

# Dreams and data: integrating indigenous knowledge into multi-hazard early warning systems in coastal Mozambique

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## Abstract

**Purpose** – To examine how indigenous knowledge intersects with formal early warning systems in cyclone-prone Mozambique, and how these interactions shape risk perception, trust and community preparedness within the EW4All agenda.

**Design/methodology/approach** – A qualitative case study was conducted in 24 coastal communities. Purposively selected key informants were interviewed, transcripts were translated and thematically analysed, drawing on PADM and SARF to interpret warning uptake.

**Findings** – Communities interpret dreams, environmental cues and ancestral guidance as legitimate indicators of impending hazards. When these align with scientific alerts and are relayed by trusted leaders, credibility increases and protective actions occur earlier.

**Research limitations/implications** – Findings are derived from a single district and a qualitative sample, which limits their generalisability. Future research should test hybrid warning approaches comparatively and evaluate behavioural outcomes using mixed methods.

**Practical implications** – Embedding local leaders in dissemination pathways, documenting indigenous indicators, and co-producing messages with meteorological services can improve trust, comprehension and timeliness of community responses.

**Social implications** – Recognising indigenous knowledge promotes inclusion, strengthens last-mile communication and builds locally legitimate systems that better reach vulnerable groups often underserved by purely technical warnings.

**Originality/value** – The study reframes indigenous knowledge as an operational early warning asset, demonstrating how hybrid systems can enhance anticipatory governance when aligned with EW4All principles.

**Keywords** Mozambique, Indigenous knowledge, Early warning systems, Disaster risk reduction, Community preparedness, EW4All (early warnings for all)

**Paper type** Research article

## 1. Introduction

The increasing frequency and intensity of climate-related disasters have reignited global attention toward inclusive, culturally grounded, and contextually legitimate approaches to disaster risk reduction (UNDRR, 2023). While scientific early warning systems (EWS) have advanced significantly, many vulnerable communities, particularly in the Global South,

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continue to rely heavily on local knowledge, traditional signs, and cultural practices to anticipate and respond to environmental hazards (Mercer *et al.*, 2010; Kelman and Stough, 2015). Recent scholarship confirms that Indigenous and Local Knowledge (ILK) remains central to community preparedness and can enhance the effectiveness of early warnings when integrated with scientific forecasts (Motsumi and NemaKonde, 2025; Lin, 2025).

The need for hybrid early warning frameworks is gaining momentum, particularly in disaster-prone regions such as coastal Mozambique. The United Nations' "Early Warnings for All" (EW4All) initiative, launched in 2022, aims to ensure that every person on Earth is protected by a multi-hazard early warning system by 2027 (WMO, 2023). However, achieving this goal requires more than just expanding technological systems. It demands the recognition of plural knowledge systems and the inclusion of cultural epistemologies in the design, communication, and implementation of EWS (Lavell and Maskrey, 2014; Blaikie *et al.*, 2004). Recent international guidance increasingly calls for the formal institutionalisation of Indigenous, local, and traditional knowledge within early warning governance as a matter of both equity and effectiveness (Start Network, 2025; UNDRR, 2025; UNESCO, 2025).

Several empirical and conceptual studies have examined the integration of indigenous knowledge and scientific early warning systems, offering comparative insights. Mercer *et al.* (2010) demonstrated that combining local and scientific knowledge enhanced preparedness in Vanuatu and Papua New Guinea through a hybrid DRR framework. Hiwasaki *et al.* (2014) developed participatory processes that integrated local forecasting with meteorological data, improving message uptake and comprehension. In Malawi, Mweta and Juma (2020) showed that flood forecasting grounded in indigenous indicators complemented official warnings and strengthened readiness.

Recent scholarship has advanced by critically interrogating how integration is conceptualised within early warning systems. A comprehensive review by Hermans *et al.* (2022) synthesised over 100 studies on the integration of local and scientific knowledge in EWS and identified a spectrum of approaches, ranging from participatory mapping and triangulation to knowledge validation exercises. The review highlights that integration is often framed as technical collaboration while insufficient attention is paid to epistemological hierarchies, power dynamics, and the social processes through which knowledge is legitimised. Moreover, most integration efforts are concentrated in the "risk knowledge" and "monitoring" pillars of EWS, with comparatively less attention to dissemination, communication, and behavioural uptake often the weakest links in practice.

Despite growing global consensus, little is known about how hybrid knowledge systems function within the broader Early Warnings for All (EW4All) agenda, particularly in highly vulnerable Mozambican coastal communities. Specifically, there remains a limited understanding of how indigenous forecasting practices interact with formal alerts to influence risk perception, trust formation, and the timing of protective behaviour. This gap is significant because warning effectiveness ultimately depends not only on forecast accuracy, but on social legitimacy and culturally embedded interpretation.

This paper therefore investigates how indigenous knowledge informs early warning interpretation and response behaviour in coastal communities of the Mossuril District, Mozambique. Drawing on qualitative interviews with local leaders and community representatives, the study examines the cultural logic underlying local forecasting practices, the intersection between traditional and formal warning sources, and the implications for designing people-centred early warning systems aligned with EW4All principles. By situating empirical findings within broader debates on knowledge integration, epistemological plurality, and risk communication, the study contributes to ongoing discussions about how "dreams and data" can co-produce more legitimate and effective early warning governance.

## 2. Literature review

Efforts to integrate indigenous knowledge (IK) into disaster risk reduction (DRR) and early warning systems (EWS) have gained momentum in recent years, reflecting a broader shift toward participatory and context-sensitive approaches. The literature review examines the theoretical underpinnings of indigenous knowledge in disaster management, the challenges of integrating it into formal systems, and relevant lessons from Mozambique, Malawi, and Madagascar, countries with deep-rooted cultural traditions and vulnerability to climate-induced hazards.

### 2.1 Defining indigenous knowledge in disaster contexts

Indigenous knowledge refers to the accumulated wisdom, practices, and belief systems that communities develop through sustained interaction with their social and ecological environments (Chilisa, 2012; Galloway McLean *et al.*, 2012). Within disaster contexts, Indigenous knowledge manifests through environmental monitoring, seasonal calendars, local hazard markers, and culturally encoded signals such as dreams, animal behaviour, wind patterns, and changes in sea conditions (Hiwasaki *et al.*, 2014). These knowledge systems are embedded within social relations, spiritual worldviews, and place-based histories that shape how risk is interpreted and acted upon.

Conventional disaster governance frameworks have often contrasted Indigenous knowledge with Western scientific knowledge, characterising the latter as formalised, standardised, and quantitatively modelled (Mercer *et al.*, 2010). However, scholars caution against reproducing rigid binaries between “Indigenous” and “scientific” epistemologies. Agrawal (2002) argues that the politics of classification frequently exaggerates distinctions between knowledge forms, obscuring their shared empirical foundations and historical interconnections.

### 2.2 Knowledge pluralism and epistemological tensions

While IK offers valuable insights, its integration into formal EWS remains controversial. The dominant approach in many disaster management frameworks privileges scientific, centralised, and technocratic models (Blaikie *et al.*, 2004). This often results in the marginalisation of local knowledge, especially when it cannot be easily codified or verified through empirical models. Such epistemological hierarchies are particularly evident in countries such as Mozambique and Madagascar, where risk assessments, response plans, and forecasts are developed by national meteorological agencies or international partners, with limited community input (Gaillard and Mercer, 2013). In Mozambique, this hierarchy is shaped not only by technical rationality but also by historical patterns of governance. Disaster management institutions emerged within post-colonial state-building processes that emphasised centralised expertise and international partnerships. As a result, meteorological forecasting and externally funded risk assessments became the primary sources of authorised knowledge, while locally embedded systems remained peripheral. This institutional configuration contributes to the continued marginalisation of Indigenous forecasting practices despite their widespread use at the community level.

As a result, local knowledge is seen as anecdotal or symbolic rather than actionable. In disaster governance, this includes questioning who is authorised to define risk, whose knowledge counts as evidence, and how institutional hierarchies shape decision-making processes. These debates challenge integration models that treat Indigenous knowledge as supplementary data to be validated by scientific institutions, rather than as sovereign epistemologies with their own internal logics, authority structures, and evaluative criteria. Nonetheless, scholars argue that IK and scientific knowledge are not mutually exclusive but potentially complementary. Mercer *et al.* (2010) propose a “knowledge hybridisation” model, wherein both systems are placed in dialogue to co-produce relevant, reliable, and legitimate

risk information. The effectiveness of such integration depends on mutual respect, institutional openness, and mechanisms for local participation in decision-making.

[Hermans et al. \(2022\)](#) further argue that integration should not be treated as a binary merging of two fixed knowledge systems, but rather as a socially negotiated process shaped by power dynamics, institutional authority, and differing ontologies. Their review identifies that most integration efforts focus on the “risk knowledge” and “monitoring” pillars of EWS, while comparatively less attention is given to dissemination and communication processes, which are often the weakest links in practice. This imbalance reflects persistent epistemological hierarchies in which scientific knowledge is privileged as authoritative, while local knowledge is selectively incorporated or used instrumentally.

### *2.3 Early warning systems: design and limitations*

Early warning systems are typically conceptualised as comprising four components: risk knowledge, monitoring and forecasting, dissemination and communication, and response capability ([UNISDR, 2006](#)). Most national EWSs focus heavily on the first two components, relying on satellite imagery, remote sensing, and meteorological modelling to produce forecasts. However, failures often occur in the remaining two components, communication and response ([Basher, 2006](#)). Studies show that EWS fail not because forecasts are wrong, but because warnings are not trusted, understood, or acted upon ([Paton, 2008](#); [Wachinger et al., 2013](#)). Therefore, cultural relevance, trust in the message source, and local interpretation are vital. This presents an opportunity for IK. Because indigenous knowledge is grounded in local experience and social relationships, it is often perceived as more credible and contextually resonant than anonymous forecasts.

*2.3.1 Theoretical framework: disaster communication and risk interpretation.* This study draws on two complementary frameworks to analyse how early warning messages are interpreted and acted upon in cyclone-prone communities: the Protective Action Decision Model (PADM) and the Social Amplification of Risk Framework (SARF). Together, these frameworks explain how individuals interpret warning messages and how social and cultural processes shape protective behaviour.

The PADM ([Lindell and Perry, 2012](#)) conceptualises warning uptake as a staged cognitive process in which individuals receive a warning message, interpret its meaning, evaluate its credibility and personal relevance, and decide whether to take protective action. In this study, PADM informed both the interview guide and the analytical coding framework by structuring themes around message receipt, credibility assessment, and behavioural response.

Complementing this, the Social Amplification of Risk Framework ([Kasperson et al., 1988](#)) emphasises that risk messages are not transmitted linearly but are filtered, reframed, and amplified through social institutions, cultural beliefs, and trusted intermediaries. SARF is particularly relevant in contexts where indigenous epistemologies coexist with scientific forecasts. In Mossuril, community leaders, elders, and religious figures frequently acted as “amplification stations,” translating technical warnings into culturally meaningful narratives. This framework helps explain why warnings delivered through trusted local actors often generate stronger behavioural responses than those issued solely through formal channels.

### *2.4 Community decision-making and hybrid preparedness practices*

Preparedness decisions often emerge from the blending of multiple information streams, including environmental observation, spiritual interpretation, historical memory, and formal meteorological alerts. This hybrid decision-making reflects everyday risk pragmatism rather than abstract epistemological alignment.

In sub-Saharan Africa, particularly in cyclone- and flood-prone regions such as Mozambique, Malawi, and Madagascar, communities frequently triangulate Indigenous environmental cues with state-issued warnings to guide action. [Mweta and Juma \(2020\)](#)

document how Malawian communities interpret local hydrological signs alongside official flood forecasts, strengthening readiness when signals converge. Similarly, [Cadag and Gaillard \(2012\)](#) show that participatory risk mapping in Madagascar improved community compliance with warnings when scientific information was contextualised through culturally embedded symbols and local authority structures. These cases illustrate that integration often occurs informally at the community level, even when institutional frameworks do not formally recognise Indigenous knowledge.

However, the degree to which such practices are supported, formalised, or marginalised varies significantly across governance contexts. In many African disaster governance systems, including Mozambique, formal early warning architecture remains technocratic and centralised, often resulting in parallel knowledge systems operating without structured coordination. Understanding how communities negotiate these parallel systems in practice is therefore essential for assessing the effectiveness of integration efforts and advancing more people-centred early warning models.

### *2.5 Mozambique's policy landscape and knowledge gaps*

Mozambique has made progress in disaster policy by establishing the National Institute for Disaster Risk Management and Reduction (INGD) and decentralised committees. However, formal disaster governance remains largely technocratic and externalised. International NGOs, meteorological services, and development partners dominate the risk information landscape ([World Bank, 2021](#)). Despite this, local communities rely on traditional indicators such as dreams, animal behaviour, and sea conditions, yet no national policy explicitly recognises such indigenous practices. Integration remains ad hoc and dependent on the openness of local officials. This policy silence reflects broader global patterns, where IK is valued in principle but marginalised in practice ([Hiwasaki et al., 2014](#)).

### *2.6 The EW4All initiative and the place of indigenous knowledge*

The “Early Warnings for All” initiative launched by the UN in 2022 explicitly calls for equity, accessibility, and inclusion in the design and delivery of EWS ([WMO, 2023](#)). While the initiative prioritises technological infrastructure and multi-hazard modelling, it also acknowledges that end users must understand and act upon warning systems. In this context, IK can serve as a bridge between formal systems and community realities. By grounding warnings in familiar narratives, cultural symbols, and trusted messengers, EWS can become more people-centred.

Indigenous knowledge holds significant potential to enhance the credibility, legitimacy, and cultural fit of early warning systems. However, integration is not automatic; it requires deliberate effort, structural change, and policy reform. Lessons from Malawi and Madagascar, as well as the realities observed in Mozambique, point to the urgent need for hybrid systems that respect multiple ways of knowing. As the EW4All agenda moves forward, recognising the value of “dreams and data” together will be key to building truly inclusive and life-saving early warning systems.

## **3. Materials and methods**

The study employed a qualitative case study approach to examine the role of indigenous knowledge in early warning systems across cyclone-prone communities in Mossuril District, Nampula Province, Mozambique. The research design was grounded in purposive sampling, targeting vulnerable communities. Selection was based on exposure to cyclones, flooding, and erratic rainfall, ensuring data collection focused on the most at-risk localities. Within each selected village, one key informant was identified, typically a local leader, elder, or representative actively engaged in disaster preparedness or community governance, on the

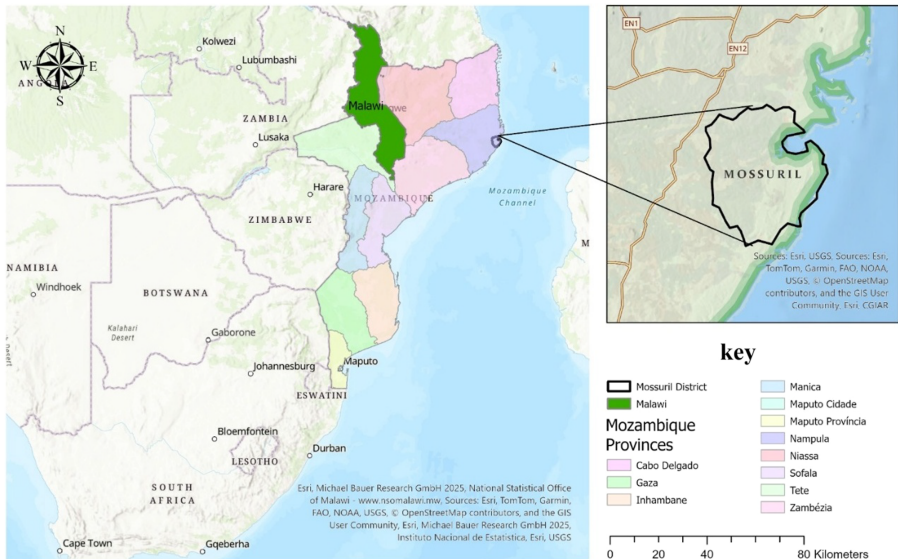
premise that these individuals possess firsthand knowledge of indigenous and formal early warning practices. [Figure 1](#) illustrates the geographical location and administrative layout of the Mossuril District within Nampula Province, Mozambique, providing spatial context for the study area.

3.1 Research context

Mossuril District is located in Nampula Province in northern Mozambique. It has an estimated population of approximately 120,000–140,000 inhabitants, representing a small but highly vulnerable portion of Nampula Province, which itself is home to over 6.5 million people ([Instituto Nacional de Estatística, 2023](#)). The district lies along the Indian Ocean coastline and is characterised by low-lying settlements, subsistence fishing livelihoods, and limited infrastructure, all of which increase exposure to hydro-meteorological hazards. Northern Mozambique is among the most cyclone-prone regions in southern Africa.

The recurrence of high-intensity cyclones, combined with limited early warning reach and socio-economic vulnerability, situates Mossuril within a broader pattern of compounding disaster risk. This context provides an important backdrop for interpreting the study’s findings, as indigenous forecasting practices have evolved within a setting characterised by repeated exposure to life-threatening hydro-meteorological events.

The majority of communities in Mossuril belong to the Makuwa ethnic group, whose cosmology integrates environmental observation with spiritual worldviews that shape local interpretations of risk. Historically, colonial governance under Portuguese rule institutionalised external administrative structures while weakening local authority systems and customary knowledge practices. Following independence, disaster governance evolved within a centralised, technocratic framework, often shaped by international development partnerships and meteorological expertise.



**Figure 1.** Map of Mossuril District in Nampula Province, Mozambique. Source: (Author, adapted from Esri, Michael Bauer Research GmbH (2026); National Statistical Office of Malawi; Instituto Nacional de Estatística; USGS)

Data collection was conducted in June 2024, coinciding with the early phase of the cyclone preparedness season in northern Mozambique. Key informant interviews were conducted across 24 communities in six administrative posts: Vila Sede-Mossuril (Namantinte, Ratane, Cabeceira Grande, Cabeceira Pequena, Chocas Mar), Namitatar (Namarral, Entente, Paquela, Naguema, Muresso, Mugeia), Matibane (Namalungo, Crusse, Nachaoro, Anduce, Munhohola, Naviana, Sanhote, Mugigivala), Lunga (Quiluvale, Muanangome, Miticuite, Muriphotana), Ampita, and Muaualo. Interviews were conducted in the local language (Makhuwa and Portuguese) with translation support. They followed a semi-structured guide focusing on indigenous forecasting practices, risk perception, and the interaction between cultural knowledge and formal warning systems.

Purposive and criterion-based sampling were used to identify information-rich participants with direct experience in early-warning communication or indigenous forecasting practices. Village secretaries and local disaster-risk reduction officers assisted in identifying informants who met these criteria. In total, 24 participants (14 men and 10 women) were interviewed across the six administrative posts. Participants included community leaders (6), elders (4), women's group representatives (5), youth members (4), religious figures (2), and local disaster-committee members (3).

All interviews were transcribed verbatim and anonymised, with participants coded as Informants A-F to ensure confidentiality. The transcripts were imported into NVivo 12, a qualitative data analysis software, to facilitate systematic coding and analysis. Thematic analysis followed Braun and Clarke's (2006) six-phase framework: (1) familiarisation with the data, (2) generation of initial codes, (3) searching for themes, (4) reviewing themes, (5) defining and naming themes, and (6) producing the report. Initial coding was conducted inductively, allowing patterns to emerge directly from the data. The North-West University's Faculty of Natural and Agricultural Sciences Research Ethics Committee (FNAS-REC) granted ethical approval for this research. The clearance was issued under ethics number NWU-01252-24-A9.

#### 4. Results

This section presents the empirical findings of the study, organised around three central themes: indigenous indicators and forecasting practices; the interaction between traditional and formal early warning systems; and the opportunities and tensions that arise from integrating indigenous knowledge into formal early warning governance. The results reported here are derived directly from the field data collected in the Mossuril District.

##### 4.1 Indigenous indicators and forecasting practices

Communities in Mossuril District rely on a range of indigenous forecasting systems to anticipate cyclones and related hazards. These systems are embedded in everyday life and are shaped by long-term interaction with the coastal environment. Indigenous indicators form part of a locally embedded forecasting system combining ecological observation and spiritual interpretation. Participants reported monitoring environmental cues, such as wind shifts, changes in sea temperature, calmness of the ocean, and bird migration, as early signs of storms. Dreams involving collapsing houses, strong winds, or heavy rain were also interpreted as warning signals, particularly when experienced by several community members, often prompting precautionary action. Table 1 summarises the most frequently cited environmental indicators.

One key informant stated, "*Some people dream about a cyclone before it comes. Others look at the sea; if it is too calm or hot, they know something is wrong.*" Similarly, Informant B, a leader of a fishermen's association, described how elders systematically track wind shifts, sea temperatures, and bird movements to anticipate storms. Informant A reinforced this point, remarking, "*Some people say they dream of a cyclone coming, and after some time, it happens.*"

**Table 1.** Common indigenous environmental indicators and their meanings in Mossuril district

Indicator/ Sign	Observed change	Local Interpretation/ Meaning	Typical community response	No. of mentions (n = 24)
Sea behaviour	Unusually calm or excessively warm sea surface	An imminent cyclone or strong winds are expected	Fishermen halt trips; families secure houses	21
Wind direction	Sudden shift from southeast to north	Storm approaching within days	Coastal activities reduced; elders alert villagers	18
Bird migration	Birds flying inland in large numbers	Heavy rains or coastal storms	Livestock moved to higher ground	15
Ant movement	Ants relocating nests upward	Flood likely	Crops and tools were moved to raised storage	12
Cloud formation	Low-hanging, fast-moving clouds from the east	Cyclone forming offshore	Preparations for evacuation begin	20
Fish behaviour	Fish swimming erratically or disappearing near shore	Sea turbulence signalling a storm	Fishing suspended	15

**Source(s):** Authors' own work (2026)

*Others watch the sea or the wind. These signs are taken seriously.*” These accounts demonstrate that ecological observation and spiritual interpretation operate simultaneously within local forecasting systems.

**Table 2** presents the most common dream-based and spiritual indicators.

Rather than existing in isolation, indigenous and formal early warning systems in Mossuril frequently intersect in everyday decision-making. Informants reported that community members often compare official messages received via radio or mobile phones with traditional signs and guidance from elders before taking action. Informant C explained: *“When the message comes from the radio and also from our leaders or signs like the wind changing, people take it seriously.”* Several participants described this process as one of confirmation.

**Table 2.** Dreams and spiritual forecasting: common themes and local interpretations

Dream/Spiritual sign	Cultural interpretation	Validation and action taken	No. of mentions (n = 24)
Dreaming of strong winds, collapsing houses, or falling trees	Ancestors warning of an impending cyclone	Elders inform the community; communal prayers or cleansing rituals are held	11
Dream of heavy rainfall flooding homesteads	Forecast of severe rain and flooding	Families inspect drainage, relocate livestock	9
Hearing ancestral voices or being called to the sea in dreams	Spiritual summons indicating ocean disturbance	Fishermen avoid sea travel until calm is confirmed	6
Appearance of certain birds or snakes in dreams	Symbolic of environmental imbalance or impending danger	Elders consult traditional healers for interpretation	7
Repeated dreams shared by several community members	Collective warning; taken as a certain omen	Immediate mobilisation of the local disaster committee	10

**Source(s):** Authors' own work (2026)

When environmental indicators such as wind shifts, sea temperature changes, or unusual bird movements coincided with formal alerts issued by the National Institute for Disaster Risk Management and Reduction (INGD), households were more likely to secure homes, suspend fishing activities, and prepare for possible evacuation.

However, participants also reported instances where formal warnings were met with hesitation. Informant E noted: *“If there is no sign in the environment, some people do not believe the message. They say: ‘We did not feel it ourselves.’”* This suggests that warnings perceived as disconnected from local observation may not trigger immediate protective action. Field narratives revealed several specific cases of convergence between indigenous and formal forecasts. In 2023, elders in Mossuril observed unusually warm sea temperatures and mass inland bird movement two days before INGD issued a formal cyclone alert. Community members recalled that preparations began earlier than usual because both local signs and official announcements pointed to the same threat.

A similar experience was recalled during Cyclone Kenneth (2019), when repeated dreams about strong winds and collapsing houses coincided with government radio broadcasts warning of an approaching tropical storm. Informants indicated that this alignment reinforced the seriousness of the warning and encouraged faster mobilisation. Overall, participants described warning uptake as strongest when formal and indigenous signals aligned, and weaker when formal alerts were not locally validated through environmental or social cues.

#### 4.2 Opportunities and tensions in integration

Integrating indigenous and scientific early warning systems in the Mossuril District presents persistent challenges and emerging opportunities. While community-based forecasting practices are trusted and culturally embedded, they remain largely excluded from formal disaster governance frameworks. The findings indicate that integration is not straightforward; it involves navigating epistemological tensions, communication barriers, governance constraints, and issues related to trust and cultural sensitivity. At the same time, there are promising pathways for collaboration, co-production of knowledge, and policy reform that could strengthen inclusivity and local legitimacy. The following subsections discuss these tensions and challenges, as well as the corresponding opportunities for integration, in greater detail.

**4.2.1 Tensions and challenges to integration.** While community members in Mossuril widely accept and use indigenous indicators, their integration into formal disaster management systems remains fraught with multiple layers of tension. The most pronounced challenge is epistemological, as formal agencies often regard dreams, ancestral messages, and environmental cues as unscientific or unreliable. This perception marginalises community-derived insights and reinforces a hierarchy of knowledge that privileges meteorological expertise over experiential wisdom. As one informant explained, *“Government people think our knowledge is old-fashioned, yet it has saved lives for years.”* Several informants indicated that government officials often prioritise scientific forecasts, while local indicators are rarely incorporated into formal warning processes.

A second source of tension stems from communication and accessibility gaps. Formal warnings are typically issued via radio or SMS, often in Portuguese, which many rural residents neither understand fully nor relate to culturally. By contrast, traditional forecasts are communicated through local languages and social networks, making them more intelligible and trusted. This disconnect contributes to inconsistent message uptake and delayed responses during hazard events. Where language and cultural framing diverge, uptake of warnings becomes uneven.

Governance and institutional fragmentation also present barriers. Despite decentralising disaster committees, indigenous practices remain excluded from formal disaster plans and policies. Local leaders and elders are rarely invited to participate in official forecasting or

response coordination, creating parallel systems that operate independently of one another. Furthermore, trust deficits rooted in colonial legacies and historical exclusion continue to shape how communities perceive government-issued alerts. Informant F reflected, “*People trust what comes from within the village more than voices from the radio.*” These gaps suggest that institutional design has not yet caught up with how people actually interpret risk on the ground.

**4.2.2 Opportunities for integration.** Despite these tensions, the study also identified several opportunities to build hybrid early warning systems that bridge local and scientific knowledge. A key opportunity lies in co-producing knowledge, where community elders, traditional forecasters, and meteorologists work together to identify, interpret, and validate warning indicators.

Secondly, integration offers a pathway to build trust and strengthen legitimacy. When scientific forecasts are communicated through trusted community figures such as pastors, chiefs, or fishermen’s associations, the messages gain credibility and encourage timely action. These intermediaries play a vital role in translating technical forecasts into culturally meaningful terms, an approach already proving effective in Mossuril’s community disaster committees. Another opportunity involves localisation of risk communication. Embedding indigenous indicators within formal dissemination channels ensures that warnings are framed in familiar metaphors, dialects, and cultural references, making them more accessible to the target audience.

Finally, the recognition of indigenous knowledge supports policy innovation and inclusivity. Institutionalising plural knowledge systems within Mozambique’s disaster governance can improve anticipatory action, community ownership, and the sustainability of early warning interventions. [Mercer et al. \(2010\)](#) note that hybrid systems, which combine scientific precision with cultural resonance, provide a stronger foundation for resilience.

In summary, three empirical patterns stand out: indigenous forecasting combines ecological cues with spiritual validation; communities are more likely to act when indigenous indicators align with formal warnings; and the continued exclusion of local knowledge from governance structures undermines consistent uptake of warnings.

## 5. Discussion

This section interprets the empirical findings presented in [Section 4](#) through the lenses of disaster-communication theory and comparative literature. It situates the results within broader debates on trust, knowledge integration, and the localisation of the Early Warnings for All (EW4All) framework.

### 5.1 Implications for community trust and local action

Trust emerged as a central determinant of whether early warnings translated into protective action. In Mossuril, formal alerts were sometimes mistrusted when they arrived in unfamiliar formats or without local interpretation. As one informant observed, “*People trust the pastor or the community leader more than the government voice on the radio.*” This pattern echoes [Paton’s \(2008\)](#) findings, which argue that people act on warnings primarily when they trust the source. In Mozambique, longstanding inequalities between rural coastal communities and centralised institutions contribute to mistrust of formal warnings, reinforcing the legitimacy of Indigenous knowledge in local risk interpretation. This pattern aligns with findings in other cyclone-prone contexts, where warnings endorsed by culturally legitimate leaders are more likely to be acted upon than those delivered solely through formal channels ([Mangara et al., 2025](#)). By contrast, indigenous indicators were regarded as credible because they derive from lived environmental experience and spiritual worldviews that communities understand and share.

The study shows that households acted most decisively when indigenous indicators and formal warnings converged. This convergence validated the risk, bridging the gap between warning generation and local decision-making. Community radios, church gatherings and fishermen's cooperatives, therefore, functioned as key "translation nodes", where scientific forecasts were reinterpreted through culturally grounded narratives before being disseminated more widely. This process reflects what Wachinger *et al.* (2013) describe as *risk translation*: warnings are not simply transmitted but continually reframed through social and cultural lenses.

The findings further illuminate how the Protective Action Decision Model (PADM) operates in culturally plural settings. PADM posits that individuals evaluate warnings based on credibility, relevance, and social cues before deciding how to act (Lindell and Perry, 2012). In Mossuril, credibility was strengthened when official alerts were delivered by trusted local figures and aligned with indigenous observations. At the same time, the Social Amplification of Risk Framework (Kasperson *et al.*, 1988) helps explain how elders, pastors and traditional leaders acted as amplification nodes, embedding scientific forecasts into familiar moral and spiritual narratives that heightened perceived urgency.

While Hermans *et al.* (2022) observe that many integration initiatives remain confined to participatory mapping or validation exercises, the Mossuril case demonstrates a more organic form of hybridisation occurring at the community level. Rather than formalised institutional integration, communities themselves triangulate dreams, environmental cues, and meteorological alerts in everyday decision-making. This bottom-up synthesis suggests that integration is already occurring in practice, even where policy frameworks remain silent.

Furthermore, whereas the review highlights epistemic hierarchies privileging scientific knowledge, the Mossuril findings reveal a context in which indigenous epistemologies retain primary legitimacy unless reinforced by formal alerts. This reverses the dominant hierarchy described in much of the literature and underscores the importance of culturally embedded trust networks in early warning uptake.

### 5.2 Enhancing the early warnings for the all agenda

The Global Early Warnings for All (EW4All) initiative presents a significant opportunity to reevaluate the design of early warning systems, particularly in contexts where diverse knowledge systems coexist. While EW4All emphasises universal coverage and technological strengthening, its effectiveness ultimately depends on how warnings are interpreted, trusted, and acted upon at the community level (WMO, 2023). The findings from Mossuril indicate that indigenous knowledge is not an obstacle to EW4All goals; rather, it constitutes a critical resource for localisation, legitimacy, and uptake.

A key implication is that localisation requires integrating knowledge systems, not simply expanding infrastructure. In practice, this means documenting local hazard indicators alongside meteorological datasets, involving community leaders as co-interpreters and communicators of warnings, incorporating indigenous knowledge into disaster education and training, and ensuring that national policies formally recognise plural knowledge systems rather than treating them as informal add-ons. Integrating trusted traditional authorities into formal dissemination pathways can therefore strengthen last-mile communication by aligning technical accuracy with cultural legitimacy (Mangara *et al.*, 2025).

Integration requires ongoing dialogue between scientific institutions and community knowledge holders grounded in mutual respect and context-specific validation. As Mercer *et al.* (2010) note, indigenous knowledge helps communities interpret risk and mobilise action within everyday realities. Taken together, the Mossuril findings, supported by regional evidence, suggest that indigenous knowledge plays an indispensable role in shaping how communities anticipate and respond to environmental hazards. Although still marginalised in formal early warning structures, it can significantly enhance the legitimacy and timeliness of scientific forecasts when meaningfully integrated.

### 5.3 Preserving indigenous knowledge in the digital era

Digital technologies have transformed early warning systems by enabling faster detection, modelling, and dissemination of hazard information. Knowledge systems based on observing sea conditions, animal behaviour or spiritual warnings are rarely captured in digital datasets. Over time, such exclusion can contribute to the perception that indigenous knowledge is outdated or unscientific, particularly among younger generations (Kelman, 2020).

This tension between technological modernisation and cultural continuity was clearly visible in Mossuril. Elders expressed concern that younger residents were increasingly relying on radio and mobile alerts while neglecting traditional cues that had historically guided preparedness. However, these local systems remain especially valuable in areas where digital connectivity is weak, warnings arrive late, or trust in external institutions is limited.

Integrating locally recognised indicators into digital platforms, for example, through participatory mapping, community radio archiving, or tailored mobile alerts, creates “knowledge bridges” that reinforce rather than replace community expertise. In this way, technological systems remain culturally grounded, thereby increasing trust and the likelihood that warnings will be acted upon.

### 5.4 Academic and theoretical implications

This study contributes to disaster-communication scholarship by showing that early warning processes operate within plural knowledge environments rather than purely technical systems. First, it extends the application of the Protective Action Decision Model (PADM) and the Social Amplification of Risk Framework (SARF) to contexts where warnings are culturally mediated and socially negotiated, demonstrating that credibility appraisal, message interpretation, and risk amplification remain central even when indigenous epistemologies shape decision-making. Second, the study advances knowledge-hybridisation research by illustrating how communities synthesise indigenous and scientific information streams to validate risk and guide preparedness. These findings extend recent critiques of knowledge integration that emphasise power asymmetries and epistemic hierarchy in early warning systems (Hermans *et al.*, 2022) by demonstrating how hybridisation is negotiated informally at the community level. Third, by situating these dynamics within the Early Warnings for All (EW4All) agenda, it highlights how global warning frameworks must engage with locally embedded knowledge systems to remain inclusive and effective. Collectively, these insights deepen theoretical understanding of how communication, culture, and cognition interact to shape protective behaviour in disaster-prone settings.

## 6. Policy recommendations

Based on the study findings, the following recommendations can enhance the integration of indigenous knowledge into early warning systems and align with the EW4All framework:

- (1) Facilitate structured dialogue between meteorologists, local leaders, and traditional forecasters to co-design integrated early warning strategies.
- (2) Disaster risk governance frameworks should formally acknowledge indigenous forecasting methods as valid components of early warning. This may include integrating IK into national disaster risk reduction policies, guidelines, and public awareness campaigns.
- (3) Community-based organisations and local government units should collaborate with researchers to document traditional early warning signs, rituals, and practices. These mappings can inform both local action and national planning.
- (4) Warning messages should be co-produced by combining scientific forecasts with culturally relevant interpretations. Dissemination channels must include traditional

communicators such as chiefs, pastors, and cooperative leaders, as well as radios, SMS, and social media.

- (5) Local leaders, disaster volunteers, and youth groups should be trained to understand indigenous and scientific warning systems, fostering mutual understanding and reducing epistemic hierarchy.
- (6) Schools and community training programs should include modules on local knowledge systems and their role in disaster preparedness. This promotes intergenerational knowledge transfer and cultural sustainability.

## 7. Conclusion

This study examined the intersection of indigenous knowledge with formal early warning systems in the Mossuril District, Mozambique. The findings show that indicators such as dreams, sea behaviour, animal movements and spiritual guidance play a trusted role in how communities anticipate cyclones and floods. These practices are embedded in cultural belief systems, transmitted across generations, and constitute a form of risk intelligence that is both contextually grounded and socially legitimate. Rather than operating in opposition to formal systems, indigenous knowledge often complements official alerts from radio broadcasts, mobile phones and disaster management agencies. Communities triangulate these sources, validating scientific messages through local signs and trusted intermediaries such as elders, religious leaders and fishermen's associations. However, integration remains largely informal and poorly supported by national policy, resulting in parallel systems that sometimes compete, create confusion, or produce uneven responses.

At the same time, small-scale hybrid practices, such as disaster committees translating warnings into local metaphors or elders monitoring environmental cues alongside meteorological alerts, demonstrate that integration is both feasible and beneficial. For the Early Warnings for All (EW4All) agenda, the implication is clear: universal access cannot be achieved solely through technology. Genuine universality requires cultural legitimacy, social trust and communication that resonates with local ways of knowing. In contexts where connectivity is limited and institutional trust is fragile, indigenous knowledge becomes a critical bridge between forecasts and action. Recognising dreams, signs and rituals as components of early warning does not undermine science; it acknowledges lived experience, historical observation and relational knowledge that continue to guide communities at risk. Warning systems that respect both science and culture are more likely to be trusted, acted upon, and sustained over time.

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