Early Warning Systems in The Southern African Development Community: A Necessity

ABSTRACT

The study explored the existence of early warning systems and related protocols in selected SADC Member States. The purpose was to ascertain whether the Southern African Development Community (SADC) member states have functional, people-centered early warning systems as part of their disaster risk management programs. The study adopted a mixed-method approach involving a review of relevant documentation, a self-administered questionnaire, and in-depth face-to-face interviews with senior managers and Disaster Risk Reduction (DRR) practitioners. Random and convenience sampling methods were used to select five Member States for data collection: Botswana, Eswatini, Lesotho, Mauritius, and Seychelles. A total of 50 respondents participated in the study. Thematic analysis was employed to capture critical perspectives. The findingsshow that all Member States have some early warning systems dominated more by meteorological weather agencies. However, very few Member States have attempted to develop an early warning system with all the requisite details for effective disaster risk reduction. There is an immediate need for all Member States to develop not only the framework for but also multi-hazardand people-centered early warning system(s) in line with the Sendai Framework for Disaster Risk Reduction (SFDRR) and the Africa Plan of Action.

Keywords: Early Warning System, SADC, Disaster Risk Management, Assessment, Multi-hazard.

1. INTRODUCTION

The SADCfirst time an acronym appears in the text, previously describes it and put it into parentheses. After that, just the acronym is necessarymember states are prone to various natural hazards such as floods, windstorms, wildfires, cyclones, drought, and earthquakes. Hydro-meteorological events such as Cyclone Dineo in 2017 affected a number of countries including Botswana, Mozambique, South Africa, and Zimbabwe; Cyclones Idai and Kenneth in 2019 that affected Comoros, Malawi, Mozambique, South Africa, and Zimbabwe, and cyclone Eline in 2000 that caused floods affecting Botswana, Mozambique, and Zimbabwe; and drought in the period (1982 – 1984, 1991 – 1993, 2014 – 2017) have had huge human, economic as well as environmental impacts. Several coastal countries, such as Mozambique, Madagascar, Mauritius, Seychelles, Namibia, and Angola experience frequent meteorological events [1, 2, 3, 4]. By contrast, inland countries like Botswana, Swaziland, Zimbabwe, Lesotho, and Malawi

experience frequent mild to severe droughts. Unfortunately, efforts to address these events seemingly continue to be carried out in a reactive manner [5](SADC 2019; [6]UNISDR, 2005). It is therefore important to continuously assess and monitor the hazards and risks and provides necessary early warning systems (EWS) information to mitigate the loss of lives, and destruction of property and infrastructure.

Hazard and risk assessment and effective early warning systems enable countries and economies to adequately adjust and prepare for the shocks from disaster events. As Baudoin*et al* (2014) argued, communication through early warning systems provides the opportunity to reduce disaster risk by enhancing preparedness.Thus, it contributes to strengthening livelihood resilience at the local level. The purpose of this study was to establish whether selected SADC member states have early warning systems in place, their application in practice, and their focus. This study only considered national-level implementation and how they interface to generate early warnings and share their findings with stakeholders and citizens.

2. MULTI-HAZARD EARLY WARNING SYSTEMS

An Early Warning System is defined as "a set of capacities needed to generate and disseminate timely and meaningful warning information of the possible extreme events or disasters (e.g. floods, drought, fire, earthquake and tsunamis) that threaten people's lives" (UNISDR, 2005; National Institute of Disaster Management, 2014). The United Nation (UN), (2016) defines early warning system as "an integrated system of hazard monitoring, forecasting and prediction, disaster risk assessment, communication and preparedness activities, systems and processes that enable individuals, communities, governments, businesses and others to take timely action to reduce disaster risks in advance of hazardous events". The foregoing is collaborated by the definition of the UNISDR which, defines early warning as "the provision of timely and effective information, through identified institutions, that allows individuals that may be exposed to a hazard to take action to avoid or reduce their risk and prepare for effective response" (UN, 2006). Such systems must be people-centred in that the messages generated must reach the intended recipients, and must be simple and clear to be understood by the recipients.

The Sendai Framework for Disaster Risk Reduction (SFDRR) (2015- 2030) as well as the Africa Plan of Action for the implementation of the SFDRR, calls for a shift in paradigm by building the resilience of nations and communities to disasters by recognizing the benefits of multi-hazard

early warning system (MHEWS). MHEWSaddresses several hazards and/or impacts in contexts where hazardous events may occur alone, simultaneously, cascading, or cumulatively over time, and considers the potential interrelated effects (UN, 2016). A MHEWSwith the ability to warn of one or more hazards increases the efficiency and consistency of warnings through coordinated and compatible mechanisms and capacities, involving multiple disciplines for updated and accurate hazard identification and monitoring (UN, 2016). In this regard, it is argued that countries which have effective MHEWS are likely to drastically reduce disaster losses and damages (UNISDR, 2005).

2.1 People-Centred Early Warning System

Early warning systems are commonly viewed as a linear chain from the risk diagnosis by meteorologists, geologists, hydrologists, and other specialists to the dissemination of alerts to high-risk groups, and this is often referred to as the "End-to-End" model (Basher, 2006; UNISDR, 2009). As Basher, (2006) argues, early warning systems should not only focus on modeling geophysical processes but include other considerations such as human vulnerability and the response processes. The author advocates for "a strong focus on the people exposed to risk, and with a systems approach that incorporates all of the relevant factors in that risk, whether arising from natural hazards or social vulnerabilities, and from short-term or long-term processes" (Basher 2006:2167). Unfortunately, predictions on their own are not useful unless they are translated into a warning and action plan that the public can understand, and the information reaches the public in a timely manner (Glantz, 2003).

According to Rivera (2016), the people-centered early warning system is contingent on establishing monitoring centers to integrate different social areas and essential issues, such as security and transportation. United Nations Office for Disaster Risk Reduction (UNDRR), (2017) (see Fig. 1 below) provides a model for a multi-hazard approach for people-centered EWS.

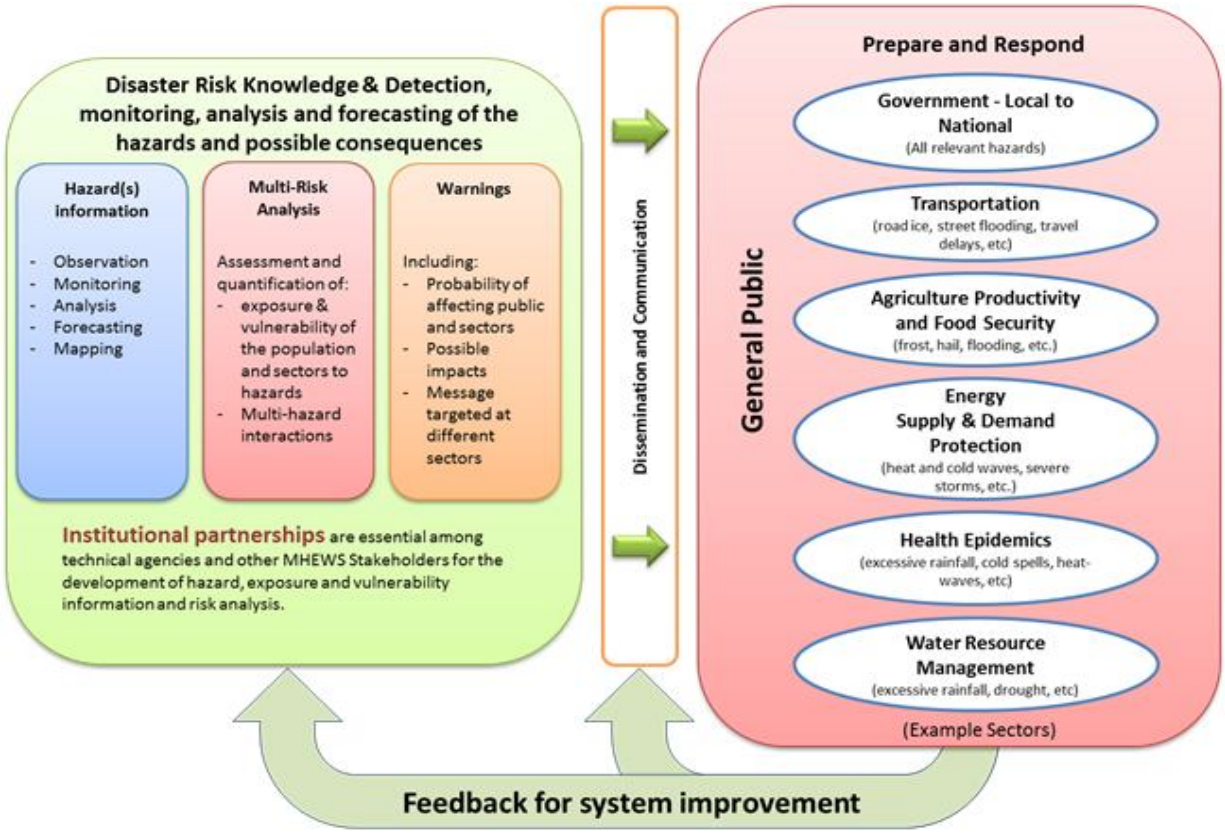

Fig. 1.Multi-Hazard Early Warning System (Source: UNDRR, 2017)

This model presented in figure 1 re-emphasizes the assertion of the Sendai Framework for Disaster Risk Reduction 2015-2030 in priority 4: 33 (b) which states that "national governments should invest in, develop, maintain and strengthen people-centered multi-hazard, multi-sectoral forecasting and early warning systems, disaster risk and emergency communications mechanisms, social technologies and hazard-monitoring telecommunications systems." Development of such systems must be through a participatory process tailoring the system to the needs of users, including social and cultural requirements, and gender. The people-centred early warning system should take into consideration the following fundamental elements at the local, national, and regional levels without which, it will be incomplete:

- The network for observation of natural hazards, relevant elements, and phenomena;
- The telecommunications system for real-time collection, transmission, and exchange of the observation data;

- The system for data processing, analysis and diagnosis, modeling, and formulation of forecasts or warnings; and
- The system for services, including the transmission and dissemination of such forecasts or warnings.

The UNISDR (2006) proposes that a people-centered early warning system should generally consist of four main components: (i) risk knowledge; (ii) risk monitoring and warning services; (iii) risk dissemination and communication; and (iv) response capability, of which failure of any component of the system will imply failure of the whole system.Similarly, the WMO (2018) lists four elements of efficient people-centered early warning systems as (i) disaster risk knowledge based on the systematic collection of data and disaster risk assessments; (ii) detection, monitoring, analysis, and forecasting of the hazards and possible consequences; (iii) dissemination and communication, by an official source of authoritative, timely, accurate and actionable warnings and associated information on likelihood and impact; and (iv) preparedness at all levels to respond to the warnings received.

Evidence of the application of Indigenous Knowledge (IK) in early warning and disaster risk management in Africa is quite low and remains undocumented in most countries even though they do acknowledge its existence in some cases. However, some countries have begun to document their IK literature (Dube&Munsaka, 2018; Lunga, 2014; Ouma, 2014; Trogrlic& van den Homberg, 2018).Iloka (2016) study on IK in EWS found that mere application of scientific knowledge in Africa did not yield satisfactory results due to exclusion of local perspectives and dynamics. A United Nations Environment Programme (2008) study on the application of IK in EWS in Kenya, Swaziland, South Africa and Tanzania shows that IK served as a valuable tool that enabled communities to develop their own forecasting and early warning systems. Similarly, Acharya and Poddar (2016) found that local communities used IK for flood forecasting in the Gandaki River Basin in India.

2.2 Existing Regional Early Warning Systems

SADC as an entity has established EWS focusing on specific hazards, i.e. drought/famine. In 1986 SADC established the Regional Early Warning Unit (REWU) which is an integrated project, based in Zimbabwe. National Early Warning Units (NEWUs) was also established in

each of the then 10 SADC Member States whose activities were coordinated by the REWU. REWU primary objectives were very much focused on issues of food security. In a similar vein, SADC relies on regional drought assessments and services provided by the WMO-UNDP Drought Monitoring Centres in Eastern and Southern Africa, the Intergovernmental Authority on Drought and Development in north-eastern Africa, and the AGRHYMET (AGRrometeorology, HYdrology, METeorology) Programme of the Inter-State Committee on Drought Control (CILSS) in the Sahel (O'Neil, 1997: 11; Tadesse, 2016: 10).

SADC and other regions saw the need to establish a regional early warning system after the 2011 drought in the horn of Africa. TheDrought Early Warning and Forecasting in Africa (DEWFORA) project of 2011-2013 was established to develop a framework to reduce vulnerability and strengthen preparedness to droughts in Africa as a whole by advancing drought forecasting, early warning, and mitigation practices. The framework addressed monitoring, predicting, timely warning, and response to droughts at the seasonal time scale, applicable within the institutional context of African countries. DEWFORA drought mitigation actions included the use of Indigenous Knowledge Systems in education and public awareness campaigns (Nile, Limpopo) (DEWFORA, 2011-2013). The lesson learned from the project is that education and public campaigns incorporating Indigenous Knowledge System (IKS) are critical in the successful implementation of early warning systems.

In addition, the Famine Early Warning Systems Network (FEWSNET) is considered a leading provider of early warning and analysis on food insecurity. It was created by USAID in 1985 after devastating famines in East and West Africa, to help decision-makers plan for humanitarian crises. It provides an evidence-based analysis of some 28 countries. FEWSNET is an active player in the humanitarian and development communities, participating in global committees to improve classification, remote sensing, and other aspects of food security analysis. It also supports and conducts training and capacity-building for national early warning systems, weather services, and other agencies. It provides services to Angola, DRC, Lesotho, Malawi, Madagascar, Mozambique, Zambia, and Zimbabwe covering the following sectors:agro-climatology, livelihoods, market and trade, and nutrition (USAID, 2019).

The South African Weather Service is an important playerin the SADC region in terms of providing warnings to neighboring countries on flash floods, hailstorms, and related climate

hazards. It also implements the SADC Regional Meteorological Development Project for the Severe Weather Warning System (SWWS). Mauritius is another member state with developed early warning systems for storm surges and tide referred to as Deltares (Deltares, 2014). There is also a Tsunami early warning system in the Indian ocean covering several countries including Mauritius (1 station), Seychelles (1 station), South Africa (11 stations), Tanzania (7stations), Mozambique (9 stations), and Madagascar (10 stations). This tsunami EWS also covers Kenya (3 stations), which is not a SADC member state.

3. METHODOLOGY

The study adopted a mixed method approach involving a desk review of official documents, research reports, annual reports, and relevant literature, face-to-face interviews as well as a survey questionnaire. The questionnaire was self-administered to 50disaster risk reduction (DRR) practitionersfrom Angola, Botswana, the Democratic Republic of Congo (DRC), Eswatini, Lesotho, Malawi, Mauritius, Mozambique, Namibia, South Africa, Tanzania, Zambia, and Zimbabwe. The questions included:

Are the hazards and vulnerabilities well known?

- What are the patterns and trends in these factors?
- Are risk maps and data widely available?
- Are the right parameters being monitored?
- Is there a sound scientific basis for making forecasts?
- Can accurate and timely warnings be generated?
- Do warnings reach all those at risk?
- Are the risks and warnings understood?
- Is the warning information clear and usable?
- Are response plans up-to-date and tested?
- Are local capacities and knowledge made use of?
- Are people prepared and ready to react to warnings?

Further, in-depth interviews were conducted with 25 key respondents from selected SADC Member States, namely, Botswana, Eswatini, Lesotho, Mauritius, and Seychelles. These were

drawn from the government DRR organizations, meteorological services, water sector, agricultural sector, health sector, and geological services. Representatives from the NGO sector and development partners were also interviewed. Their views were analyzed based on the people-centered early warning system which has four components, namely, (i) risk knowledge, including the use of indigenous knowledge in early warning systems, (ii) monitoring and warning services, (iii) dissemination and communication, and (iv) response capability.

Data analysis was conducted in two ways. Firstly, data was captured using Statistical Package for the Social Sciences (SPSS) to generate findings on trends, patterns, and relationships among various variables. The intention was to determine the extent and nature of early warning systems in the SADC region. Further, thematic analysis was done for complementary purposes to articulate the voices of diverse participants in the study.

4. RESULTS

The findings are presented in the broad areas as identified by the literature review includingi) knowledge and understanding of the importance of early warning in DRR, ii) actors in early warnings and gaps in governance mechanisms, iii) knowledge of hazards, vulnerabilities, and risks, iv) hazard monitoring and detection,v) communication and dissemination of warnings,vi) response preparedness and capability, and vii) the use of indigenous early warning system.

Knowledge and understanding of the importance of early warning systems

Approximately 80 percent (n=50) of the respondents were of the view that knowledge of natural hazards, levels of exposure, and risks have not been translated into appropriate policies, programs, and practices to ensure effective and efficient implementation of EWS. This is mainly because the DRR agencies are not adequately resourced to provide people-centred EWS services. For example, in Lesotho, a respondent stated that "*We have been assisted by the World Bank to acquire EWS equipment but we have not set up the center for lack of resources to recruit appropriate personnel."*

Another respondent from Botswana also indicated that *"one of the challenges is that there is no budget for DRR generally. As such, NDMO* [National Disaster Management Office] */NDMA*

[Disaster Management Agencies/ Authorities] *must prioritize its services and end up focussing on emergency response than establishing EWS."*

Disaster Risk Management Structures in the Member States

Most SADC Member States have some form of disaster risk management structures in place but these are not uniform. For example, some have a National Disaster Management Office (NDMO) or Management Centre. Other countries have a National Civil Protection Agency (NCPA), namely Angola and Zimbabwe often located in the Presidency or Prime Minister's office. Only four (4) countries Eswatini, Lesotho, Mauritius, and Seychelles have Disaster Management Agencies/ Authorities (NDMA). The distinction between these structures lies primarily in the fact that an agency/authority is autonomous of the executive branch of government as created by an act of parliament. Respondents identified the key actors in the detection and implementation of early warning including Meteorological Services Departments, Hydrological Services Departments, Geological Services, Fire Management Services, Epidemiology Management Services, and Food Security agencies, among others. These may carry different names across the Member States but provide similar services. Among these service providers, hydro-meteorological services, in particular, the Meteorological Services Departments are identified as the most commonly known service providers of early warning information.

The study also found that within SADC member states, there is a network of institutions at the national, provincial / district, and community levels to communicate early warnings and prepare communities for appropriate responses. However, 75% (n=50) of the respondents are of the view that EWS in most countries in the region lack capacity and are under-resourced which compromises their ability to provide effective warning services. The lack of advanced technologies to enable member states to effectively discharge their mandate was cited as the major challenge. For example, in Lesotho, it was reported that although the government received technical and equipment support from the World Bank to strengthen its central early warning system, it has not been able to commission the project due to financial constraints (operational, maintenance, and human resources).

Moreover, 90 percent (n=50)of the respondents argue that many Member States do not have updated hazard, exposure, and risk maps, which are crucial to any functional early warning

system. Lastly, it was found that, while many national disaster risk management institutions have adopted official government operational protocols, the process of activating said protocols during emergencies oftentimes have to deal with issues of unwarranted political influence.

At the regional level, respondents identified the SADC Climate Services Centre in Botswana as the main center providing operational, regional services for monitoring and predicting extremes in climate conditions. The center develops and disseminates meteorological, environmental, and hydro-meteorological products. These products have contributed to improved disaster risk management and have helped ensure that Member States are better prepared for weather and climate extremes, conservation, and protection of natural resources. A Botswana respondent indicated that "*The center has benefitted from in-kind and funding support from many international cooperating partners.*"

The Regional Early Warning Service (REWS) is considered important for monitoring food security and drought with the support of national agencies. One respondent from Eswatini observed that "*The food security bulletins on crop performance, failure, and potential shortfalls in food availability are provided but the stakeholders do not understand the scientific language used. So, the Agricultural EWS must break it down for the region in a way that farmers will know what to expect and what to do.*"

Another respondent from Lesotho said "*Drought is easy to predict as a threat to food security. Meteorological and SARCOF forecasts on drought have been reliable but such information is not helpful to the farmers. For example, a report might say there will be an above average rainfall which may come in one month or be scattered along the planting season.*"

Furthermore, respondents identified other international organizations operating and supporting regional early warning systems. For example, FEWSNET,as a respondent from Zimbabwe stated that "*FEWSNET needs to incorporate other hazards that may have a negative effect on food security.*"

Knowledge of hazards and risks

Many SADC countries are affected by similar hazards and risks. As a result, most citizens have increased knowledge of the common hazards, risks, and vulnerabilities in their countries. However, most respondents believe that the characteristics of these key hazards in terms of geographical extent, magnitude, intensity, frequency, probability, and impending hazardous events, must be continuously analyzed. Historical data must be evaluated, and potential future risks assessed. Moreover, they argue that hazard maps that locate the geographical areas and people that could be affected by hazards have not been developed and/or updated. A respondentfrom Mauritius noted: *"People-centred EWS require the use of hazard maps which are regularly updated for effectiveness. For example, there could be a regional laboratory for a testing specimen for epidemiological threats in one of the Islands".*

Another respondent from DRC said:*"We are constrained by limited financial resources to develop and update hazard, risks, and vulnerability maps for the country."*

The study found that only 40 percent of the SADC countries have updated hazard, risks, and vulnerability maps, and they are not readily accessible to other stakeholders and communities. Seychelles, Mauritius, and Mozambique are some of the few countries with integrated EWS detailing the hazards, the protocols, and the colour codes that show the risk at different stages. One respondent from Seychelles stated that *"We have to educate the members of the public about the warnings and colour codes for each hazard."*

Respondents in this study argued that vulnerabilities and exposure to the hazards have been exacerbated by the prevalence of other factors such as corruption, which leads to poor quality services and infrastructures, poverty, lack of oversight mechanisms, and epidemics. A respondent from Zimbabwe argues:

"*In most instances, it is common for bridges and roads in some countries to be swept by floods, potable water contaminated, and emergency relief mismanaged".*

This study shows that Mozambique and Mauritius appear to be advanced with the availability of historical data and in the mapping of hazards, risks, and vulnerabilities than most other countries in the region. The study found that nearly 50 percent of SADC Member States have adequate

knowledge of hazards, risks, and vulnerabilities in their respective countries. However, in some countries, knowledge of hazards, vulnerabilities, and risks is confined to the DRR organization responsible for the national and district coordination of disaster risk management. In Malawi, the situation is unique because the government has established civil protection committees at the village and district levels comprising senior traditional authorities to manage disaster risk management activities. This has improved the knowledge of hazards/ risks, and vulnerabilities at the community and district levels. Similarly, Eswatini, Lesotho, and Mauritius have established community disaster management committees involving traditional leaders, local extension workers, CBOs and NGOs. Botswana has strong national and district structures while community-based disaster management structures are non-existent. In Zimbabwe, only urban areas are covered by public education through the media while rural areas rely heavily on indigenous knowledge systems and NGOs for early warning. A respondent from Zimbabwe said that *"rural people are able to foretell drought, rains and/ or floods by observing certain birds. Such information is passed on by word of mouth from one generation to another. However, the younger generation and people in urban areas tend to rely on scientific warnings."*

Monitoring and Warning services

An approach to people-centered EWS requires monitoring of hazards to ensure the effectiveness and efficiency of the EWS at national, district, and community levels. This study observed that while some form of EWS exists in all SADC Member States, they are not fully developed, of low quality, and are under-resourced to enable them to play a significant role in providing a timely warning. The current system is predominantly a one-way process involving DRR practitioners informing the public about hazardous threats. There are no mechanisms to enable communities to contribute to the generation of early warnings. A majority (90%) of participants lamented the lack of proper equipment to detect, monitor, analyze, and forecast the hazards and possible consequences. One respondent from Lesotho highlighted that *"wherever it exists, the technology used for measuring rivers and dam water levels is obsolete and barely useable"*. Another Eswatini respondent indicated that *"Automatic weather stations are needed to process real-time data from substations across the country. As for now, it is difficult to process data and generate timely and accurate warnings to the public. There is a need for financial, material, and human capacity development."*

There seem to be improvements in the reporting of weather-related information in the Member States which has led to the production of daily, weekly and monthly weather bulletins. However, these weather reports appear to be too general and do not speak accurately to the vast regions and communities in each of the countries. This, in some cases, has created doubt in terms of the reliability of early warnings issued. Table 1 below captures a summary of the systems in place in the consulted SADC member states.

Table 1. A summary of early warning detection, monitoring, analysis, and forecasting in consulted SADC Member States

Country	Hazard types	Early Warning System	Real-Time	Organization
Botswana	• Hydro-meteorological: Rains, floods, drought, temperatures • Environmental: wild-land fires • Geological: earthquakes, tremors, mudslides • Biological: HIV/AIDS, Malaria, Cholera, FMD	• Hydro-meteorological • Fire-management System • Geo-management systems • Epidemiology & Vector management	No data was provided. These are for monitoring of hazards	Meteorological Dept & Water Affairs Dept Dept of Fire and Range Resources Geological Dept Ministry of Health and Agriculture
Eswatini	• Hydro-meteorological: Rains, drought, floods, hailstorm • Biological: Locusts /pests • Geological: Earthquakes, tremors	• Hydro-meteorological • Epidemiology & Vector management • Geo management system	Currently in the process of establishing a centralized EWS	Meteorological Services & Water Affairs Ministry of Health and Agriculture Geological Service Dept
Lesotho	• Hydro-meteorological: Rains, drought, floods, hailstorm • Biological: Locusts /pests • Geological: Earthquakes, tremors	• Hydro-meteorological • Epidemiology management • Geo management system	Equipment available but not installed. These are for monitoring of hazards to generate warnings.	Meteorological Services & Water Affairs Ministry of Health and Agriculture Geological Service Dept
Mauritius	• Hydrometeorological : storm surges, flash floods, cyclones, tsunami • Environmental: fire • Geological: Rock falls, land/mudslides	• Flood risk management and water resource management • Fire and rescue services • Geo-systems	3-6hrs for flash floods 5.5-9.4 mins for fires 5-7 hours before tsunami waves	Mauritius Meteorological Services: Multi-Hazard EWS Environmental Services and National Development Unit

Mozambique	• Geological: earthquake, tsunami, • Hydro-meteorological: cyclones, storms, heat & cold waves, floods, drought • Biological: environmental pollution, human & animal pandemic, pest infestation, bio-chemical weapons	• Geological hazard management • Flood risk management; Cyclone Warning System • Environmental hazard management • Epidemiology management	None 3 colors code indicating the number of hours before a tropical cyclone makes landfall (blue – between 24 and 48 hours; yellow – within 24 hours; and red –within 6 hours	Hydro-met; National Institute of Meteorology (INAM) and the National Directorate of Water Resources Management (DNGRH) and Regional Water Administrations (RWA)
Seychelles	• Geological: earthquake, Tsunami, landslides • Hydrometeorological: cyclones, hurricane, storms, heat & cold waves, floods, drought • Biological: environmental pollution, deforestation, human & animal pandemic, pest infestation, bio-chemical weapons, • Chemical, Industrial & Nuclear Accidents: chemical, industrial, oil spills, fires, nuclear	• Geological hazard management • Flood risk management and water resource management • Land use management & Environmental hazard management • Engineering hazard management	Seychelles has an EWS policy that sets response times for various hazards.	Seychelles has an EWS policy that sets response times for various hazards.

Legislation and EWS

The findings of the study have revealed that legislation on DRR is fragmented. Each of the actors on DRR has its own legislation which spells out its functions. These legislations may include sectoral EWS responsibilities. Rivera (2016) and Basher (2016) have argued that legislative fragmentation negatively affects the effective coordination of EWS by the National Disaster Management Structures. For example, in Botswana, the National Disaster Management Policy of 1996 is not supported by an Act of Parliament, unlike the Meteorological Services. Consequently, Meteorological Services are not obliged to report early warnings to the National Disaster Management Office.

DRR laws in Mozambique, Malawi, Namibia, and Zimbabwe do not include early warning systems. In South Africa, the National Disaster Management Act allows for the national disaster

management center to develop a database on early warnings but runs short of pronouncing the roles of different actors in early warnings. The Weather Service Act of 2001 (RSA 2001) empowers the South African Weather Service (SAWS) as the institution legally responsible for the weather and climate forecasting and issuing severe weather-related alerts in South Africa. There are several EWSs for different sectors and different weather elements in the country. Examples include the Advanced Fire Information System (AFIS), the South African Weather Service's Severe Weather Warning System, and the South African Flash Flood Guidance (SAFFG) system. Members States can, however, draw lessons from Seychelles which has defined its EWS key players and related protocol, including the risk level color codes.

Dissemination andcommunication of warnings

It was found that countries like Seychelles, Eswatini, South Africa, and Mauritius have the functions, roles, and responsibilities of each actor in the warning dissemination process defined in theirdisaster management/meteorologicallaws. As for other countries, it is not clear who must disseminate the warning information and this situation gives rise to confusion and a lack of coordinated response. One Eswatini respondent said that *"We have coordination meetings to verify and correct the information to be shared with the public. The Ministry of Agriculture also prepares key messages to relay to farmers in specific areas."*Another respondent from Eswatini said, *"Sometimes information to the communities is distorted because it has not been packaged appropriately and there is no DRR communication strategy to guide information dissemination."*

Response capability

It was found that the response capability in many of the SADC Member States is inadequate due to several factors:

- Hazards and vulnerability assessments have not been updated, leading to inadequate information on hazard and vulnerability profiling;
- Response plans are not updated and tested, resulting in reactionary approaches in the event of emergencies;
- Where response plans exist, they are confined to the DRR practitioners and do not reach the target audience; and

- The lack of simulation exercises affects public education and awareness of hazards, vulnerabilities, risks, and actions necessary for response.

EWS needs to be part of national DRM strategies and plans and updated risk information enables all actors on early warnings to identify the threats, the exposed institutions and populations, and their vulnerabilities and design appropriate response plans.

Use of indigenous knowledge in EWS

In Mozambique, IK has also been captured and used to strengthen the scientific early warning knowledge systems. The vulnerable communities in Mozambique were involved in hazard, risk, and vulnerability assessments and ultimately the development and implementation of EWS and related protocols. For example, the Buzi community working with external organizations after the 2000 floods, developed an early warning system based on the observation of birds, trees, clouds, and wind movement combined with scientific early warning systems to warn their members of impending danger. In many countries, the Indigenous Knowledge Systems have been appreciated but not mainstreamed and considered when communicating early warnings (Dube&Munsaka, 2018; Lunga, 2014; Trogrlic& van den Homberg, 2018). This is generally so in Angola, Botswana, Eswatini, Lesotho, Malawi, Mauritius, and Zambia. For example, a respondent from Botswana said "*a traditional healer with regular contacts with the Meteorological Services warned of a storm in 2018 which actually came to pass but his contribution was never officially acknowledged*." Interviews in Eswatini and Lesotho further established that the IKS are predominantly used by smaller rural communities to predict hazards and risks by observing the behavior of birds, and animals, the status of stars, and wind direction as indicators of the prediction of impending hazards and early warning. Often the scientific and indigenous knowledge systems appear to be in conflict. It is believed that the indigenous knowledge system lacks modern scientific precision and rigor. This leads communities who appreciate IKS not to instantly value science-based early warning messages. In Mauritius, due to the high levels of urbanization, IKS is not very much appreciated and is usually thought of as belonging to the past, rural areas, and older generations. It is often frowned upon.

The research found that sources of indigenous knowledge are generally the elderly, traditional leaders, and traditional healers who have lived in communities for many years. They usually use spiritual discernment, natural observations, and wisdom to interpret weather patterns and

determine the risks involved. IKS is passed on from one generation to another by word of mouth and is rarely documented and exchanged with people outside the indigenous circles. In some countries, for example, Eswatini, Lesotho, Seychelles, and Zimbabwe, the elderly farmers, fishermen, and environmental groups are the source of indigenous knowledge. In Botswana and Eswatini, it is the traditional healers and the elderly spiritualists who possess such indigenous knowledge.

5. DISCUSSION

The Sendai Framework for DRR (2015-2030) (see Priority 1: Understanding Disaster Risks) at the global and regional levels, advocates for enhancing the development and dissemination of science-based methodologies and tools to record and share disaster losses and relevant disaggregated data and statistics, as well as to strengthen disaster risk modelling, assessment, mapping, monitoring and multi-hazard early warning systems. In addition, it seeks to promote the conduct of comprehensive surveys on multi-hazard disaster risks and the development of regional disaster risk assessments and maps, including climate change scenarios. All these must be undertaken by national agencies in collaboration with regional and international partners, and sub-national and community-based organizations. Despite this, the impacts of hazardous events, particularly those of hydro-meteorological origin, continuously affect lives and livelihoods, causing significant damage to property and infrastructure, with adverse economic consequences in the SADC region.

A people-centered MHEWS should provide for and use indigenous knowledge systems together with modern scientific knowledge to ensure that warnings generated cater to different types of end-users. Evidence from empirical studies in Africa and Asia underscores the importance of IKS in EWS. Currently, EWS in several member states is unable to produce timely early warning data due to fragmentation, lack of community ownership, and coordination. There is a need to strengthen the technical, financial, and operational capacity of SADC Member States to enable them to set up their early warning centers. The information generated must be able to accurately inform the public to take appropriate actions to prevent, mitigate, and respond to threats. All these have resource implications for the national budgets of the Member States. Therefore, there is a need for Member States to develop comprehensive national DRM programs, build synergies with other countries in the region,and ensure the inclusion of effective EWS in those national

DRM structures. In addition, there is a need to update hazard, risk, and vulnerability maps into risk atlases to inform decision-makers and those most at risk in areas prone to hazards and disasters. An integrated MHEWS requires the various specialized agencies/actors to work together in the generation and dissemination of early warning data (Mathafeni, Osupile, &Maripe, 2015). Particular attention needs to be paid to the development of information management systems and a communication policy/strategy to enable consistent and reliable information.

6. CONCLUSION AND RECOMMENDATIONS

Few SADC Member States have some form of people-centred early warning systems within their national disaster management framework. Member States such as the Seychelles, Mauritius, Lesotho, and Eswatini have demonstrated the political will to establish statutory bodies to implement early warning systems. Specifically, Seychelles, Mauritius, and Mozambique are advanced in terms of developing a comprehensive MHEWS with appropriate risk levels for various hazards. There remain implementation challenges. The findings revealed that several SADC member states donot have established early warning systems. Furthermore, the use of scientific jargon especially for hydro-meteorological and geological warnings, makes it difficult for local people to understand the messages and act timely on the warnings. Therefore, many people often ignore scientific warnings and tend to use IKS and most often, are caught unprepared when disasters strike. Thus, there is a need to build people-centered early warning systems in the member states taking into account both IKS and science-based approaches.

In lieu of the gaps that exist and the challenges faced by SADC Member States in developing functional, multi-hazard and people-centred EWS, the research makesseveral recommendations.

- Member States in the short term should prioritize the inclusion of people-centered and multi-hazard early warning systems in DRR structures and partner with relevant actors to strengthen the effectiveness and efficiency of EWS. In doing so EWS should become an integral part of community life to appreciate the benefits arising from early warning systems as a tool for human development. It will also encourage communities to participate in the design of, and have ownership of EWS. This in turn will promote

resilience to hazards, vulnerabilities, and risks. The incorporation of IKS into modern early warning systems to enhance people's confidence and reliability of warnings remains imperative. The promotion of public education and awareness of EWS will ensure community ownership and appropriate actions once a hazard occurs.

- The SADC Secretariat should in the mid-term provide member states with the technical capacity to strengthen their scientific and data foundations for early warning systems to ensure accuracy, timeliness, reliability, and effective dissemination of early warnings.
- SADC Member States to undertake research, document early warning systems best practices,and train adequate human capital to undertake disaster-related research with local tertiary institutionson hazards, vulnerabilities, risks, and warning capacities to ensure the effectiveness and efficiency of EWS.
- SADC Member States should in the long term develop a platform for people-centered early warning systems for multi-hazards especially those that have the potential to affect multiple neighboring countries drawing on their best practices and capacities.Member States to incorporate EWS in pre, during, and post-disaster interventions to enable the DRM agencies to generate and disseminate timely warnings and monitor the changing patterns of hazards and risk.
- Member states to appoint communication specialists to unpack technical information for the benefit of farmers. Unfortunately, many developing countries are faced with financial constraints.
- There need for wider distribution of hazard and risk maps as well as the establishment of a color-coding system for hazards, risks, and vulnerabilities by the SADC Member States. This will enable knowledge of the hazards, risks, and vulnerabilities in the various localities.
- Most importantly, the key activities that increase or compound risk must be identified and evaluated and the technologies used in the warning systems be updated to improve accuracy, speed, timing, and reliability to enhance consumer confidence in the warning systems.

DISCLAIMER

The findings, interpretations, and conclusions expressed in this publication do not necessarily reflect the views of the World Bank, the Executive Directors of the World Bank or the governments they represent, the ACP Secretariat, SADC Secretariat and the European Union. The World Bank does not guarantee the accuracy of the data included in this work.

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