Zambezi Watercourse Commission (ZAMCOM)

Zambezi River Basin Flood Forecasting and Early Warning System Strategy

September 2012
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Overview

Currently, there is no comprehensive, integrated flood warning system or protocol for the Zambezi River Basin, leaving flood-prone communities at risk to the annual loss of life and property. In response to the recent damaging floods in Southern Africa, the United States Agency for International Development (USAID) and World Meteorological Organization (WMO) agreed in 2009 to a joint initiative to develop a strategy for a basin-wide flood forecasting and early warning system for the Zambezi River Basin. In collaboration with the Interim Zambezi Watercourse Commission (ZAMCOM) Secretariat (IZS), three USAID-WMO Teams concurrently visited the eight riparian countries in August 2011 to (a) brief riparian staff and (b) discuss the current and potential capacity, and willingness of each country to participate in the development of the Strategy. The teams prepared Consultative Reports on Angola, Namibia, Botswana, Zambia, Zimbabwe, Malawi, Tanzania, and Mozambique for review and comment by the national agencies after the conclusion of the National Consultative Visits.

These activities were undertaken against the background of the Integrated Water Resources Management Strategy (ZAMSTRAT) for the Zambezi River Basin which was formulated within the framework of the Zambezi River Action Plan (ZACPLAN) Project 6 Phase 2 (ZACPRO 6.2). ZACPLAN is an initiative of SADC aimed at achieving environmentally sound planning and management of water and related resources in the Zambezi Basin. ZACPRO 6.2 has succeeded in establishing an enabling environment and water resources management strategy for the Zambezi Basin. The IWRM Strategy for the Zambezi River Basin is seen as a vital tool for cooperative and sustainable management of the water resources of this important Basin in the SADC. In parallel to the Strategy the internet-based Zambezi Water Information System (ZAMWIS) has been developed. Similarly to the ZAMWIS, the Zambezi River Basin Flood Forecasting and Early Warning System (FFEWS) Strategy, once adopted, will form an integral component of ZAMSTRAT.

Based on the Reports and feedback received, and further consideration of the Strategy at and after a Regional Stakeholder’s Workshop held in Lusaka, Zambia from 8 to 9 May 2012 and the ZAMCOM Transitional Technical Committee (TTEC) meeting on 10 May 2012, the USAID and WMO have prepared this strategy document for presentation to a meeting of Zambezi Council of Ministers in late 2012. This Strategy incorporates background information on the National Consultative Visits, and the findings and recommendations of the three USAID-WMO Teams. The findings and recommendations are presented in the context of Basin-wide Flood Forecasting and Early Warning; National Organizational Issues; Basic Hydrometeorological Observational Infrastructure; Unified Hydrologic Modeling Forecasting System; Service Delivery and Dissemination of Warnings; Human and Technical Capacity; and Sustainability. The Strategy proposes the potential creation of a basin-wide organization (basin-wide flood forecasting and warning entity). This will require definitional of relative responsibilities, the USAID and WMO provide in Annex 1 a first-draft division of potential responsibilities between (1) a basin-wide flood forecasting and warning entity and (2) national counterpart organizations, as a basis for consensus development of the proposal with the riparian countries.
The Strategy envisions a participatory process by which representatives of riparian countries and technical representatives of International Cooperating Partners (ICPs) collaborate to define system development needs, at both national and basin-wide levels, as the basis for eventual preparation of investment-ready projects to implement the system.

The Regional Stakeholder’s Workshop held in Lusaka, Zambia from 8 to 9 May 2012 made the following recommendations which were later acknowledged by the ZAMCOM Transitional Technical Committee meeting on 10 May 2012:

1. That the ZAMCOM TTEC should comment on the draft Zambezi River Basin Flood Forecasting and Early Warning System Strategy and endorse a process for its finalization.

2. That the Strategy be presented to the Zambezi Council of Ministers for final approval.

3. That a Steering Committee for the implementation of the Strategy be established, under the auspices of ZAMCOM.

4. That the TTEC, through the IZS, begin action on the following priority areas:
   - Develop a Concept Paper for how you would operationalize a basin-wide FFEWS, based on an analysis of the information collected from the national consultations.
   - Commence the design of a FFEWS Strategy Implementation Plan, addressing the above elements;
   - Undertake an evaluation of the data and information needs and requirements specifically addressing gaps.
   - Commence a process for establishment of standards and protocols for data collection, data transmission, data storage and data sharing;
   - Identify and agree on basin-wide data collection, data management and equipment standards;
   - Develop a basin-wide proposal for the Zambezi FFEWS modeling framework;
   - Address current modeling capabilities and gaps as identified through the national consultations against the agreed basin-wide framework;
   - Design a capacity development program to support the FFEWS Strategy addressing all of the above elements; and
   - Commence the design of a FFEWS Strategy Implementation Plan, addressing the above elements.
Zambezi River Basin Flood Forecasting and Early Warning System Strategy

Introduction

The Zambezi River Basin is home to approximately 30 million people that reside in eight countries in southern Africa. The Zambezi River is the fourth longest river in Africa draining over 1.32 million square kilometers, which is about the half of the size of Nile River basin. The Zambezi River drains parts of Angola, Namibia, Botswana, Zambia, Zimbabwe, Malawi, Tanzania, and Mozambique before emptying into the Indian Ocean. Zambia contains the largest percentage of the Basin’s area, approximately 40.7 percent, whereas Namibia contains the smallest, approximately 1.2 percent. In declining percentages, Angola contains 18.2 percent, Zimbabwe, 16.0 percent, Mozambique, 11.4 percent, Malawi, 7.7 percent, Botswana, 2.8 percent, and Tanzania, 2.0 percent.

There are two large reservoirs in the watershed, which are behind the Kariba and Cahora Bassa dams. The multi-purpose use of these reservoirs presents additional challenges to flood and water-resources management in the Basin. Releases from these reservoirs can aggravate flooding downstream communities, especially when intense rainfalls or tropical cyclone events coincide with above-normal inflows to the reservoirs. Beneficially, seasonal flooding also has served to replenish aquatic habitats, and restore soil moisture and nutrients that support wildlife and agriculture. However, above normal floods have been and continue to be a threat to lives and property of floodplain residents. These high-risk populations depend on the River for livelihoods, but are challenged by changes in the watershed-and-river system, such as urbanization and forest clearings, environmental degradation, increased population in the flood-prone areas, as well as climate change and variability. Zambezi River floods are recurring disasters.

Currently, there is no integrated flood warning system or protocol in the Basin. In response to the continuing loss of life and property to floods in Southern Africa, the United States Agency for International Development (USAID) and World Meteorological Organization (WMO) agreed in 2009 to collaborate on developing a strategy for a basin-wide flood forecasting and early warning system for the Zambezi River Basin. Based on deliberations in Maputo, Mozambique in late 2009, the USAID, and WMO in partnership with National Meteorological and Hydrological Services (NMHS) organized National Consultation visits to all eight Zambezi River Basin countries during August 2011 to (a) brief riparian staff on this initiative and (b) discuss the current and potential capacity and willingness of each country to participate. Three teams composed of USAID and WMO consultants, and national Focal Points concurrently visited the riparian countries; one Team visited Botswana, Angola, and Namibia, a second Zambia, Zimbabwe, and Tanzania, and a third Mozambique and Malawi. Before and after the National Consultation visits, the Teams met with the Interim Zambezi Watercourse Commission (ZAMCOM) Secretariat (IZS), in Gaborone, Botswana to liaise about the flood forecasting and early warning initiative.


After the completion of the visits, the USAID and WMO prepared a National Consultative Report for each riparian country that was reviewed by the country Focal Point and stakeholders during December 2011 through March 2012. Each report was based on information gained from (a) responses to questionnaires that WMO circulated and received from the riparian countries, (b) reports provided by riparian organizations, (c) Internet searches, (d) riparian country consultative workshops and (e) one-on-one visits with selected riparian stakeholders during each three to four day-consultative visit. After the Consultative Reports were reviewed they were revised and be available on the web as well.

This draft Strategy Document is based on the Teams’ findings, as documented in the National Consultative Reports, which are aggregated below, along with recommendations.

Findings

The National Consultative Report findings are presented below under the following general headings.

- Basin-wide Flood Forecasting and Early Warning;
- National Organizational Issues;
- Basic Hydrometeorological Observational Infrastructure;
- Unified Hydrologic Modeling Forecasting System;
- Service Delivery and Dissemination of Warnings;
- Human and Technical Capacity; and
- Sustainability.

Obviously, each Zambezi Basin country is unique and a 3-4 day visit to each does not provide the basis for detailed national findings or basin-wide collaboration. However, the visits did provide a basis for broad, basin-wide generalizations that can be a framework for follow-on cooperation to define and implement improvements. In parallel with the development of this strategy, a demonstration project in the lower Zambezi River Basin is in the process of being implemented. This demonstration project will empower the institutions concerned and serve as a preview on the performance of Early Warning System Flood Zambezi basin as a whole.

Basin-wide Flood Forecasting and Early Warning

There is broad support for strengthening international cooperation for water-resources management in general, and basin-wide flood forecasting and warning in particular. This is evidenced, in greater part, through the establishment of the establishment of the ZAMCOM Secretariat both in the Transitional and Permanent phases. Hydrometeorological data sharing often is a difficult issue in many international river basins throughout the world. However, this seems to be less the case in at least parts of the Zambezi Basin where bilateral or trilateral data sharing among the hydrometeorological and disaster-management communities is already taking place. For example, Zambia, Zimbabwe, and Mozambique have strengthened data sharing and personnel interaction in support of water-resources and dam management in the lower part of the Basin. Moreover, many recognized that a potential basin-wide flood forecasting and warning entity could be an instrument for human and technical capacity development, improved planning for the flood season, and a continuing forum for Integrated Water Resources Management (IWRM) in general. There also are needs for measuring equipment for data collection and exchange, and economic analysis of extreme events (floods
and droughts). The availability of funds for operation and maintenance of equipment into the future will be essential for its sustainability.

**National Organizational Issues**

In parallel with the lack of data sharing in many international shared river basins, collaborations of National Hydrologic and Meteorological Services (NHMS) within countries is typically weak in many places around the world. In general though, in the Zambezi Basin collaboration between these organizations and with national disaster–warning organizations is relatively high, but still can be enhanced. In many countries financial austerity measures have weakened many of the NMHSs, which have (a) lost staff to retirement, the private sector, lack of career development, and disease, (b) prevented adoption of improved technologies to gather and analyze data, and prepare forecasts, and (c) impeded delivery of warning information to disaster-management organizations—all of which is exacerbated by turnover by political leaders.

**Basic Hydrometeorological Observational Infrastructure**

Data collection networks in the Basin in general have been in decline in recent years, with hydrologic networks suffering more than meteorological networks. Moreover, most stations are manually operated with little real-time\(^3\) data being collected. Most WMO Hydrologic Cycle Observing System\(^4\) (HYCOS) stations in many Zambezi Basin countries are inoperative, because of the lack of qualified staff and insufficient funds for travel, repair, periodic maintenance, and sensor replacement. Hydrometeorological networks are generally inadequate throughout the basin and networks are not very robust because of the limited number of gauges, such as real-time meteorological observation stations, rain gages, and stream gages. Also many stations lack automation, so data cannot be quickly collected and relayed to where it is needed. Increasingly, in some countries rating tables for water-level river gauges are out of date because discharge measurements are not being made. In many instances, it is the lack of a strong community (public and private) demand for access to this hydrological information that results in it falling into disrepair and value. A fully operational flood forecasting and warning system meeting the demands of all sectoral stakeholders places requirements on operations and maintenance of the basic supporting infrastructure.

**Unified Hydrologic Modeling Forecasting System**

Although there are hydrologic models in use in the Basin—such as Mike 11, Pitman model, HEC3, HEC5, HECRAS – Namibia, HYData, HYDSTRA, IQQM Integrated quantity quality models and others—there is no standard or unified approach to hydrologic modeling. Many of the NHMSs lack the basic hydrologic modeling and forecasting tools and staff for predicting flood events or managing their domestic rivers. In contrast, International flood forecasting and early warning systems have become more integrated and interactive in many parts of the world, while the data collection and communications aspects of the systems have become highly automated. No single hydrologic or hydraulic or hydrologic model can provide river and flood forecasts throughout a river basin with the varied characteristics of the Zambezi River. Rather,

\(^3\) In the context of hydrology, real-time data are those that are collected and communicated to central data centers every few hours. For a large relatively slow responding river like the Zambezi data real-time could be as infrequently as every 12 or 24 hours, initially.

\(^4\) HYCOS is a program guided by the WMO, see http://sadcycos.dwaf.gov.za/default.aspx
hydrologists create, calibrate, and maintain libraries of linked simulation models and use the most appropriate model for each sub basin or river segment to be forecasted. These sub-basin forecasts then are linked by a forecast system structure so as to provide hydrologic forecasts at numerous river gages and communities throughout the entire Basin. These tools require (a) historical data for calibration, (b) Geographical Information System parameters, (c) real-time rainfall and hydrologic data, and (d) highly trained and experienced operators and forecasters to prepare river-and-flood forecasts. There are large voids in the domestic systems and in some cases, disaster-management organizations prepare flood warnings on the basis of forecasted intense rains, completely bypassing the possible capability of rivers to respond to the anticipated high runoff.

Service Delivery and Dissemination of Warnings

Many disaster-management organizations have collegial relationships with their NMHS counterparts, but do not receive adequate meteorological or hydrological forecasts that are needed to provide the basis for warning preparation. In general, the disaster-management organizations cannot afford dedicated communications networks to disseminate community specific warnings to communities most at risk, and must rely on public radio and television to disseminate warnings to the broad public at large.

Human and Technical Capacity

Austerity measures in many countries have reduced the ranks of NHMS and disaster-management organizations as older hydrologists and technicians retire, and positions remain vacant. Moreover, the brain drain of younger staff to the private sector has added to the constraint on human capacity development. Nevertheless, in many countries there still remains enthusiasm for capacity development, both human and technical.

Sustainability

In many countries, current organizations, staff, technologies, and networks are in decline and sustainability obviously is in the critical path to success. As this Strategy goes forward, national ministries of finance must be engaged in the process. As noted above, the system once in place will attract grass-roots support from all stakeholder groups who will be well placed and eager to demand the sustainability of the system.

Strategy

Based on the findings above, the USAID and WMO provide the following strategic directions for collaboration by ZAMCOM and the respective Zambezi countries. These collaborations must link and draw from existing agreed-to strategies and agreements, including ZAMCOM IWRM strategies, objectives, and operations. Moreover they should build on the local practices and lessons learnt from other basin initiatives and address information needs for all users, especially those at risk to floods. They also should encourage participation of, and feedback from, the communities involved in determining the system requirements, design and development, and must demonstrate due regard to cultural and environmental issues, where they are relevant. In the process they must address ensuring interoperability and accommodating agreed-upon standards for technical systems, and data and information interchange. The collaborative
process, of course, must be transparent to the ICPs so as to maximize the convergence of the interests of both communities.

**Basin-wide Flood Forecasting and Early Warning**

The Zambezi countries should collaborate on defining the requirements for a basin-wide forecast and warning organization, to include a consensus definition of the responsibilities, staffing, budget, technologies, and other attributes of the organization. To the greatest extent practical, the basin-wide entity shall be compatible with nationally based forecast and warning systems, giving due consideration to sharing distributed databases and information systems at all levels. It is important to highlight the role played by the Zambezi Water Information System (ZAMWIS) as a platform for information sharing.

**National Organizational Issues**

Strengthening the capabilities of the NHMS and disaster-warning organizations in the basin is a fundamental step in the implementation of the strategy. The way to address this challenge is to create awareness, with “marketing” and image building, demonstrating the economic value of meteorological and hydrological information. This has to be done at the highest political level and with Finance Ministry included. In some countries, there is no legal mandate for the hydrological or meteorological services to warn the population of impending floods. Communications across and between these agencies need to be improved. Even if a robust basin-wide forecasting and warning system becomes operational, there will always be a need for domestic-river forecasting for both flood-warning and meeting IWRM objectives. National flood and river forecasting needs should be met with compatibility in mind, both with other national systems and the basin-wide system.

**Basic Hydrometeorological Observational Infrastructure**

Each riparian country should be supported, where required, to review the capacity of its current hydrometeorological data-collection networks with stakeholders, so as to identify priorities of data collection and unmet stakeholder needs. The review should consider the value and cost of real-time data, not only to preserve life but also to provide economic IWRM benefits. Stakeholders should be encouraged to quantify the economic benefits they can provide as a result of strengthened data-collection and communication networks.

**Unified Hydrologic Modeling Forecasting System**

A unified Hydrologic Modeling Forecasting System should be the overall framework within which both basin-wide and domestic systems are conceptualized and developed. There is a wide degree of latitude within which this can be done, depending on the degree to which the basin-wide organization and national forecast centers share flood forecasting and warning responsibilities, as well as staff.

**Service Delivery and Dissemination of Warnings**

The process of communicating flood forecast information to the various users in all of the countries visited uncovered unmet technology, staff, and financial needs that need to be addressed. The adopted flood forecasting and early warning system will only be as strong as its
weakest link and reaching and empowering the community at risk should be the ultimate aim of
the system and must be achieved. There also are needs for (a) improving the coordination
mechanisms of National Disaster Management Forums and () Memoranda of Understanding by
member states for the rescue of population living in border areas

**Human and Technical Capacity**

Human and technical capacity must be a continuing priority for the riparian countries. Though
many organizations have lost some of their most skilled staff to retirement and the private
sector, enthusiasm and motivation of current staff are high to undertake capacity development
and benefit from technology transfer. Capacity building can be achieved through a range of
mechanisms, from improved education systems, improved hydrologic university curricula, and
targeted training courses of practitioners, including distance learning, exchange of lessons
learned, and on the job training.

**Sustainability**

This Strategy encourages participants to consider sustainability of systems that are developed
in response to national and basin-wide needs they define. There are inherent conflicting needs
for (a) data-collection, forecasting, and warning against (b) inadequate financial and human
resources that will be available in the future, requiring continuing engagement of national
ministries of finance in the process of Strategy development. Technical, human, and financial
constraints must be considered by system developers when conceptualizing systems to meet
national and basin-wide needs.

**Organizational Responsibilities**

Noting that the Zambezi community have the ZAMCOM agreement in place, the Riparian States
are well aware that the creation of any organization that will have basin-wide responsibilities
must be accompanied by agreement about the division of responsibilities among the
organizations. As a starting point, USAID and WMO provide in Annex 1 a first-draft of the
division of responsibilities between (1) national counterpart organizations and (2) a basin-wide
flood forecasting and warning entity.

**Performance Indicators**

Performance Indicators provide objective measures of the return of social and economic
benefits that result from meeting stakeholder needs. Participants may seek to consider
adopting processes to assure that stakeholder needs and performance requirements are met
and documented in an ongoing manner. The benefits of saving lives and reducing property
damage due to floods, combined with IWRM benefits can accrue economic and social benefits
that exceed long-term capital and operational costs of implementing the system, as has been
demonstrated in many parts of the world.

**Next Steps**

Several steps of Strategy implementation are envisioned, consisting of review, possible
amendments to, and provisional acceptance of the Strategy itself. The implementation process
documented herein is briefly stated in order for this document to be brief and high level. Upon
acceptance, more details will be included for review and approval through a consensus building process by ZAMCOM and the within riparian countries. The USAID/OFDA and WMO are committed to follow up with defining a system design and implementation plan and will work with donors to fund and build the system over the next twelve months. This effort will be coordinated with SADC Dam Synchronization efforts since flood forecasting is a major component of needed to achieve effective flood management as well as multiple resource optimization in the operation of both dams. In addition the OFDA project will continue to coordinate with World Bank hydrometeorological modernization country projects as well as other donor initiatives that are closely aligned to disaster risk reduction and water resources management.

Once adopted it is proposed that the Strategy will be returned to the riparian countries and ZAMCOM in anticipation of their participation in a basin-wide Strategy meeting. The basin-wide meeting will attempt to finalize consensus on the Strategy and initiate planning of investment-ready projects in anticipation of formal Strategy acceptance at a subsequent ZAMCOM decision makers’ meetings. The basin-wide meeting will provide preliminary guidelines for format and content of projects, and draft schedule for project preparation. As indicated above, the Zambezi River Basin FFEWS Strategy will complement and be integrated with the wider the IWRM Strategy for the Integrated Water Resources Management Strategy for the Zambezi River Basin (ZAMSTRAT).

At the heart of the Strategy is a participatory process in which riparian representatives—assisted by representatives from ICPs- will collaborate on defining riparian and basin-wide needs for flood forecasting and warning, optionally to include broad IWRM needs as well.

**Investment-Ready Project Proposals**

Project Proposals

Strategy implementation teams will prepare draft needs requirements and project proposals, at the riparian and basin-wide levels. At the riparian level the needs mainly will focus on upgrading technical and human capacities of (a) hydrologic organizations, (b) meteorological organizations, and (c) disaster management organizations in each country so that they are positioned to be contributing and beneficial partners with the basin-wide organization.

A team of riparian representatives and international experts will convene to define the organization, staffing, and capital investment and operational budgets for the basin-wide organization. At that level, the project proposals will focus on the process of (a) documenting performance needs of the basin-wide entity and (b) implementation planning. Because riparian projects generally will build upon existing organizational, technical, and human infrastructure it is likely that implementation of riparian proposals will proceed more readily than basin-wide proposals.

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5 An investment-ready project or proposal is one that has (a) meets a defined set of needs, (b) has sufficient detail and probabilities of success and sustainability, and (c) is consistent with an ICPs investment guidelines to be considered for funding.

6 An initiative of this organizational complexity—multiple proposals from each of eight countries and the basin-wide entity—will require a continuously staffed Program Management Unit (PMU) to refine planning and coordination of the overall initiative.
Project proposals will need to take into consideration other related initiatives being implemented in the Basin, such as the SADC Dam Synchronization Study report. It is essential that the actions proposed for the FFEWS are closely aligned with such initiatives.

**Project-Proposal Reviews**

This activity will go forward at its own pace, depending upon the submission of project proposal needs requirements. A team of representatives of the Strategy process and ICPs will review project prior to submission to the Zambezi Technical Committee (ZAMTEC), which acts under the policy guidance of the ZAMCOM Ministerial Council.

**Implementation of Projects**

Implementation will go forward as projects are approved. Project proposals will be prepared collaboratively to define the needs for national and basin-wide forecasting and warning systems. This will be an initiative of organizational complexity because of the prospect of multiple proposals concerning each of eight countries and the need for a basin-wide entity is selected—and will require a continuously staffed Project Management Unit (PMU) to refine planning and coordination of the overall initiative, if strategic goals are to be achieved. A preferred approach is to establish a river basin program that is Administered by ZAMCOM, is staged (done in steps—such as clusters of countries versus trying to do all countries concurrently) and that provides a single contract for technical and capacity development support to develop and implement an integrated system for the entire Zambezi Basin.

**Summary**

The USAID and WMO have worked together on the preparation of a Zambezi River Basin Flood Forecasting and Early Warning System Strategy and though collaborative efforts with ZAMCOM and eight Zambezi Basin countries. This resulting Strategy discussion document provides a path to conceptualize and implement future organizational capacities on national and basin-wide levels, as well as their interactions and products. The path includes a highly participatory process in which riparian representatives and strategy implementation representatives collaborate on defining the needs for investment-ready project proposals, which will be reviewed by ICPs and approved by the ZAMTEC and the Council of Ministers, prior to formal submission of the proposal to the ICPs.

**Acronyms**

- HYCOS: Hydrologic Cycle Observing System
- IWRM: Integrated Water Resources Management
- ICP: International Cooperating Partner
- IZS: Interim ZAMCOM Secretariat
- NMHS: National Meteorological and Hydrologic Services
- PMU: Program Management Unit
- USAID: US Agency for International Development
- WMO: World Meteorological Organization
- ZAMCOM: Zambezi Watercourse Commission
- ZAMTEC: Zambezi Technical Committee
## Basin-wide Flood Forecasting and Warning Entity

### Draft National and Basin-wide Responsibilities

#### National

Table A1.1 – Riparian flood forecasting, warning, and associated responsibilities

<table>
<thead>
<tr>
<th>Topic</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrometeorological data collection</td>
<td>National hydrometeorological data-collection networks are the responsibility of riparian countries, which will share selected historical and real-time data sets with the basin-wide entity to support basin-wide forecasting</td>
</tr>
<tr>
<td>Riparian river forecasting</td>
<td>Forecasting of national rivers is a riparian responsibility, though riparian countries and the basin-wide forecasting entity are encouraged to harmonize their processes and share results</td>
</tr>
<tr>
<td>Flood-disaster management</td>
<td>National flood-disaster management is the responsibility of each riparian country.</td>
</tr>
<tr>
<td>Health and Disease</td>
<td>Mitigation of diseases in humans and animals is a riparian responsibility; effective national and basin-wide hydrologic monitoring, forecasting, and warning can assist management of diseases that flourish during floods and droughts.</td>
</tr>
<tr>
<td>Water-control structures</td>
<td>Operation of dams and other water-control structures is a riparian responsibility, or a shared responsibility under the provisions of existing and future treaty obligations among the riparian countries</td>
</tr>
<tr>
<td>Operating rules</td>
<td>Water-control structure operating rules are a riparian responsibility, or a shared responsibility under the provision of existing and future treaty obligations among the riparian countries. To facilitate basin-wide river forecasting, control-structure operators shall share structure operating rules and current-release information with the basin-wide forecast entity.</td>
</tr>
<tr>
<td>Decision support</td>
<td>Water-control structure decision support systems are a riparian responsibility, or a shared responsibility under the provision of existing and future treaty obligations among the riparian states</td>
</tr>
</tbody>
</table>
## Basin-wide

### Table A1.2 Basin-wide flood forecasting, warning, and associated responsibilities

<table>
<thead>
<tr>
<th>Topic</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Basin-wide flood forecasting</strong></td>
<td>Basin-wide river forecasting at selected sites on the Zambezi River is the responsibility of the basin-wide entity and—if agreed to by the riparian countries—forecasts may be made available on the basin-wide entity’s Internet website and other media outlets.</td>
</tr>
<tr>
<td><strong>Basin-wide flood warning</strong></td>
<td>Basin-wide flood warning shall be provided by the basin-wide entity promptly to only riparian-state water and disaster management organizations for their consideration and action.</td>
</tr>
</tbody>
</table>
| **Hydrometeorological and disaster management human capacity development** | Under the guidance of the riparian countries, the basin-wide forecast entity shall facilitate human capacity development support to riparian countries on the topics of:  
  
  - Hydrometeorological data collection standards, harmonization, processing, modeling, and analysis  
  - Dam-break analysis  
  - Flood-disaster management  
  - Flood-plain mapping and analysis  
  - Other appropriate topics |
| **Hydrometeorological technology transfer** | Under the guidance of the riparian countries, the basin-wide entity shall facilitate technology transfer of appropriate flood-related forecasting and warning technologies to riparian-state staff. |
| **Annual Flood Meeting**                   | The basin-wide entity shall plan, conduct, and document an annual thematic flood meeting to:  
  
  - Review riparian and basin-wide forecasting, warning, and management of past floods  
  - Review preparation for the coming annual flood  
  - Invite participation from riparian countries and—in support of technology transfer—invite other riparian and international organizations to participate in the meeting  
  - Provide donor insight into opportunities to promote flood-disaster mitigation |
| **Flood-dispute mediation**                | In the event of a dispute among the riparian countries concerning a perceived flood-related problem and—at the written request of all affected countries—the basin-wide entity shall seek impartial technical analysis of the flood-related problem from experts outside the Zambezi River Basin |