ZAMCOM

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Zambezi Basin Seismic Activity Factsheet

Recent Earthquakes And Tremors In The Zambezi River Basin

INTRODUCTION

Seismic activities associated with earthquakes and tremors are related to the shaking of the earth. Concerns have been raised on the increased occurrences of higher magnitude earthquakes in the Zambezi River Basin, as well as the related potential devastation to socio-economic systems and livelihoods that could result.

According to the English Oxford Living Dictionaries, seismic activity is defined as relating to earthquakes or other vibrations of the earth and its crust. In the Zambezi River Basin (Figure 1), earthquakes and tremors are primarily attributed to natural causes emanating from the tectonic movements of the East African Rift System (EARS) (Figure 2).

The other significant cause of earthquakes and tremors in the Zambezi River Basin is related to filling of large reservoirs and lakes as well as the associated fluctuations of water levels (reservoir-induced seismic activity). Such seismic activities have been recorded in relation to the building of Lake Kariba since the completion of the dam in 1958.

Other causes of earthquakes and tremors include mining activities, hydraulic fracturing (fracking) and volcanic eruptions.

Figure 1: The Zambezi River Basin

Figure 2: Major geological feature containing East African Rift System (EARS) with the position of the mid-Zambezi Valley sub-basin given (Nyambe, 1993).

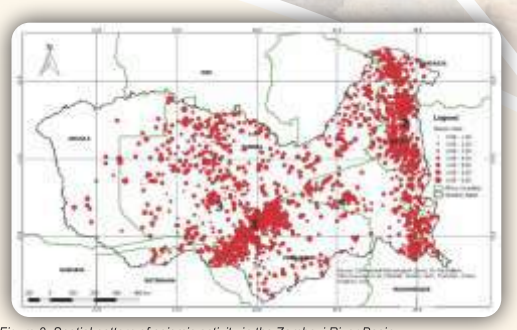

Figure 3: Spatial pattern of seismic activity in the Zambezi River Basin. Notice that concentrations follow the fault areas of the Zambezi Rift and the East African Rift System (EARS) and more pronounced in water holding areas (1 = Lake Kariba; 2= Lake Malawi/Nyasa/Niasa and Shire River; 3= Itezhi-Tezhi Dam; 4 = Cabora bassa Dam). Compare with Figure 2 and notice the alignment with the geological structures.

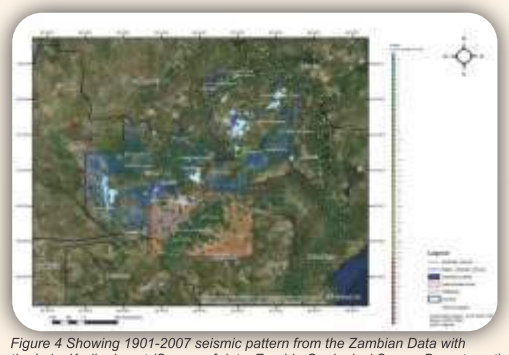

Figure 4 Showing 1901-2007 seismic pattern from the Zambian Data with the Lake Kariba insert (Source of date: Zambia Geological Survey Department)

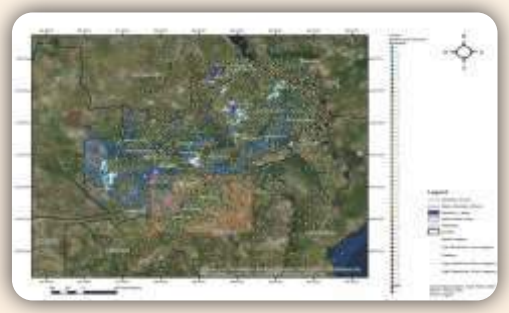

Figure 5 Showing 1967-2017 seismic pattern from the Zambian Data with the Lake Kariba insert (Source of data: Zambia Geological Survey Department)

State and Trends of Seismic Activity in the Zambezi River Basin

With reference to Figures 3, 4 and 5, it is evident that the Zambezi Basin is subject to pronounced seismic activities. These figures clearly show that dense concentrations of earthquakes and tremor events in the Basin are associated with large water bodies - Lake Kariba (1), Lake Malawi/Nyasa/Niasa (2), Itezhi-Tezhi Reservoir (3) and Lake Cahora Bassa (4).

The spatial occurrence pattern shows that while the Luangwa Valley and Lake Malawi/Nyasa/Niasa and Shire systems are dominated by EARS associated natural seismic activities, the other large water body areas are primarily subject to man-made

reservoir-induced seismic activities.

The Zambian Copperbelt region is also subject to significant seismic activity which is highly likely induced by concentrated mining activities. Also quite apparent is low seismic activities in the western part of the Basin especially in Angola. This may be due to the existence of a naturally stable geological formation.

Zambia's Department of Geological Survey recorded a total of 4600 natural and induced seismic activities in the Zambezi River Basin over a 116-year period stretching from 1901 to 2017. Refer to Figures 4 and 5 for details.

While the Zambezi River Basin is generally considered a relatively quiet region seismically when compared to places such as the state of California in the United States of America (USA), earthquakes of magnitudes larger than 4.0 on the Richter scale have been recorded. Refer to Table 1 for details.

Table 1: Major Earthquakes in the Zambezi River Basin

Date	Time	Latitude (°S)	Longitude (°E)	Magnitude (mb)	Region
13.12.1910	11:34	- 8	31.0	7.1	South Tanganyika
13.12.1942	13:40	-11.4	34.5	6.7	Western Malawi / Nyasa/Niasa
25.09.1963	07:03	- 16.73	28.4	6.4	Lake Kariba
18.07.1986	15:07	- 16.36	28.48	5.4	Lake Kariba
10.05.1991	01:12	- 17.35	24.98	4.8	South West Mulobezi
21.07.2011	15.55	- 15.96	25.98	5.2	Itezhi-tezhi
04.02.2012	15.55	- 16.94	27.64	4.5	Lake Kariba
09.01.2016	03:05	-16.05	28.55	4.6	Chirundu

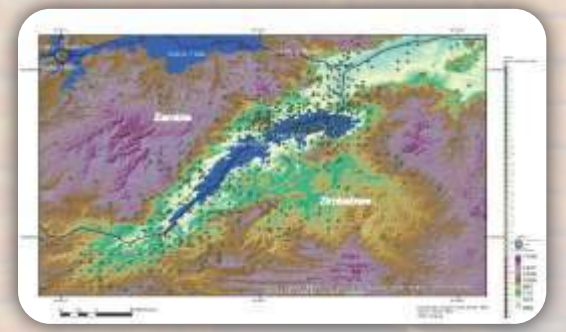

Figure 6: Earthquake events in the Middle Zambezi zone dominated by Lake Kariba (Source of data: Zambia Geological Survey Department)

In 1910, the largest earthquake with a magnitude of 7.1 on the Richter scale occurred in the southern part of Lake Tanganyika affecting parts of Zambia, Tanzania and Malawi. This was a natural seismic event.

The filling of large man-made reservoirs in the Basin is known to be associated with triggering intense seismic activity. An example is Lake Kariba which triggered numerous tremors as it filled from 1961. After filling was achieved in August 1963, Lake Kariba triggered the world's first known high magnitude earthquakes greater than 6.0 on the Richter scale. From 23rd to 25th September 1963, six such high magnitude earthquakes occurred in addition to the numerous lower magnitude tremors.

In the early 1960s, Lake Kariba caused numerous earthquakes in the area, 20 of them larger than magnitude 5 on the Richter scale.

Between 1961 and 1963 a total of 750 aftershocks were recorded.

Although the seismic activity decreased thereafter, numerous tremors whose epicenters are in the Lake Kariba basin have been recorded. The Department of Meteorological Services in Zimbabwe recorded a total of 2,416 seismic events emanating from the Lake Kariba area in the Middle Zambezi Sub-Basin over a 58-year period stretching from 1959 to 2017. In 2016 alone, Zimbabwe recorded over 50 earthquakes ranging from magnitude 1.5 to 4.6 on the Richter scale with Lake Kariba area being the epicenter. See Figure 3 for details.

Before construction of Lake Kariba, no known seismic activity had its epicenter in the Lake Kariba basin (Gough, D.I., 1978). Figure 6 shows earthquakes of varrying magnitudes recorded in the Middle Zambezi basin whose main feature is Lake Kariba.

Impacts of Seismic Activities

Earthquakes that occur in heavily populated areas are seismic activities' most devastating natural hazards.

As was with the magnitude 5.4 to 6.0 earthquake swarm which occurred in Karonga in Malawi from 6th to 20th December 2009. The adverse impacts of such events include the following:

- **Loss of life – both human and livestock:** In the case of Karonga, four people were killed and over 300 were injured;
- **Infrastructure Destruction:** Whole populations in affected areas are left vulnerable to collapsing infrastructure which includes residential buildings, roads and bridges, water supplies and sanitation facilities, schools and health facilities. In Karonga the area's population of 1.2 million was left vulnerable;
- **Homelessness:** People are subjected to homelessness due to destruction and collapse of residential buildings. About 2,870 houses were destroyed while at least 15,000 people were left homeless in Karonga;
- **Loss of Livelihoods:** Where settlements are on steep mountain slopes, sustenance production systems are prone to landslides. In the case of Karonga which is a mountainous region with steep slopes, sources of livelihoods such as crop fields, grazing land, water sources and the environment were affected by landslides.
- **Food Insecurity:** In areas of high agricultural activity, earthquakes induce food insecurity through destruction of production systems. In the case of Karonga which is a highly cultivated area, people were subjected to food insecurity after the destruction of their crops and food storages.
- **Socio**-psychological stress is felt by those who suffer losses to earthquakes and they need targeted support to get back on track.

- Threats to human health through loss of health provision facilities, water and sanitation facilities, and, nutritional sources.
- Loss of regional economic contributions to the national economic wellbeing through devastation of regional production systems.
- Straining meagre national budgets as resources are diverted from essentials to emergency situations so as to save lives and assist recovery through relief efforts. In Karonga, the Government of Malawi allocated a total of Mk2.5 million for immediate emergency relief work.

Overall, earthquakes and tremors cause serious damage to socio-economic infrastructure such as buildings, bridges and dams. In a situation where a dam for hydropower generation were to collapse, that would mean total loss of generation capacity that could lead to complete shut down and possible collapse of the dependent socio-economic sectors. This scenario can be extended to the Kariba Dam which could also cause loss of downstream infrastructure, wildlife habitats and tourism, and, possibly Lower Zambezi livelihoods.

Fortunately, most of the earthquakes and tremors that have occurred in the Zambezi River Basin have not had significant adverse impacts on the socio-economic and environmental systems.

Coping and Resilience Mechanisms in the Zambezi Basin

Disaster Management Legal and Institutional Arrangements: There is no evidence of standalone legal and institutional arrangements for earthquakes and tremors among the Riparian States of the Zambezi Basin.

However each country has in place legal and institutional arrangements that are targeted at disaster risk management. The hazards that are addressed include floods, pest infestations, droughts, storms, landslides, accidents, heat waves, veld fires and earthquakes.

Each of the Riparian States has a disaster risk management institution. These are Department of Civil Protection (Zimbabwe), Department of Disaster Management Affairs (DoDMA) (Malawi), National Disaster Management Office (Botswana), National Institute of Disaster Management (Mozambique), Civil Protection Unit in the Ministry of Interior (Angola), Disaster Risk Management Unit (Namibia), Disaster Management and Mitigation Unit (Zambia), Disaster Management Department (Tanzania).

There is evidence that each of the Riparian States has legal instruments that include statutes or acts, policies, strategies and plans that address disaster management and mitigation (UNECA, 2015). Most of these legal instruments are quite recent i.e. instituted after 2010 (UNECA, 2015).

Through membership of SADC, the ZAMCOM Riparian States adopted the SADC Regional Disaster Preparedness and Response Strategy in November 2016.

The Riparian States are also part of the SADC/UNECA/UNISDR project which is on mainstreaming and implementing disaster risk reduction in Southern Africa. The project is being implemented within the framework of the United Nations Development Account project on strengthening the capacities of African policymakers to mainstream natural disaster risk reduction into national and regional development policies and strategies in Africa. The project was conceived and implemented by the Economic Commission for Africa (ECA) and the United Nations Office for Disaster Risk Reduction (UNISDR) in conjunction with SADC (UNECA, 2015).

It can be concluded that the earthquake hazard is taken seriously within the wider disaster management context by each of the Riparian States as well as at the Basin level within the framework of SADC and at the global level through the United Nations Disaster Risk Reduction convention.

What may need to be addressed is the adequacy with which the legal and institutional arrangements at the national, regional and global levels address the specific issue of the earthquake hazard at the Zambezi Basin level.

Stakeholder Participation in Earthquake Disaster Risk Management

All the riparian states in the Zambezi Basin have disaster risk awareness programs that they run in conjunction with stakeholders and in this case the vulnerable communities.

However, in Zimbabwe the Seismology Section of Meteorological Services Department working together with Department of Civil Protection, has been educating people on earthquake risk and earthquake-related disaster preparedness through participation in the design of disaster risk management plans for different districts and provinces (Kwangwari M. J 2017).

Figure 7: Example of the Zimbabwe Seismic Station and the inside (Photos, courtesy of Mr. Marimira Kwangwari, Meteorological Services Department, Zimbabwe).

Infrastructure for Monitoring Seismic Activity:

Each of the Riparian States in the Zambezi Basin has seismic activity monitoring institutions. These include the Departments of Geological Surveys as is the case with Zambia and Departments of Meteorological Services as is the case with Zimbabwe. Refer to Figures 7 and 8 for appreciation.

Since earthquakes are transboundary in nature whereby the tremors are felt far and wide in the Basin, countries collaborate in their monitoring efforts. Figures 3 and 4 on the spatial occurrence of earthquakes and tremors in the Basin illustrate the corroboration of events among countries.

These efforts at bolstering resilience against seismic related hazards also enjoy support from the USGS which also monitors earthquake and tremor activities in the region through advanced techniques, instrumentation and reporting.

Policy Options

Policy and strategic options should be developed in all Riparian States as follows:

- **Strengthen Zambezi Basin Capacity in Earthquake Disaster Risk Management:** Earthquakes and tremors are increasing in frequency and magnitude and will remain hazards to worry about. Policy needs to focus on strengthening regional capacity to develop and implement regional policy, strategy and plan that minimise vulnerability of Basin socio-economic and environmental systems while strengthening their resilience.
- **Improve quality of Infrastructure and Housing:** Homelessness is a real issue in the event of a destructive earthquake as was the case with Karonga in 2009 where houses collapsed or were rendered inhabitable due to massive cracking. Poor quality structures are primarily due to most local artisans venturing into the building business with no formal training and are unfamiliar with better building principles. Policy needs to focus on quality housing that can withstand such hazards. Raising awareness of disaster risk reduction and adaptive infrastructure among local artisans and building contractors is an effective way of promoting disaster risk reduction mainstreaming in the building sector.
- **Development of community-based earthquake disaster risk reduction programs:** Since it is communities that bear the brunt of adverse impacts of seismic activities as was with the communities of Karonga in Malawi in 2009, it is important to focus on developing programs that reduce vulnerability to the vagaries of earthquake and tremor hazards.; and
- **Preparedness and Relief provision:** Governments through the Disaster Management and Mitigation Units and other relief agencies should incorporate earthquakes and tremors in their designs and operations and work across borders to coordinate and align disaster risk reduction policies, strategies and plans. Data on which to base the designing of such responsive measures should include seismic records as those available from Zambia's Geological Survey Department.

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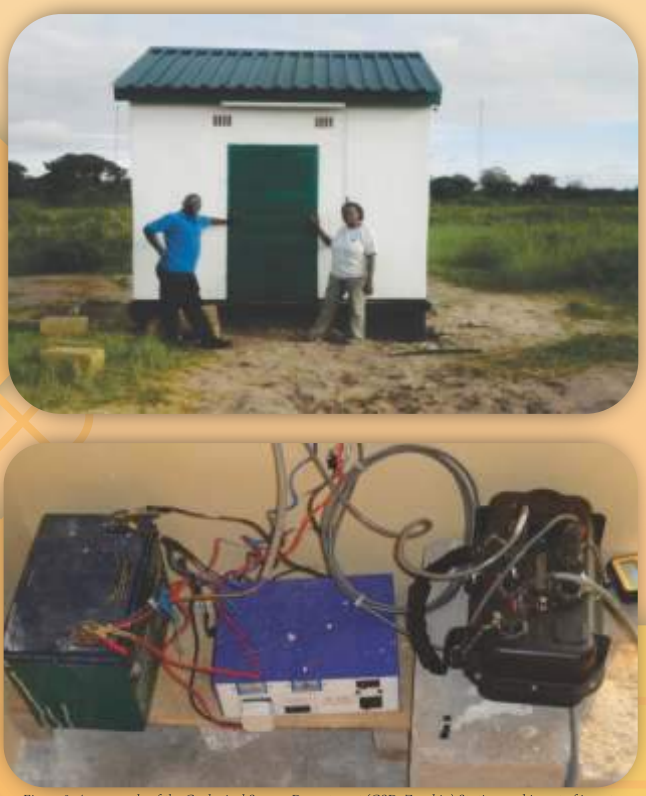

Figure 8: An example of the Geological Survey Department (GSD, Zambia) Station and insert of insert (Photo courtesy of Gift Chafwa, GSD)

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