with better monitoring, better data collection and better analysis/ modelling. Scientific and applied research abilities are needed to support these abilities and achieve the necessary transformation. This requires, among others, meteorological and hydrological monitoring networks, flood and high- and low-risk areas mapping, land-use and land-cover mapping, poverty and livelihood monitoring and agricultural practices and production monitoring.

Figure 32 below shows the usefulness of medium and high-resolution imagery for DRM. The combination of both is most beneficial and cost effective; the potential and cost effectiveness of high-resolution imagery is expected to increase as the costs are expected to decrease in future. In addition, water abstractions from the three rivers need to be monitored or estimated. It would be useful to explore the feasibility of EBA solutions in the basins, together with the construction and improved management of dams (e.g., as done in the Save River).

In brief, transformative abilities can be strengthened by:

a. Empowering communities to participate in DRR and DRM implementation (human resources, funding, and equipment);
b. Effective DRR and DRM collaboration between the public sector-private sector and communities (e.g., all are represented in Zimbabwe DRR and DRM Platform);
c. Upscaling towards transboundary DRR and DRM management (e.g., BuPuSa, OKACOM, LIMCOM & ZAMCOM);
d. Balancing ICP activities between relief and response support and reconstruction/ resilience building/ DRR; this also involves greater attention of relief and response efforts in the countries' national and local economies (e.g., sourcing local material and expertise); and
e. Integrating DRR and CCA in development and land use planning.

Figure 30: DRM applications and potential of medium- and high-resolution imagery.

Medium resolution imagery

With free access to data and the datasets medium-resolution imagery programmes can provide cost effective platforms for wide-area mapping and monitoring. Medium resolution data are widely used for terrestrial mapping and monitoring applications, and there are a many accepted processing methodologies and algorithms available to support land, river basin and DRM programs:

- Sentinel 1 and 2 imagery is available on a variety of internet-based platforms, and directly from the EU Copernicus program;
- With a catalogue stretching back to the 1970s, the USGS Landsat Program provides equivalent access to data through the Earth Explorer platform; and
- The Google Earth Engine provides access to a script-driven cloud-computing geospatial analysis environment, which also has full catalogue access to both programmes described above.

The analysis of the above data sets gains confidence with ground truthing and field work. This is a requirement for future work. In the case of basin-wide monitoring, medium-resolution data can be highly effective for landcover mapping, monitoring and change detection. Regular landcover mapping at basin scale is now an achievable goal, making post disaster event assessments easier to conduct. The introduction of GEE processing approaches means that organizations need less physical infrastructure, as the source data and processing software are on the cloud platform. This and other similar platforms provide a unique opportunity to overcome some financial, institutional, and physical (ICT infrastructure) obstacles that currently complicate the application of geospatial analysis in DRM. Free medium-resolution remote sensing data are not appropriate for operational

mapping of features less than a certain scale (1:50,000), and are not feasible sources for detailed mapping and monitoring activities required in DRM.

High resolution imagery

Fortunately, high-resolution imagery has become more cost effective and widely available and applied to areas, including DRM. It has advantages over medium-resolution imagery, mostly in terms of the level of detail available from these data, which enable the identification and extraction of smaller features on the earth surface. In the case of the current study, the value of high-resolution imagery was demonstrated through the damage assessment and damage density analysis. The features used in the damage assessment in this project were extracted manually, but automated feature extraction processes will soon enable feature rapid extraction and update. Other expected developments include the use of machine learning algorithms to automatically detect changes in state of buildings and other features.

6 Summary, recommendations & follow-ups

6.1 Summary

This project aimed to provide a comprehensive assessment of the impacts of and handling of the impacts of Cyclone Idai in Mozambique and Zimbabwe, with reference to the Buzi, Pungwe and Save Basins. The Government of Mozambique and Zimbabwe are establishing a joint commission for the management of these three transboundary river basins. The project included a socio-economic assessment based on available literature and statistics (section 4.2), a geospatial impact assessment (medium resolution RS for the entire BuPuSa basin and an in-depth, high resolution RS assessment of Chimanimani and Beira areas; section 4.1)), and stakeholder consultations (reported in chapters 4 and 5).

Cyclone Idai struck Mozambique and Zimbabwe in mid-March 2019 or over one and a half years ago. The cyclone was unique in its intensity and caused widespread human suffering, loss of livelihoods, significant damage to economic sectors and assets, and destruction of critical infrastructure. The agricultural sector was hardest hit, crop production. The total damage and loss costs were estimated to be around US$3.5 billion, mostly in Mozambique; recovery and rebuilding costs are in the same order of magnitude. A wide range of negative social and environmental impacts were also recorded, mostly in qualitative terms.

Response and relief efforts (1-2 years after the disaster strikes) were rapid and significant. However, they are not yet complete, in part because funding has been inadequate to-date. Both governments are implementing reconstruction and recovery projects, mostly aimed at restoring livelihoods, public and community infrastructure. Increasing resilience requires more resilient infrastructure, more diversified livelihoods, enhanced capacities of households and national government to anticipate and be prepared for future cyclones (see e.g., INFORM scores for risk areas and areas for risk management improvement). Enhancing capacities involves improved monitoring networks (hydrological, meteorological and livelihoods monitoring), improved cyclone and flood forecasting, further improvements in effective EWS and investments in resilient infrastructure and other DRM interventions that prepare for and limit the impacts of future cyclones. It is particularly important that local DRM institutions are established and capacitated with the necessary means (e.g., shelters, evacuation transport means, basic WASH and food supplies).

In the long term, countries and individual households need to be able to manage and overcome disasters themselves. This requires that households have a decent and diverse livelihood base that can prepare for and adjust to disasters. Similarly, countries should have the means to handle and overcome disasters. Neither situations exist in the countries. Poverty is widespread, household livelihoods are stressed and not diversified, relying primarily on subsistence agriculture. Both countries face large challenges in terms of being able to handle major disasters. They are low-income countries, with low and medium levels of human development (Mozambique and Zimbabwe respectively) and a high-risk vulnerability index (INFORM). This coupled with the enormous scale and intensity of Cyclone Idai, made the countries dependent on large scale international financial and technical assistance. This dependency should be reduced in future, but it is likely to continue in the short to medium term. Effective and well-coordinated international support is and will remain critical for some time, also in terms of increasing resilience for future disasters. The work of the large number of ICPs is essential but needs to be coordinated and pressure on local institutional capacities needs to be minimized (e.g., through the cluster approach).

6.2 Recommendations

Given the countries' situation, it is not realistic to address all challenges and areas for improvement immediately. It is important that government together with non-state actors (e.g., private sector, communities, and NGOs), identify priorities and interventions that can be implemented with the available capacities and abilities. In due course, the coverage can be expanded to address additional issues when means and capacities increase.

It is recommended that the countries and BuPuSa adopt a **focused, prioritized**, **do-able** and **incremental** approach led by the lead DRM institutions (INGC and DCP) with active participation of all stakeholders and focused on **strengthening community resilience**.

Below, we make suggestions as to which institutions should follow up the recommendations that are made. It should be stressed that the decisions regarding the recommendations and the institutions responsible for their implementation must obviously be made by the countries themselves, BuPuSa and where relevant the collaborating ICPs. Given their mandates, the INGC and DCP will be 'lead' institutions and we suggest that they work closely in this regard with the Department of International Rivers (DNGRH) in Mozambique and the Department of Water Resource Planning and Management, Ministry of Lands, Agriculture, Water and Rural Resettlement in Zimbabwe.

6.2.1 BuPuSa and member states

Many recommendations emerged from the project. This section structures the recommendations under ten key issues:

1. Continue to strengthen national DRM capacity;
2. Integrate DRM & CCA in development and land use planning;
3. Identify and maintain critical infrastructure;
4. Building community resilience through DRM structures and livelihood diversification;
5. Development of TWM DRM strategies;
6. Form effective partnerships – cluster approach;
7. Balance short term humanitarian aid (relief/ response) & resilience building (mitigation, preparedness);

8. Rapid need assessment and follow ups;
9. Info/data & info/data base, forecasting and info/data (base) access; and
10. Environment.

1 Strengthening the national DRM capacity

The countries and BuPuSa face different types of disasters, the most common one being droughts followed by floods and cyclones (in Mozambique). Therefore, the DRM institutions need to be prepared for droughts as well as floods and cyclones. Countries' DRM capacity is determined by the institutional structures involved as well as their technical and financial capabilities.

Both countries have strong DRM lead institutions. Zimbabwe has the DCP and a national multi-stakeholder National Civil Protection Committee (NCPC), but decentralization of DRM resources is needed, and the draft DRM Act needs to be finalized and approved (NCPC and DCP to consider for action). The NCPC and DCP Effectively linked DRM institutions at the national-provincial and local level are essential (INGCC and NCPC/ DCP to consider for action). Consultations showed that there is need to build more capacity particularly at the local and provincial levels.

Both countries have a DRM Fund, but the funds need to be increased and ringfenced, i.e., exclusively used for DRM (Ministries of Finance, DCP and INGC to consider for action). These funds should exceed immediate relief efforts and cover disaster mitigation and preparedness. If the DRM Fund would also cover mitigation and preparedness, ICPs could also contribute to the national DRM Funds, particularly to support resilience building (ICP to consider for action). The feasibility of a SADC DRM Fund, particularly for transboundary resource management initiatives, needs to be assessed as a supplement to national funds (SADC Secretariat and member states to consider for action).

It is important that local DRM structures are established and where they exist -as in many Mozambican villages- strengthened. It is recommended that Zimbabwe reviews the best way to establish local DRM structures (DCP and CPUs to consider for action). DRM capacities can also be strengthened at the SADC level, e.g., through the establishment of a rapid SADC DRM 'force' to support disaster struck SADC countries (SADC Secretariat and member states to consider for action). RBOs need to include DRM in their strategic development plans for their basins (SADC RBOs to consider for action).

2 Integration of DRR and CCA in development planning

Disasters are recurrent and climate change generally increases the frequency and intensity of disasters. Disasters and climate change are both 'facts of life' that need to be recognized and considered in development planning. Given the links between DRM and CCA and the limited institutional capacities, it is important to fully harmonize DRM and CCA, and incorporate both in national and provincial development and land use plans. To facilitate this process, the risks and costs of disasters and the benefit from mitigation, prevention and preparedness need to be shown to development planners. Disasters and climate change also need to be fully integrated on EIAs and SEAs. This also applies to transboundary water resource management (TWM). These actions need to be considered by DCP, INGC and the Ministries responsible for climate change adaptations and targeted to the Ministries of Development Planning and responsible for EIAs.

3 Identification, (re-)building and maintenance of critical infrastructure

Critical infrastructure may refer to infrastructure from the public sector, communities, and the private sector. The project showed that different types of infrastructure are interlinked and, failure of one component can lead to failure or disruption of others (e.g., energy and communication/WASH, road closure and delivery of relief material and medical supplies). The PERC report identifies roads, communication, rescue equipment, hospitals/ clinics, and energy networks as critical infrastructure. Gaps and weaknesses of critical infrastructure need to be identified to increase the resilience and performance of the package of critical infrastructure in e.g. BuPuSa, which then leads to building back better and building better.

The following is recommended (to be considered for action by the responsible ministries with the INGC and DCP as catalysts):

a. Avoid rebuilding and building of critical infrastructure in high-risk areas (where possible);
b. Rebuild climate smart and resilient agricultural infrastructure (e.g., irrigation schemes);
c. Rebuild and build climate smart and resilient water sector infrastructure, including hydrological and meteorological infrastructure. Better dam design & re-assessment of safety and resilience of existing dams in view of DRM and CCA;
d. Harmonization of dam operating guidelines to ensure sufficient environmental flows, optimal development benefits and flood avoidance;
e. Review the options for nature-based adaptations and their feasibility; and
f. Prioritize maintenance of critical infrastructure. Ideally, all infrastructure needs to be adequately maintained. When maintenance funds are inadequate, critical infrastructure should be prioritized.

4 Building community resilience through DRM structures and livelihood diversification

Community resilience can be strengthened by the establishment of local DRM structures, by strengthening and diversifying livelihoods and by special attention for vulnerable groups. Local DRMCs have benefited DRM in Mozambique. This system can be expanded to more settlements in disaster prone areas in Mozambique and to Zimbabwe. Existing local DRMCs need to be strengthened to:

a. Become more pro-active and mitigate, prevent, and be prepared for future disasters. Currently they are mostly responding to disasters that have happened. DRM should be a continuous effort. This change would be facilitated by the development of simple local DRM strategies to deal with: relief and responses, reconstruction and mitigation, prevention, and preparedness. The Flood Resilience Measurement tool could be tested and adapted to the local conditions to raise awareness and preparedness. Community involvement in monitoring of meteorological and hydrological conditions in the basin and local risk mapping and monitoring would also assist community preparedness when combined with action-oriented early warning in local languages;
b. Acquire and maintain community-based DRM facilities and equipment (e.g., shelters, boats and other means of transport, radios, mobile phones, water purification & storage equipment, storage facilities for food, basic medicines, and water purification). Standardization of equipment is essential to enhance the effectiveness of support; and

c. Raise awareness about disasters and 'best responses' (short and longer term).

The DCP, INGC as well as NGOs such as the national Red Cross organizations and ICPs could spearhead these efforts. They could also support the involvement of local DRMCs in EWS, including providing feedback about the early warnings after each event to improve EWS effectiveness. The lessons from Idai include make early warnings more practical action-oriented for communities, further improve on the timeliness and use of local languages and different modes of communication (e.g., radio, mobile phones, etc.).

Improved and diversified livelihoods will make households more resilient. This links DRM directly with rural development planning. Reduction of agricultural dependency and agricultural diversification are essential to better and more secure livelihoods. DRM efforts need to pay special attention to vulnerable groups to ensure that these groups are better prepared for disasters and are fully covered by relief and response efforts. Development ministries, ICPs and NGOs should support economic and livelihood diversification and protection of the vulnerable groups.

5 Development of TWM DRM strategies

Currently, BuPuSa does not have a formal DRM strategy and DRM is handled at the national level by Mozambique and Zimbabwe. The project clearly showed that a basin-wide DRM strategy is needed, either separately as a DRM strategy or through DRM and CCA integration in basin development, investment and land use plans as well as EIA/SEA requirements. The preparedness at the basin level needs to be improved to the benefit of Mozambique and Zimbabwe. The following interventions should be considered:

i. (Re)Building of meteorological, hydrological and livelihood monitoring networks in the basins;
ii. Modelling and forecasting of hydrological conditions and floods and translation of the main results in regular result briefs and coordinated EWS and early warnings;
iii. Development of an integrated flood risk management framework;
iv. Mapping of high-risk areas in terms of rainfall, cyclone frequency and flooding;
v. Establishment of effective flood resilient basin-wide communication networks;
vi. Harmonization of dam operating guidelines to manage water resources for economic development and flood avoidance; and
vii. Basin-wide water infrastructure and ecosystem-based interventions to manage water resources for economic development and flood damage avoidance.

Cyclone Idai clearly showed that the scale of disasters exceeds national capacities. While ICPs are instrumental in providing financial and technical assistance, it is important that SADC as a regional organization gets involved in DRR and DRM by pooling technical and financial resources. Possible interventions would be the establishment of a SADC DRM Fund and a Rapid Disaster Relief and Rebuilding team. In addition, regional high-risk areas and flood mapping exercises can be undertaken to assist RBOs and SADC countries. It is important that SADC DRM efforts are not confined to relief but also aim at improving preparedness and resilience.

6 Effective DRM partnerships

The Idai experience has shown that partnerships are essential. DRM is not just a matter of governments or the directly affected households. A host of non-state actors, communities and the private sector have contributed to Idai relief and reconstruction. The NCPC in Zimbabwe includes representatives from all relevant institutions inside and outside government. Mozambique may establish a similar platform (INGC to consider CCGC to consider for action).

The current UN-cluster approach has shown to be useful in coordinating relief efforts of different partners. It is recommended that the cluster approach is extended beyond relief and response to establish new clusters for disaster mitigation, prevention, and preparedness. This will coordinate efforts to build longer term resilience. The UN and other multilateral and bilateral agencies together with national governments (led by the INGC and DCP) should consider this for action.

ICPs offer indispensable technical and financial support. It is recommended that ICPs match short-term relief and response funding with longer term DRM support aimed at resilience building. Moreover, where possible local equipment, material and expertise should be used to support economic recovery and livelihoods. It is important to -where possible- standardize support equipment and select the most effective type of equipment, and to limit the number of different brands to facilitate efficient maintenance and reduce the risks of breakdowns.

7 Better balancing short- and long-term DRM interventions

With the expected increase in disasters and greater intensity of the disasters, DRM will require more human and financial resources in future. It is important to minimize human tragedies and as prevention is cheaper than relief and responses, more interventions and resources are needed to prepare for and -where possible- prevent negative impacts. This implies building resilience at the national and household levels. Global assistance for human relief needs to continue but it needs to be matched by greater contributions to mitigation, prevention, and preparedness. The UN and other multilateral and bilateral ICPs should consider this for action. This can be promoted through the establishment of DRM resilience clusters in addition to the existing relief clusters and by availing international DRM resilience funding through the national DRM Funds as additional funds.

8 Rapid needs assessments and follow ups

Rapid needs assessments are essential to quickly assess the damage and relief and reconstruction needs. National governments need to lead this process, assisted by ICPs. It is important that the impacts on the private sector and people's livelihoods are assessed in greater detail than done in the Mozambique PDNA and Zimbabwe RINA. It is also important that stakeholders and the directly affected population is consulted. The rapid assessments should contribute to the development of medium to long-term plans, and include specific activities on mitigation, prevention, and preparedness. It is recommended that PERC studies are carried out with a few years intervals to learn lessons and to assess the progress with resilience building. The project clearly showed that relief and rebuilding take time and need to continue for a considerable period (e.g., 5-10 years). National governments (with INGC and DCP as catalysts) together with ICPs need to support the incorporation of these aspects in rapid assessments.

9 Info/data & info/data base, forecasting and info/data (base) access

DRM and EWS require adequate data and monitoring networks, covering meteorology, hydrology, social, livelihoods/ development and environmental data. Moreover, regular mapping of high-risk areas, floods, rainfall, settlements, livelihood zones, land use etc. is essential. Data should be integrated into a BuPuSa Data & Info System that should be easily accessible to stimulate more research in the basin (e.g., open access data sharing platform). Easy and quick info/data availability is essential to improve community resilience. It is equally important that the info/data inform development and land use planning, for example to identify high risk areas and avoid further developments in such areas.

It is also important to initiate a data base for cyclone DRM experiences with details about the nature of the cyclone, the impacts and damage caused, and the DRM efforts (relief/ response, reconstruction/ rebuilding, mitigation, prevention, and preparedness) in terms of nature of the interventions, institutions involved, level of efforts (human and financial resources) as well as lessons learned (INGC and DCP to consider for action with support of multilateral ICPs).

Member states may have their 'own' data collection systems and data base. It is recommended that data collection systems and national data base are standardized as much as possible to facilitate upscaling to the basin level (INGC, DCP and RBO member states to consider for action).

10 Environment

Idai has shown that cyclones cause significant environmental damage and risks (e.g., remaining unstable boulders in Chimanimani) that environmental rehabilitation and nature-based solutions may increase future resilience. There is need for slope stabilization to prevent future landslides, to restore and protect mangrove forests to maintain their essential functions such as flood control, coastal protection, and fish breeding. There is also need for land rehabilitation and re-afforestation in the worst affected forests and PAs.

Nature based solutions that improve resilience need to be identified and their feasibility assessed. These include development of green areas in settlements and coastal revegetation. The PERC study (Norton *et.al.,* 2020, p.46) gives the following example: *Concrete flood walls along Beira's coastline were heavily damaged by Cyclone Idai's storm surge. Rather than replace these with similar structures, the government and donors should explore Ecosystem-based Disaster Risk Reduction Solutions, such as coastal revegetation, that might provide substantially better protection over time, as sea level rises".* Another NBS is to create more space for river floods by reducing encroachment into the river plains. This would also reduce people and human activities to flood risks. Creation of more space for river would be linked to the resettlement program. The above should be considered for action as part of the Beira rehabilitation plan (e.g., for Beira by the Beira Municipality under the Beira Recovery and Resilience Plan and the World Bank and Dutch development assistance under the CERPP project World Bank, 2019b).

6.2.3 Other RBOs

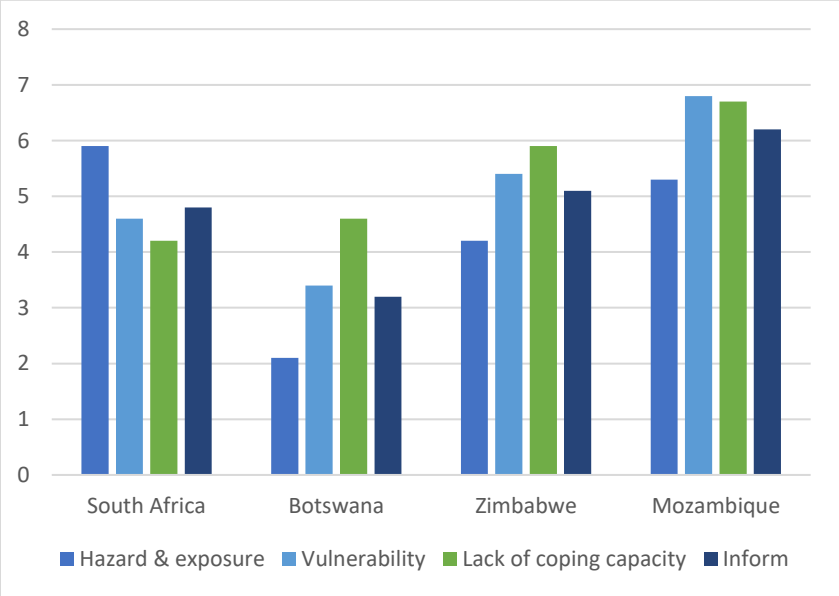
In this section, we briefly review some project findings and lessons for consideration by LIMCOM and OKACOM.

LIMCOM

The Limpopo River Basin runs through South Africa, and Zimbabwe, and ends in the Indian Ocean in Mozambique. The basin is heavily developed, with significant infrastructural developments such as dams, large scale irrigation and water transfer schemes. Upstream the river is regularly over-utilized. While the Limpopo River is historically considered a perennial river, it has de facto become ephemeral in parts of Botswana and South Africa. During periods of heavy rainfall, uncoordinated and large discharges from upstream dams have caused severe flooding in Mozambique in the past. This shows the importance of a basin wide EWS and data sharing. A detailed description of the basin is provided in (Aurecon, 2013).

According to INFORM, Mozambique and Zimbabwe are high-risk countries followed by South and Botswana as medium- and low-risk countries. The country index INFORM ranges from the lowest 3.2 (Botswana) to the highest of 6.2 (Mozambique; Figure 31). The highest risk components vary by country: South Africa: hazards & exposure; Botswana and Zimbabwe: lack of coping capacity and Mozambique: vulnerability.

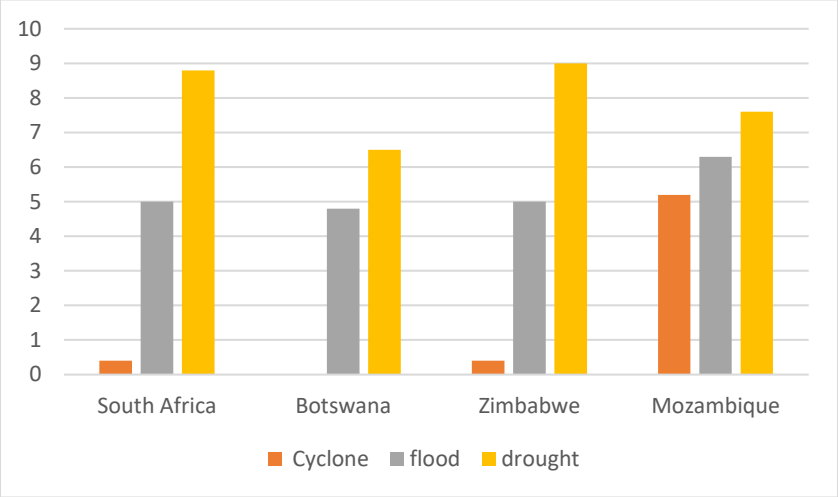
Figure 31: Index for risk management by category in LIMCOM member states.



Source: INFORM data on https://ec.europa.eu/jrc/en/publication/index-risk-management-inform

In terms of natural hazards, droughts pose the highest risk (over 6 index value in all countries), followed by floods, especially in downstream Mozambique. Cyclones pose a significant risk in Mozambique (Figure 32).

Figure 32: Risks of cyclones, floods, and droughts in LIMCOM member states.



Source: INFORM data on https://ec.europa.eu/jrc/en/publication/index-risk-management-inform

LIMCOM has a final draft DRM Action Plan (GWP-SA, 2016). The DRM AP identified eight vulnerability zones in the basin as resilient action areas, starting from upstream going to downstream. It recognizes the low adaptive ability within the basin due to inadequate planning and infrastructure and weak institutions. It prioritizes actions for the four key Sendai areas (GWP, 2016, p. vi). It further identifies nine key resilience factors and challenges (p.22):

a. Socio-economic: poverty, lack of economic diversification, lack of gender data, little understanding of community dynamics, poor planning and understanding of damage and losses associated with cyclones;
b. Institutional: inefficiencies, fragmented institutional approaches and overlapping mandates;
c. Physical: poor planning of critical infrastructure and flood zoning; lack of use of resilient building materials; limited or absent dam rehabilitation; limited joint dam operation to minimize transboundary effects; need to develop flood and drought mitigation interventions'
d. Environmental: lack of understanding of impacts of cyclones and floods on biodiversity and ecosystems; lack of integrated planning and realization that population growth puts pressure on natural resources; lack of monitoring tools;
e. Political: mostly re-active approach; inadequate vertical and horizontal linkages in policy implementation; overlapping mandates and need to encourage cooperation between state and non-state actors;
f. Cultural: poor documentation and use of indigenous knowledge;
g. Financing: lack and uncertainty of funding; DRM is nor prioritized in national budgets; bureaucracy delays delivery to affected people;
h. Information: unrelated/ national EWS models; weak hydrological info sharing and inadequate hydro-met data; focus on specific areas instead of basin; poor EWS reach out to local population; weak institutional arrangements to support transboundary flood and drought forecasting; and
i. Technology: Inadequate investments in DRR technologies; limited access to DRR technologies.

The draft DRM Action plan is comprehensive and forms a good foundation for DRM and DRR in the Limpopo Basin. The intervention areas covered are like the ones that emerged from the Idai project and need to be pursued. An additional recommendation from the Idai project is to establish effective local DRMCs with adequate means and tools and adequately trained. The plan still appears to be a draft and needs to be finalized and adopted by the member states. Moreover, the institutional structures to implement the plan need to be established and mobilized. Resilient Waters should support the finalization of the plan, and its implementation, particularly at the community level. Finally, it would be useful to connect LIMCOM DRM interventions and experiences with SADC-wide DRM efforts to benefit from technical and final capacity in the region as well as share lessons and experiences with other RBOs (e.g., in a SADC data platform.

OKACOM

The Cubango Okavango River originates in Angola, passes through Namibia, and ends in the Okavango Delta in Botswana. The Cubango Okavango River Basin (CORB) is largely undisturbed at present, without significant infrastructure such as dams, large scale irrigation and transfer schemes, and underutilized. This is likely to change with population growth and future developments. The three countries have formed OKACOM to jointly manage the basin.

The OKACOM has developed several strategic documents such as the basin's Vision, the Transboundary Diagnostic Analysis (TDA; OKACOM, 2011a), the Strategic Action Plan (SAP; OKACOM, 2011b), a MultiSectoral Investment Opportunity Assessment (MSIOA) and OKACOM is currently developing a Decision-Support System (DSS). However, there is no specific DRM strategy.

The basin is expected to experience significant changes due to population dynamics, land use changes, economic development, climate change and widespread poverty. OKACOM's SAP aims to manage developments in the basin and achieve its vision of better livelihoods for the inhabitants of the basin. The plan distinguishes four areas of future concern:

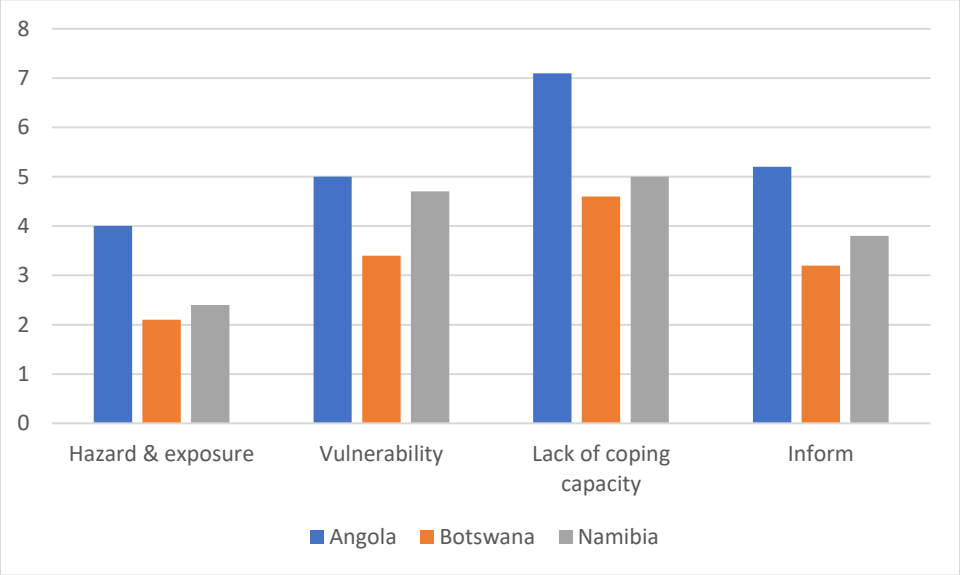
a. Changes in hydrological flows;
b. Sedimentation dynamics;
c. Water quality; and
d. Abundance and distribution of biota.

Driver of changes are population dynamics (growth and distribution), land use changes, poverty, and climate change (higher temperatures, increased water flows and greater flow variability). The SAP does not have disaster risk management as one of its thematic areas but recognizes that floods and droughts are likely to increase and require managements.

The main factors behind increased disaster risk exposure are climate change and land use changes. Climate change is currently expected to lead to higher temperatures, increased rainfall, particularly upstream, and increased variability of the river flow. Floods may become more likely. Population and economic development can be expected to increase the pressure on the riverbanks and flood plains, i.e., high-risk areas. This would be enhanced by widespread poverty and expose particularly vulnerable groups.

According to the INFORM, Angola is a high-risk country (index of 5.2), Namibia a medium 3.8) - and Botswana a low-risk country (3.2) (Figure 33). The lack of coping capacity in Angola is the highest risk component (7.1).

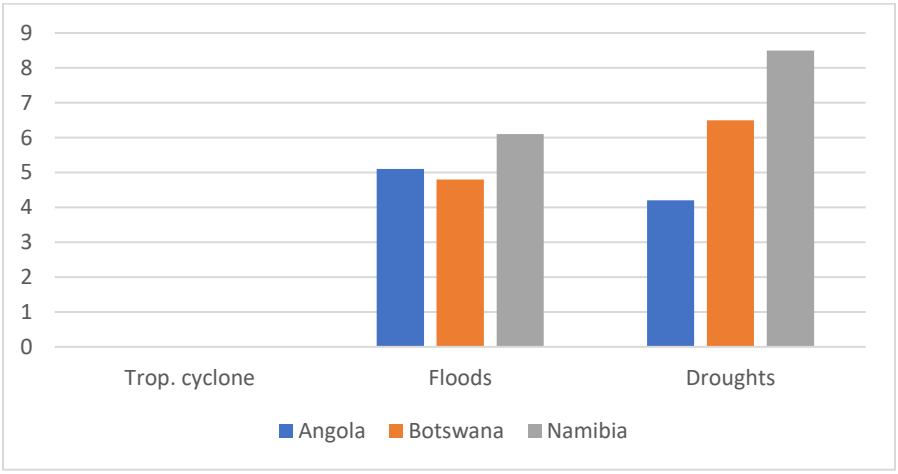
Figure 33: Index for risk management by category and OKACOM member states.



Source: INFORM data on https://ec.europa.eu/jrc/en/publication/index-risk-management-inform

In terms of natural hazards, the risk of cyclones is minimal in the basin, but floods and droughts are important risks, and highest in Namibia (Figure 34).

Figure 34: Risk of floods, cyclones, and droughts by OKACOM member states.



Source: INFORM data on https://ec.europa.eu/jrc/en/publication/index-risk-management-inform

The following relevant DRM activities are envisaged in the TDA and the SAP (OKACOM, 2011a & b):

a. Investments in meteorological and hydrological networks after reviewing the existing networks;
b. Upgrading the hydrological models for the basin;
c. Development of a DSS and information management system;
d. Review of climate change on water resources, including demand;
e. Development of drought management plans and flood forecasting models, flood preparedness plan and early warning systems (EWS), leading to reduced flood damage;

f. Resilient land use mapping; and
g. Economic diversification of livelihoods to increase resilience.

It is recommended that OKACOM develops a concise DRM plan for the basin (e.g., supported by Resilient Waters) that is fully integrated with development and land use plans for the basin and its member states as well as climate change adaptation strategies. Important components would be the assessment of the countries' DRM structures, harmonization of relevant DRM and CCA policies and upscaling to the basin level, establishment of local DRMCs, in particular in high-risk areas. There could be a window for CCA and DRM as part of the CORB Fund that will be established. The strengthening of the meteo-hydro network and data sharing protocols and mechanisms is important, particularly for the flood forecasting. The CORB has the 'advantage' that it is currently under development and water resources are under-utilized. This advantage should be exploited by fully integrating DRM in EIAs and SEAs by the identification of high-risk areas and avoid their permanent development (where possible). These suggestions also imply that DRM should be fully integrated in the DSS that is currently being developed.

6.3 Follow-up activities Resilient Waters in BuPuSa

Based on this project, the focus of Resilient Waters follow-up works should be on increasing community preparedness and resilience to disasters such as Idai. This requires a medium to longer term commitment; in the case of Resilient Waters for the remainder of the project duration and possible extensions. Specially, Resilient Waters requested suggestions for the selection of villages-settlements to focus on.

Settlement – community-based activities

In our view, stakeholders in both countries and BuPuSa should make the final selection in 2021. We suggest considering the following criteria for the selection of villages:

a. Size of settlements, including urban & rural settlements;
b. Extent of damage;
c. Level of relief & reconstruction support;
d. Relocation – high/low risk areas;
e. With and without local DRMC (Mozambique);
f. BuPuSa and country priorities.

In terms of damage, the rainfall intensity map showed that the following settlements received more than 600 mm of rain:

- ✓ Mozambique:
  - 400-600 mm: 23 settlements in Sofala (11) and Manica (12). Examples Buzi & Dondo
  - Over 600: Tica, Inchope and Nhamatanda
- ✓ Zimbabwe:
  - Chimanimani and Chipingwe: 400 to 600 mm Three settlements received over 600 mm:

The damage was highest in Sofala Province in Mozambique and Chimanimani and Chipinge District in Zimbabwe. The rainfall intensity and cyclone frequency maps combined are indicative of high-risk areas. These maps should be complemented by a flood risk map to identify the high-risk areas more accurately.

The Mozambican authorities know which settlements have a local DRMC and which ones have not. It would be interesting to choose one village with and one village without a local DRMC.

The settlement-based activities may include the following:

a. Local assessment of Ida impacts and progress with rebuilding, mitigation, prevention, and preparedness for the next cyclone;
b. Livelihood assessment with the community and identification of diversification options;
c. Needs assessment: review of local DRM structures and processes, equipment, and facilities;
d. Establishment of a basic local DRM infrastructure (e.g., shelters, evacuation plan, storage of strategic stocks, essential transport means);
e. Training needs assessment and training activities;
f. Community participation in meteorological and hydrological monitoring as well as livelihood monitoring; testing & adjustment of "Flood Resilience Measurement Tool"
g. Community mapping of high-risk areas and inventory of IK regarding DRM (e.g., lessons learned) and climate change (adaptations);
h. Community EWS needs assessment and their active participation in EWS.

Local government and non-government institutions need to partner with the communities to increase their resilience and livelihoods. It is recommended that Resilient Waters collaborates with IFCRC and UNESCO on BuPuSa activities to benefit from their experience. Additional external support can be provided by the Centre for Applied Research (socioeconomic assessments) and Hatfield Consultants Africa (RS analysis for communities).

Other BuPuSa DRM activities could be:

i. Assist BuPuSa with development of a DRM strategy;
ii. Assist BuPuSa with the restoration of the meteorological and hydrological monitoring stations and networks;
iii. Assistance with implementation of resettlements from high to low-risk areas;
iv. Development of dam operating guidelines (in conjunction with CRIDF?); and
v. Assess the potential of nature-based solutions (e.g., increasing the space of the rivers, revegetation as coastal protection and green spaces in settlements).

It is further recommended that Resilient Waters supports the recommended LIMCOM and OKACOM activities above to strengthen the basins' and their communities' resilience.

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