【原著論文】

Evolution in the Policy Framework of the Community based Early Warning System in Mozambique.

モザンビークにおけるコミュニティ主体の早期警報システムの政策枠組みの発展

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SUMMARY

Mozambique, which is highly vulnerable to natural disasters because its location along the Indian Ocean coast, has enhanced its Early Warning Systems through significant reforms and the integration of community-based approaches since the devastating floods of 2000. This study explores these advancements, particularly focusing on integration of Community-based Early Warning Systems through the creation of Local Committees for Disaster Management and Risk Reduction which bridge national strategies with local actions. The study employs qualitative methods, including a comprehensive literature review and analysis of institutional documents, to assess the evolution of policy changes and stakeholder dynamics. The evaluates The enhancements in Mozambique's Early Warning System are evaluated and the critical role of both top-down meteorological forecasts and bottom-up community-driven initiatives are highlighted. Despite these improvements, challenges remain in last-mile connectivity and the effective dissemination of warnings to vulnerable communities. This study identifies these issues, proposes strategic recommendations, and contributes to the broader discourse on disaster risk reduction, emphasizing the importance of community involvement in national frameworks to improve disaster preparedness and response globally.

Key words

Early Warning Systems, Community-based Early Warning Systems, Disaster Risk Management, Tropical Cyclones and Floods, Institutional Reforms and Policy Changes

要約

インド洋沿岸に位置しているため自然災害に対して非常に脆弱なモザンビークは，2000 年

の壊滅的な洪水以降，大幅な改革とコミュニティベースのアプローチの統合を通じて早期警報システムを強化してきた．本稿では，これらの進歩について検討し，特に，国家戦略と地域活動を橋渡しする災害管理・リスク軽減のための地方委員会の設立を通じたコミュニティベースの早期警報システムの統合に焦点を当てる．この研究では，包括的な文献レビューや組織文書の分析などの定性的な方法を採用して，政策変更の進化と利害関係者のダイナミクスを評価する．これにより，モザンビークの早期警報システムの強化を評価し，トップダウンの気象予報とボトムアップのコミュニティ主導のイニシアチブの両方が果たす重要な役割を指摘する．しかしながら，これまでの改善にもかかわらず，一人ひとりの住民に対して，あるいは脆弱なコミュニティに対して警報を効果的に伝達するには，いまだ課題が残っている．この論文は，これらの問題を特定し，戦略的な政策提言を行い，災害リスク軽減に関するより広範な議論に貢献することを目的とし，結論として，世界的に災害への備えと対応を改善するための国家枠組みへのコミュニティの関与の重要性を強調して指摘する．

1. Introduction

Mozambique, situated along the southeastern coast of Africa, is frequently exposed to severe natural disasters, including floods and tropical cyclones, because of its proximity to the Indian Ocean. These extreme weather events underscore the need for effective Early Warning Systems (EWS) to mitigate their impact. Since the catastrophic floods of 2000, which marked a significant turning point, Mozambique has undertaken substantial reforms to improve its disaster management strategies by integrating a Community-based Early Warning System (CBEWS) into the national EWS framework.

Despite this reform, Mozambique still suffers from a significant number of human casualties owing to annual floods. This may be partly due to the recent increase in the severity and frequency of floods caused by global climate change. However, we should question whether the reform of EWS in Mozambique is moving on the right track, and identify the challenges that remains for further flood risk reduction. Therefore, this study identifies the evolution and effectiveness of Mozambique's EWS and its remaining issue, focusing on significant legislative and institutional reforms initiated in response to these disasters.

This study aims to share the policy lessons of the CBEWS in Mozambique within the global discussion on Disaster Risk Reduction (DRR). We employ a qualitative research approach through a review of policy documents and stakeholder analyses that offer both historical and contemporary perspectives on the development and challenges of Mozambique's CBEWS. Evidently, the evolution of Mozambique's CBEWS can be characterized by two models: a community as agent (CAA) model and a community as partner (CAP) model.

The remainder of this paper is organized as follows: It begins with an introduction that sets the stage for our discussion. Following this, we explore the literature review followed by the historical context of EWS development in Mozambique, detailing phases such as post-independence disaster management from 1975

to 1999, structural reforms and policy evolution from 2000 to 2006, and the creation of the National Center for Emergence Opertions (CENOE) with multi-stakeholder coordination from 2006 to 2019. This section also examines the challenges revealed by the 2019 Idai and Kenneth tropical cyclones and subsequent reforms in the disaster management policy framework. We then analyze the development of the CBEWS in Mozambique, distinguishing between the CAA Model before 2006 and the CAP Model thereafter. We also address the challenges in the implementation of EWS in Mozambique, and conclude by synthesizing the findings and offering recommendations to refine Mozambique's CBEWS to enhance future disaster preparedness and response.

2. Existing Policy studies on CBEWS.

A community, in the context of DRR, is defined as a group of people living in a specific geographical area who share common interests, values, and concerns, particularly regarding disaster risks and resilience[1],[2]. This includes neighborhoods, villages, or any collective of individuals who are directly affected by potential natural hazards and who collaborate to enhance their collective safety and preparedness[3]. The community concept of DRR emphasizes the involvement of local populations in planning, decision-making, and implementation of measures to reduce disaster risks and enhance resilience[1],[2].

As the definition of a community is ambiguous, its size varies depending on the situation. Mozambique, has no fixed population or specific territorial dimensions that defines communities. The population of a community ranges from a few hundred to several thousands. A community is the smallest unit of collective DRR activity.

CBEWS refers to systems that empower local communities to actively participate in disaster risk reduction by integrating local knowledge with scientific data to enhance early warning and response mechanisms[4]. These systems are expected to bridge the gap between top-down governmental strategies and grassroots-level actions, ensuring that warnings are effectively communicated and that communities are prepared to respond promptly[5].

Despite its high policy importance, the studies concerning CBEWS in Mozambique are limited, and a clear delineation of the concept is often lacking. While Artur and Kovisto have contributed to the broader discourse on disaster management in Mozambique, their works do not specifically address CBEWS and its evolving impact on policy frameworks[6]-[10]. Several scholars have also explored how CBEWS works in Southern Africa. For instance, Chinguwo conducted a significant study on the effectiveness of river gauges in Malawi within the framework of CBEWS[11]. The research was benchmarked against critical elements including risk knowledge, technical monitoring and warning services, dissemination and communication of warnings, and response capability. This study, which is crucial for identifying operational challenges and suggesting improvements, serves as a resource for understanding how CBEWS can be better integrated into policies and practices, thus

enhancing their effectiveness[11]. The situation in Namibia illustrates a similar need for integration but highlights distinct challenges[12]. The primarily top-down nature of Namibia's flood EWS is known to be problematic, marked by a disintegrated and reactive approach that often neglects community engagement and proper institutional role definition[12]. Recommendations from studies advocate for a redesigned, more proactive system that emphasizes continuous, inclusive community participation as essential to the effectiveness of EWS[12].

In Latin America and South Asia, countries such as El Salvador and Nepal have demostrated various approaches to integrating CBEWS into their national disaster management strategies[13], [14]. Post-Hurricane Mitch, El Salvador, significantly improved its EWS by adopting new technologies and reforming institutions to foster a more proactive disaster response framework[13]. This is in contrast to Nepal, where enhancements in flood forecasting methodologies are being integrated with traditional community-based data collection practices to improve early warning lead times[4]. Despite these advancements, challenges remain, particularly in terms of effectively communicating and operationalizing forecasts within community response frameworks[13],[14]. Moreover, the global perspective underscores a recurrent theme: the effectiveness of CBEWS is often compromised by insufficient local engagement, inadequate preparedness, and the failure to effectively translate disaster risk reduction policies at the community level[14].

Therefore, these insights collectively advocate a scientific discourse that emphasizes the necessity for EWS to be technologically apt and deeply integrated within the communities they aim to serve[14]-[17]. The study of CBEWS in Mozambique, as an experience of a low-income country in the world, will benefit countries that are going to embrace a more integrated approach, emphasizing not only technological and institutional readiness but also prioritizing community involvement and capacity building as central pillars of disaster management strategies.

3. The History of the Development of EWS in Mozambique

This chapter provides a comprehensive overview of Mozambique's EWS development, illustrating its progression from a reactive and centralized top-down approach to a more proactive, integrated, and community-based framework. Each phase builds on the previous phase, aiming to enhance the country's disaster management capabilities while addressing persistent operational challenges. The following subsections describe the phases listed in Table 1.

3. 1. Post-Independence Disaster Management (1975-1999)

The development of EWS in modern Mozambique began to be formally documented following its independence in 1975. As a newly sovereign nation, Mozambique initially adopted EWS strategies utilized by other African countries, primarily focusing on famine and food insecurity, similar to the

Table 1　Chronological Events and Policy Changes in Mozambique's EWS Development

Phase/Period	Key Events and Legislation	Type of EWS and Goals	Main Stakeholders Involved	Coverage	Limitations Leading to Next Phase
I: Post-Independence Disaster Management（1975-1999）	**1975**: Mozambique gains independence **1980**: Establishment of DPCCN	• EWS focused on famine and food insecurity • Monitor and warn about food shortages and drought	• DPCCN, • Mozambique Red Cross（CVM）, • UN agencies	National level with limited local implementation	• Focused mainly on famine, food insecurity, and tracking refugees and IDPs; • Limited technological resources; • Reactive rather than proactive
II: Structural Reforms and Policy Evolution（2000-2006）	**2000**: Catastrophic floods（2000）; Establishment of INGC; **2001**: Initiation of the CBEWS approach in Mozambique **2001-2005**: Implementation of pilot projects for CBEWS in Buzi and Vilankulo districts	• Shift to multi-hazard EWS • Goal: Integrate community responses with national EWS	• INGC; - National and local governments; • NGOs and international partners	Pilot regions: Buzi（floods）, Vilankulo（cyclones）	• Inadequate communication and warning systems; • Lack of comprehensive national coverage; Limited community engagement
III: Development of Multi-Stakeholder Coordination（2006-2019）	**2006**: Approval of 10-year Master Plan; Creation of CENOE and integration of CBEWS in DRR framework. **2014**: Legislative changes: Law 15/2014	• Multi-hazard EWS with multi-stakeholder coordination; • Goal: Enhance coordinated disaster response	• CENOE INGC, INAM, DNGRH; • NGOs, civil society, international organizations	National, regional, and local levels	• Unequal distribution of resources; • Challenges in inter-institutional collaboration; • Technological and communication gaps
IV: Post Idai and Kenneth Reforms in Disaster Management Policy Framework（2019-	**2019**: Cyclones Idai and Kenneth strike Mozambique; **2020**: Enactment of Law 10/2020; **2022**: Approved the SIFIAPCC（2022-2030）	• Comprehensive EWS including all hazards • Goal: Improve disaster risk management and enhance community resilience	• INGD; CENOE, National, regional, and local governments; • Broader inclusion of NGOs, civil society, and International humanitarian agencies	Expanded national coverage with a focus on last-mile connectivity	• Persistent operational deficiencies; • Need for better community-level integration, • Challenges in resource allocation and communication mechanisms

response strategies in the broader Sahel region led by the Famine Early Warning Systems Network[6],[10],[18],[19]. These systems were instrumental in monitoring potential food shortages, malnutrition rates, market food prices, and rainfall levels[17]-[19].

To integrate disaster management initiatives into the formal institutional framework, the government of Mozambique established the Department of Prevention and Combat of Natural Calamities (DPCCN) in 1980[6],[9],[10]. This was the first significant initiative to enhance the disaster management framework, signifying a strategic shift toward a more structured response to disasters, including the development of EWS[6],[10]. The creation of the DPCCN was formalized through a presidential decree under the Ministry of Foreign Affairs and Cooperation[6]. As a reactive agency, the DPCCN's primary mandate was to provide relief to those affected by drought, food insecurity, and the ongoing civil war[18]-[20]. With this capacity, an EWS was specifically established to monitor and warn about these issues[6]. Additionally, the EWS strategy was expanded to include tracking internally displaced persons[20],[21] and refugees at risk of starvation and those affected by civil war (1977-1992)[22]. To effectively fulfill its mandate, the DPCCN collaborated closely with the CVM, various international humanitarian agencies, and national non-governmental organizations (NGOs)[9],[20].

In alignment with global trends toward disaster risk reduction, and in response to the United Nations General Assembly's proclamation of the International Decade for Natural Disaster Reduction from 1990 to 1999[17], the Mozambican government established a framework for the 1999 National Policy on Disaster Management[6],[10]. This policy marked a pivotal shift towards a more proactive and holistic approach to disaster management within the country[6],[10].

3.2. Structural Reforms and Policy Evolution (2000-2006)

The EWS policy framework reform initiated by the creation of the National Policy on Disaster Management in 1999 was accelerated by the catastrophic floods of 2000, marking a turning point in disaster management strategy in Mozambique[6],[9],[10],[20],[23]. Coinciding with the country's 25th anniversary, this period experienced an unprecedented series of devastating floods, primarily triggered by persistent rainstorms from the depression Connie in early February, followed by the impacts of the tropical cyclones Eline and Gloria later that month[20],[23]. These meteorological events caused extensive flooding across several major rivers, including Limpopo, Incomati, Umbeluzi, Save, Buzi, and Pungue, severely impacting both rural and urbanized areas, particularly in the provinces of Maputo and Gaza[23],[24]. The floods resulted in at least 700 deaths, displaced 650,000 people, and affected a total of 4.5 million, with economic damages estimated at $273 million and reconstruction costs soaring to approximately $428 million[20],[23],[24].

The tragic events of 2000 revealed inadequacies in the existing disaster management framework[6],[10],[20],[22]. Despite intense rescue and relief efforts, a post-disaster

assessment revealed that effective communication and warning systems were severely lacking[17],[20],[23],[24]; and and only a small fraction of the affected communities received timely warnings[20],[24]. The aftermath of the disaster underscored the urgent need for a multi-hazard EWS that would incorporate various stakeholders and connect local and national capacities with a global approach to provide effective, timely warnings and actions for at-risk communities[6],[10],[17],[20],[23].

In response to these challenges, Mozambique undertook policy reforms and institutional changes to enhance its disaster management capabilities[6],[9],[10]. Central to these reforms was the establishment of the National Institute for Disaster Management (INGC)[6],[7]. The transition of the DPCCN to the INGC in 2000 marked a shift towards a broader, more integrated role designed to encompass all aspects of disaster risk reduction — prevention, preparedness, mitigation, response, and recovery[10],[20],[22]. This transformative shift in disaster management strategy was influenced not only by the floods but also by crucial global and national developments, including the end of Mozambique's civil war in 1992, the transition from socialism to democracy, and the global emphasis on disaster reduction, notably marked by the first Global Early Warning System Conference in 1998 in Germany[9],[17],[22].

To ensure that warnings effectively reached at-risk communities, the INGC initiated the establishment of Local Committees for Disaster Management (CLGRCs), marking a step in decentralizing EWS to vulnerable communities in Mozambique, facilitated by community-based volunteer organizations[17],[25]-[27]. To this end, the INGC launched a five-year pilot project from 2001 to 2005 to evaluate the effectiveness of integrating national EWS with community-driven responses[25],[26]. Two distinct regions were chosen for the pilot study: the Buzi district in Central Mozambique, to assess flood hazards[26], and the Vilankulo district in the southern region, to evaluate cyclone threats[25].

The pilot projects were supported by international NGOs, including the Munich Re Foundation through the German Agency for Technical Cooperation[26] and the Danish Red Cross in partnership with the CVM[25]. In Buzi, the project aimed to replicate successful flood control models from Honduras, and adapt them to the local conditions to enhance flood resilience[26]. Conversely, in Vilankulo, the initiative drew on the Red Cross and Red Crescent's disaster preparedness programs, which have proven effective in the Philippines in establishing cyclone-specific EWS[25]. Both initiatives involved recruiting and training 15-18 community volunteers, including traditional leaders and local government representatives, from areas significantly impacted by the 2000 and 2001 tropical cyclone and floods[6],[27]. These volunteers formed the core of the local disaster committees, taking on responsibilities ranging from issuing early warnings and leading evacuations to assessing post-disaster impacts, ensuring that communities were not only prepared but could also effectively respond to imminent threat[25]-[27].

3. 3. Development of Multi-Stakeholder Coordination (2006 to 2019)

Following reforms aimed at establishing an organized approach to disaster management, Mozambique recognized the necessity of aligning with global DRR standards[6],[9],[10]. Consequently, the government adopted the Hyogo Framework for Action[15],[28]. This international framework has been instrumental in guiding the ongoing reformulation of national disaster management policies, ensuring Mozambique's strategies adhere to global standards and are effectively adapted at the local level[6],[9].

In 2006, building on these efforts, the government approved a 10-year master plan to prevent and mitigate natural disasters[6],[9],[10]. This initiative strengthened the institutional framework and led to the establishment of the CENOE with branches across the southern, central, and northern regions to ensure a coordinated disaster response[21]. Designed as a multi-sectoral coordination center, CENOE facilitates both political and technical decision-making through the Coordinating Council of Disaster Management (CCGC) and the Technical Council for Disaster Management (CTGC)[21]. The CCGC, which includes ministers and is chaired by the Prime Minister, and the CTGC, composed of National Directors of Ministries and chaired by the head of INGC, also incorporate NGO and civil society members for broader involvement[28],[29]. This structure is replicated and decentralized at the province and district levels through the establishment of Emergency Operation Centers[21]. These centers ensure that the strategies and communication methods used at the national level are effectively extended to local administrations, enhancing the coordination and responsiveness of disaster management efforts across all administrative levels of the country[21],[28],[29].

Key meteorological and hydrological agencies, namely the National Institute of Meteorology (INAM) and the National Directorate of Water Resource Management (DNGRH), along with Regional Operational Water Administrations, are integral to CENOE. These agencies play crucial roles in the early detection and monitoring of natural hazards, ensuring timely dissemination of information to at-risk communities' threat[21],[28],[29]. The INAM is responsible for monitoring atmospheric conditions and issuing timely weather forecasts, particularly for cyclones and severe rainfall[21]. The DNGRH manages hydrological data critical for anticipating flood events[22],[28]. When potential threats are detected, these agencies generate alerts that the CENOE uses to initiate disaster response efforts and, disseminate warnings to the provincial and local administrative levels[26],[30].

With the creation of the CENOE, the adoption of a color-coded alert system was a significant feature that characterized the concept of policy reform. The system standardized the response across all stakeholders in disaster management operating in Mozambique (see Table 2), and is expected to serve as a trigger for the autonomous evacuation behavior of alerted communities. This coding system is based on the severity, magnitude, and expected impact on the affected population and

Table 2 Colored-based alerting system code in use in Mozambique

Level of alert	Meaning	Type of surveillance	List of actions
Green	Normal situation	Surveillance without alert	Surveillance and monitoring of potential disaster risks, including updating response plans and sharing information and warnings (activities related to prevention, mitigation, and preparedness).
Yellow	Imminent emergency	Surveillance/ Partial Alert	Increasing hazards monitoring, preparation of response protocols, updating and communicating useful information with the public; activating and ensuring that the CLGRCs are ready for an emergency.
Orange	Imminent Disaster with possible reversion	Partial Alert	The CENOE is partially activated: issuing warnings to communities at-risk for evacuation to safe places, and mobilizing human resources, materials, and equipment to target areas. *informing* and *recommending* communities to seek safe places, and *updating* warnings and information for the public and the government body.
Red	Disaster, decreed by the President of the Republic	Total Alert	Total activation of the CENOE and civil protection entity; *coordination* of immediate response, privileging search and rescue operations, and humanitarian assistance; communication to population on response activities and gther damage information.

Source: CENOE/INGC-Mozambique[29]

communities. The alert levels (green, yellow, orange, and red) indicate the degree of threat and corresponding response actions. For example, green indicates normal conditions with routine surveillance, yellow signifies an imminent emergency requiring increased monitoring and preparation, orange denotes an imminent disaster with the partial activation of emergency protocols, and red represents a full-scale disaster requiring the total activation of emergency responses.

A color-coded alert system is used by various stakeholders, including national and local government entities, NGOs, and community organizations. The CENOE determines the alert level based on real-time data and forecasts provided by the INAM and DNGRH, considering the potential impact on communities[29]. This system allows efficient resource allocation and ensures that responses are proportionate to the threat level[21],[28],[29]. This significantly affects communities by providing clear action guidelines. Through the Local Committee for Disaster Management and Risk Reduction (CLGRD), communities can autonomously initiate local alerts and responses based on the color-coded systems, enhancing their proactive engagementand adaptability in disaster management[27],[30].

Despite the creation of the CENOE, challenges persist, including the unequal distribution of technological resources, especially in remote areas, and difficulties in mobilizing financial, human, and material resources[22],[28]. Socioeconomic barriers, such as low literacy rates and limited access to communication technologies, compounded by cultural and linguistic diversity, hinder the effective dissemination of understandable warnings across communities[15],[17],[31]. Additionally, coordination between national forecasts and local responses varies, affecting the overall efficacy of the system threat[21],[28],[29].

To address these challenges, Mozambique's

parliament enacted Law 15/2014, known as the Disaster Management Law, in 2014[22],[28]. This legislation established essential legal principles and mechanisms for mitigating and coordinating future hazards, emphasizing the importance of a prompt and efficient EWS and robust collaboration among all stakeholders in disaster management threat[21],[28],[29].

With the expiration of the former Master Plan, the government adopted a new National DRM Master Plan from 2017-2030[32]. This plan, developed to align with both global and local frameworks for disaster risk reduction, specifically the Sustainable Development Goals and the Sendai Framework for Disaster Risk Reduction 2015-2030, aims to enhance disaster management capabilities and improve EWS in Mozambique[32].

3. 4. Post-Idai and Kenneth Reforms in Disaster Management Policy Framework (2019-)

The evolution of Mozambique's legal framework has significantly enhanced its ability to issue disaster warnings and coordinate effective responses. Nevertheless, these improvements were tested and ultimately found lacking during the occurrence of two consecutive devastating tropical cyclones Idai and Kenneth in 2019[33],[34].

Cyclone Idai, which made landfall central region of Mozambique on March 14 with winds over 220km/h, led to the deaths of 603 people and affected more than 1,500,000 persons[33],[34]. Shortly afterward, Cyclone Kenneth struck the northern region on April 25 with 200km/h winds, resulting in the deaths of 45 people and affecting over 280,000 individuals[35]. These events have exposed critical shortcomings in disaster management system, including issues with inter-institutional collaboration and centralized information flows that impeded effective disaster response[33],[35]. These cyclones underscored the need for improved last-mile connectivity — the capacity of warning systems to promptly and effectively reach the most vulnerable populations[17],[35].

In response to these challenges and lessons learned from the impact of COVID-19 pandemic, Mozambique enacted the Disaster Risk Management and Reduction Law (Law 10/2020), which replaced the earlier disaster management law[36]. This new law has broadened the scope of disaster management to include a wider range of hazards, reflecting a shift from a primarily natural disaster-focused approach to a more comprehensive risk management framework[36]. This includes not only natural disasters but also human-induced hazards and health emergencies, thereby providing a legal basis for more integrated and flexible response mechanism[36]. The law emphasizes a more systemic approach to disaster risk reduction, including improved stakeholder collaboration, enhanced resource allocation, and the strengthening of community-level resilience measures[31],[36].

Under Law 10/2020, the Mozambique government undertook significant restructuring of its disaster management institutions. This included renaming the INGC to the National Institute for Disaster Management and Risk Reduction (INGD) and the Local Committee for Disaster Management to the aforementioned CLGRD[36],[37]. This change

reflects a broader approach to disaster management, expanding the institute's mandate to encompass not only natural disasters but also other types of hazards, including pandemics and anthropogenic risks[36].

Finally, in 2022, the government of Mozambique implemented the Regulation for the Operationalization of the Integrated Platform for the Dissemination and Communication of Early Warning Systems for Floods and Cyclones (SIFIAPCC-2022-2030)[31],[38]. This regulation was designed to enhance the technological and operational aspects of disaster warnings, ensuring that they were more effective and reached all community segments in a timely and efficiently[38]. The key objectives of this new framework include ensuring timely access to accurate information on floods and cyclones for all people at risk through the diversified use of dissemination and communication methods, such as SMS, local radio, and online platforms[31],[38]. Additionally, it aims to strengthen inter-institutional collaboration among ministries overseeing meteorology, water resources management, and the disaster risk management and reduction sector, enhancing their ability to act swiftly and cohesively in disaster scenarios[38].

Through these legislative and operational initiatives, Mozambique has taken notable steps to develop a legal framework specifically tailored to enhance the efficacy of EWS[31],[38]. Despite advancements, significant challenges persist[28], as underscored by the devastating impacts of tropical cyclones Idai and Kenneth in 2019[35],[39]. These events highlighted critical gaps in inter-institutional collaboration and information dissemination, which impeded effective responses to disaster scenarios at the community level[9],[10],[21].

4. Analysis of the Development of CBEWS in Mozambique.

This section introduces two models to illustrate the development of CBEWS in Mozambique, which is beneficial for understanding the objectives and directions of the policy reforms mentioned in the previous section.

4. 1. The CAA Model (2001-2006)

In the initial implementation stage, the community volunteer organization for disaster management in Mozambique adopted a strategy in which the community acted as a government agent in the disaster response. We propose this approach as the CAA model. This approach is primarily characterized by a top-down operational structure, enabling CLGRCs to act as local executors of national EWS directives[27],[30]. The primary stakeholders involved included the meteorological agency (INAM), the water management agency (DNA, now DNGRH), the disaster management agency (INGC), local government entities (provincial and district), and the CLGRCs[26],[30]. Figure 1 illustrates the stakeholders and the flow of disaster information within the CAA model in Mozambique. This model ensures a controlled and uniform disaster management strategy but limits local flexibility and the integration of community-specific needs into disaster planning.

The meteorological agency is responsible

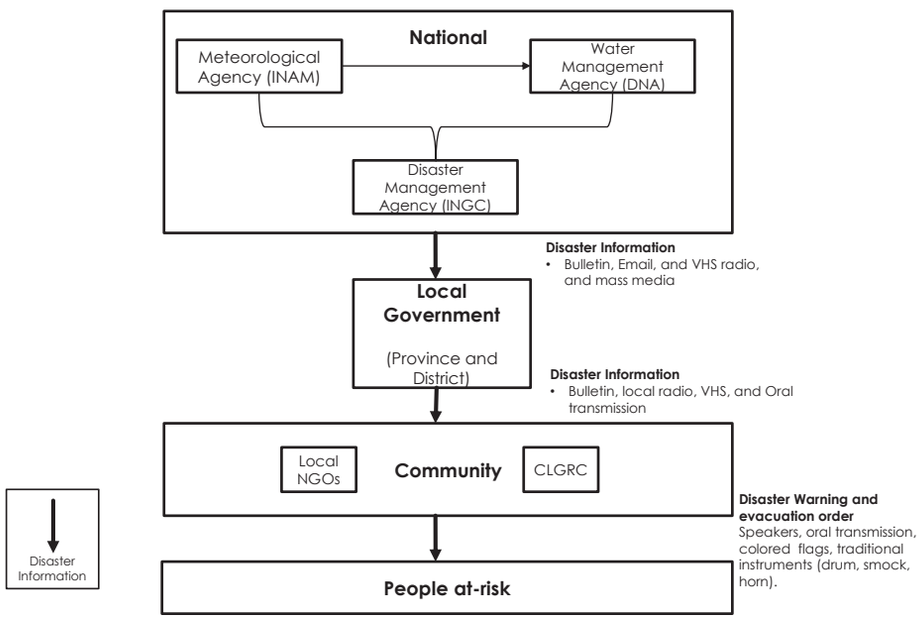

Figure 1　Information and communication flow of EWS under CAA model.
Source: Adapted by the author

for monitoring atmospheric conditions and issuing weather alerts, while the water management agency manages flood warnings. The disaster management agency coordinates efforts across all levels, ensuring that responses were enacted from the national to the local level, including issuing disaster warnings[26],[30]. Local governments were tasked with implementing these response plans, relying heavily on CLGRCs to execute them at the community level[26],[30]. National and local government use various communication methods to disseminate information, including bulletins, VHS radios, emails, and faxes. Mass media channels have also been utilized to ensure a broader distribution of critical information[30]. The CLGRCs executed these plans and collected data on disaster impacts, which they fed back to the disaster management agency, completing a loop of information flow and response evaluations[30]. Traditional methods such as oral transmission, speakers, sirens, and flags, and traditional instruments such as drums, smocks, and horns rely heavily on disseminating information[25],[26].

Under the CAA model, the community was expected to closely follow government directives, acting as an intermediary between the government and the local population. This model emphasized a hierarchical flow of information, with limited feedback from the community, and the primary role of the community was to implement top-down directives and report back to the authorities. The size of the community varied; it was typically the selected most at-risk neighborhood in the district, exposed to the impact of floods or tropical cyclones in the most vulnerable segment of the populations[25],[26].

The expected behavior in this system was for community members to follow evacuation

orders issued by the government[25]. The warning issued was predominantly scientific, based on monitoring and forecasting by the meteorological agency and the water management agency, and communicated through formal and traditional channels[26]. This approach ensures a controlled and uniform disaster management strategy, although it restricts local flexibility and limits the integration of community-specific needs into disaster planning.

Although the CAA model provided a structured approach to disaster management, it also has significant limitations. This top-down nature restricted local communities' ability to adapt to responses based on their specific contexts, and the heavy reliance on traditional communication methods often hinders the timely dissemination of warnings. Additionally, the limited influence of CLGRCs on proactive disaster management policies highlights the gaps that must be addressed to improve the effectiveness of CBEWS in Mozambique.

4. 2. The CAP Model (2006-)

After the establishment of the CENOE in 2006, Mozambique's approach to CBEWS significantly evolved[6],[9],[30],[35]. This new phase, which we characterized as the CAP model (Figure 2), marked a shift toward a mixed approach that combines top-down and bottom-up strategies. The CAP model ensures that communities are not merely passive recipients of information but active participants in disaster management[29]-[31],[40].

The CAP involves a broad range of stakeholders, centrally coordinated by the disaster management agency (INGD). At the national and regional levels, key players include the meteorological agency (INAM), the water management agency (DNGRH), national NGOs, international humanitarian organizations, and

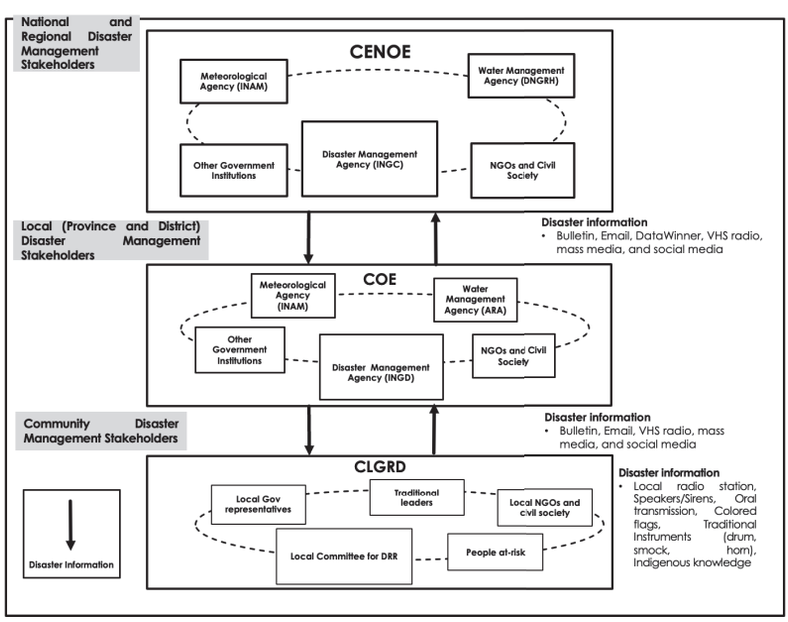

Figure 2 Information and communication flow of EWS under CAP model.
Source: Adapted by the authors

civil society groups[26],[30],[35]. These entities use various formal communication channels such as bulletins, faxes, emails, WhatsApp, VHF radios, DataWinner (an application platform for warning message delivery), mass media, and social media to disseminate warnings and coordinate disaster response strategies[29]-[31],[41]. This communication scheme is replicated at provincial and district levels through their respective Emergency Operation Centers, focusing on direct community engagement, warning dissemination, and resource allocation for immediate response actions[26],[35].

CLGRDs play crucial role[25]. Unlike the earlier CAA model, in which the community's role was limited to executing government directives, the CAP model expects and empowers CLGRDs to actively localize and contextualize information such as by incorporating indigenous knowledge[29]-[31],[40]. Moreover, CLGRDs transform national and local government directives into actionable community-based responses, such as incorporating local practices to make warnings and response strategies more relevant and actionable for specific communities[27]. Furthermore, they use a variety of communication tools to ensure that warnings and disaster preparedness strategies are accessible to all community members, including local radio broadcasts, public address systems, community meetings, traditional methods such as colored flags, speakers, sirens, oral transmission, and traditional instruments, such as drums, smocks, and horns[29]-[31],[41]. These methods are particularly effective in rural areas where modern communication infrastructure is limited[9],[15],[17].

A significant enhancement of the CAP model is the ability of communities to operate autonomously when national warnings are unavailable. Party owing to the adaption of the colored-based alerting system shown in Table 2 CLGRDs autonomously establish local alert systems to initiate dissemination and communication operations upon reaching alert thresholds[6],[27],[42]. These volunteer groups equip the community with essential information to take necessary actions and subsequently report these activities to the higher authorities[26]. CLGRDs actively gather and utilize local insights and traditional methods for risk assessment and early warning dissemination, including the use of local warning symbols and indigenous knowledge for weather forecasting and disaster response[25]-[27].

The size and population of the community typically involved in the CAP model vary but generally include a neighborhood within a locality in districts highly exposed to natural disasters[27]. The expected behavior in the CAP model is for community members to engage in autonomous and proactive evacuation based on localized and contextualized information[29],[31]. In addition, warnings are issued using both scientific methods, based on monitoring and forecasting by the INAM and DNGRH, and traditional methods, based on local knowledge and natural signs. The stakeholders involved in this model include national and local government entities, NGOs, international humanitarian organizations, and civil society groups[29]-[31],[41].

Although the CAP model has significantly enhanced community engagement and flexibil-

ity in disaster response, challenges remain. Continuous capacity building, resource allocation for disaster response, and the maintenance of robust communication channels are essential to ensure the timely and effective dissemination of warnings. Therefore integrating traditional and modern communication methods, strengthening stakeholder collaboration, and enhancing community-level resilience measures are critical for the continuous improvement of the EWS framework. This comprehensive approach addresses technical and logistical aspects and considers the social dynamics essential for a proactive and inclusive disaster management system.

The CAA and CAP models illustrated in Figure 1 and 2, respectively, represent distinct approaches to integrating community involvement in EWS and disaster management. These differences are summarized in Table 3.

Table 3　Comparison between CAA and CAP Models in CBEWS

Aspect	CAA Model	CAP Model
Approach	Top-down approach	Mixed approach integrating both top-down and bottom-up strategies
Role of the Community	The community acts as an agent executing government directives.	The community is one of the partners in decision-making and implementation.
Decision-Making Process	Decisions are made by central authorities and implemented by the community.	Collaborative approach: decisions are made jointly by the government and community members.
Source of Warning	Alerts issued by the national government based on scientific monitoring and forecast.	• Alerts issued by the national government based on scientific monitoring and forecast. • Local monitoring and observation, based on indigenous knowledge.
Means/Channels Used for Information	Government bulletins, radio, television, VHS radio, and official announcements.	Government bulletins, radio, television, local announcements (e.g., sirens, loudspeakers), community meetings, and traditional communication methods (e.g., drums, smock, horns).
Communication Flow	Information flows from national to local levels, with limited feedback from the community	Bi-directional communication: information flows both ways, allowing for community feedback and input.
DRR Plan Implementation	Centralized implementation: local committees carry out national directives without significant autonomy.	Decentralized implementation: local committees have autonomy to adapt and implement strategies based on local needs and contexts.
Function of the CLGRCs	Deliver evacuation orders from the government to the community in charge.	• Deliver evacuation orders from the government to the community in charge. • Operating local alert system by equipping monitoring system such as sensors and hydrometers. • Impact report to the government.
Flexibility and Responsiveness	Less flexible and responsive to local conditions and specific community needs.	More flexible and responsive, allowing for tailored solutions to local conditions and community-specific needs.
Capacity Building	Focuses on executing predetermined tasks with limited emphasis on building local capacity and resilience.	Emphasizes capacity building and resilience through training, education, and active engagement of community members.
Expected Evacuation Behavior	Following the evacuation order from the government.	Autonomous and proactive evacuation.

5. Challenges in the Implementation of Early Warning Systems EWS in Mozambique

Despite significant advancements in Mozambique's EWS, the CAP model faces substantial operational challenges, particularly the catastrophic floods induced by Cyclones Idai and Kenneth in 2019[33],[35]. As previously discussed, CLGRDs are expected to translate and localize messages from national governmental agencies. However, this is often hindered by ineffective communication and misalignment with local realities[6],[9],[10],[31] for several reasons.

The first issue is the lack of adequate equipment and maintenance, which hinders the functionality of local systems and their capacity to deliver timely and accurate warnings to communities at risk[14].

The second issue concerns the effectiveness of CLGRDs and local leaders[26],[27],[41]. These groups are supposed to bridge the gap between modern warning systems and local practices, utilizing social capital to enhance trust in the EWS[43],[44]. However, trust in these systems is notably low, stemming from a history of unmet expectations and frequent failures of past disaster responses, which led to skepticism and a delayed response to new warnings[43],[44].

The operational capacity is further challenged by their reliance on volunteerism[43]. Volunteers often prioritize personal livelihood activities such as farming over their duties in disaster management. This led to the disintegration of these committees, with a notable instance in 2017 where only 698 of the 1,218 committees were adequately equipped with communication tools such as radios, mobile phones, automatic-sensors, sirens, and local alert systems[45], highlighting a severe resource shortfall that affects last-mile connectivity[7],[27],[43]. Moreover, substantial barriers exist to early evacuation. These include the lack of clear and actionable alerts that are understood and trusted by the community[14],[15],[17],[46], and physical and logistical challenges that promptly prevent people from moving to safer areas[14],[15],[39],[46]. This situation is exacerbated by insufficient collaboration among stakeholders and the inadequate allocation of resources, which continue to affect the operational effectiveness of the EWS[14].

Efforts to address these deficiencies, such as the introduction of Law 10/2020[36] and the 2022 Regulation for the Operationalization of the Integrated Platform for the Dissemination and Communication of Early Warning Systems, aim to broaden the scope disaster management to include all hazards and enhance inter-institutional collaboration[38]. Despite these regulatory enhancements, ongoing issues of stakeholder collaboration and resource allocation continue to impede the effectiveness of EWS at the community level[31],[38].

Therefore, although Mozambique has made commendable progress in developing its EWS, the effectiveness of these systems at the community level remains compromised by challenges such as inadequate equipment maintenance, lack of trust in CBEWS, and significant barriers to early evacuation. The integration of traditional and modern commu-

nication methods, bolstering stakeholder collaboration, and strengthening community-level resilience measures are critical for the continuous improvement of the EWS framework. This approach not only addresses the technical and logistical aspects but also considers the social dynamics essential for a proactive and comprehensive disaster management system.

Given these numerous challenges, an important question has emerged: Do systemic issues and operational deficiencies affect the effectiveness of community evacuations and responses during emergencies? Enhancing the responsiveness and overall effectiveness of the system can significantly affect how communities act based on warnings and their ability to manage evacuations when facing imminent threats.

6. Conclusion

Mozambique has made significant strides in enhancing its EWS to effectively manage natural disaster risks, particularly floods and cyclones. The adoption of a mixed approach that integrates top-down directives and bottom-up community engagement through legislative and institutional reforms has notably strengthened the nation's disaster response capabilities. The transformation from the CAA model the CAP model exemplifies this modern approach to CBEWS, promoting deep community participation and integration.

Despite these advances, the operational effectiveness of an EWS continues to pose significant challenges. Persistent issues such as inadequate last-mile connectivity, inconsistent communication methods, and limited resource allocation severely hamper the system's efficacy. Particularly at the community level, the effectiveness of CBEWS is compromised by the lack of adequate equipment and maintenance, limited infrastructure — including insufficient electricity and network coverage —, and the volatility of volunteer groups, whose primary livelihood activities, such as farming, can weaken from their disaster management roles. These factors highlight the urgent need for ongoing enhancements and support.

Moreover, the effectiveness of CBEWS is critically influenced by social dynamics within communities, including fluctuating levels of trust and social capital, which affect how warnings are received and acted upon. This highlights concerns regarding whether current EWS effectively prompt community evacuation and other proactive responses in times of imminent danger. To address these issues, it is imperative that Mozambique continues to fortify the capabilities of the CLGRD by ensuring that they receive sustainable funding, consistent training, and the necessary resources to perform effectively. Enhancing the infrastructure to address communication barriers during emergencies is also crucial.

Future research should explore the effectiveness of evacuation procedures and assess whether the EWS frameworks function efficiently during disasters. This includes considering innovative methods that can augment the dissemination of information and boost community engagement and responses, such as harnessing indigenous knowledge, which may offer valuable insights into natural signs and community-specific risk management.

Strengthening inter-institutional collaboration to ensure that national warnings are well-aligned with local realities is crucial for developing a resilient EWS capable of effectively mitigating the impacts of future disasters. Further research focused on understanding the factors that influence social capital and trust within communities could provide deeper insights into improving the efficacy of CBEWS, ensuring that these systems do more than inform — they actively mobilize community action.

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Appendix

List of Abbreviations

Abbreviation	Full Term
CAA	Community-As-Agent
CAP	Community-As-Partner
CBEWS	Community-Based Early Warning Systems
CENOE	National Center for Emergency Operations
CLGRD	Local Committees for Disaster Management and Risk Reduction
CLGRC	Local Committees for Disaster Management
CVM	Mozambique Red Cross
DNGRH	National Directorate of Water Resource Management
DPCCN	Department of Prevention and Combat of Natural Calamities
DRR	Disaster Risk Reduction
EWS	Early Warning Systems
IDP	Internal Displaced People
INAM	National Institute of Meteorology
INGC	National Institute for Disaster Management
INGD	National Institute for Disaster Management and Risk Reduction
NGO	Non-Governmental Organization
SIFIAPCC	Regulation for the Operationalization of the Integrated Platform for the Dissemination and Communication of Early Warning Systems for Floods and Cyclones
UN	United Nations
UNDRR	United Nations Office for Disaster Risk Reduction
VHS	Very High Frequency Radios

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