EARLY WARNING FOR EARLY ACTION

Toward More Behaviorally Informed Early Warning Systems

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ACRONYMS

ALRMP	World Bank funded Arid Lands Resource Management Project
ALLPRO	Livestock and Rural Livelihoods Support Program
ASAL	Arid and Semi-Arid Land
BC-EWEA	The Behavior Change for Early Warning & Early Action Framework
CBEWS	Community-centered early warning system
CPF	Common Programme Framework
DCM	Drought cycle management
DEWSs	Drought early warning systems
DMC	Drought Monitoring Centre
DPIRP	Drought Preparedness Intervention and Recovery Programme
DRR	Disaster risk reduction
EDE	Ending Drought Emergencies
EPPM	Extended Parallel Process Model
EW	Early warning
EWS	Early warning system
FH	Food for the Hungry
GoK	Government of Kenya
HBM	Health Belief Model
ICHA	International Center for Humanitarian Affairs
IFRC	International Federation of Red Cross and Red Crescent Societies
IK	Indigenous knowledge
NDMA	National Drought Management Authority
NGOs	Non-governmental organizations
NYSE	New York Stock Exchange
PAMD	Protective Action Decision Model
PC-EWSs	People-centered early warning systems
PMT	Protection Motivation Theory
PoP	Probability of precipitation
PPEW	Platform for the Promotion of Early Warning
PSP	Participatory Scenario Planning
SARF	Social Amplification of Risk Framework
SBC	Social and behavioral change
SF	Seasonal forecasts
SFDRR	Sendai Framework for Disaster Risk Reduction
UNDRR	United Nations Office for Disaster Risk Reduction
UK	United Kingdom
UNISDR	International Strategy for Disaster Reduction

ABSTRACT

Early warning systems (EWSs) have traditionally focused on collecting and analyzing hazard data to produce warning messages that help inform stakeholders of impending disasters and when, where, and how to initiate response activities. Social constructivist understandings of risk have led to more people-centered approaches to EWS design and development. The resulting systems, though better informed, have consistently struggled to produce the preparation and early actions of exposed and vulnerable populations. This paper builds on decades of psychology and social and behavioral change theory and practice to propose a social and behaviorally informed approach to EWS design, development, and implementation. The approach focuses on identifying proper early actions and the determinants of those behaviors in order to improve the likelihood that affected populations heed early warnings and take proper action to protect themselves and the resources they may require for recovery.

EXECUTIVE SUMMARY

Early warning systems (EWSs) are based on the premise that hazard-related information can be gathered, analyzed, processed into a warning message(s), and disseminated with sufficient lead time to warn exposed and vulnerable populations of the impending disaster. Ideally, these warnings prompt preparation and/or early action that prevents or mitigates the impact of the disaster. As our understanding of socio-economic and political constructions of risk have evolved, so too have our understandings of what is required for timely and effective early warning. The resulting movement toward more people-centered EWSs has improved the overall quality of warning information gathered and analyzed along with the timeliness and quality of warning messages. However, as the literature review finds, EWSs have primarily been designed from a technocratic perspective, aimed at informing governments and official stakeholders of when, where, and how to initiate humanitarian relief efforts. Such systems are complex, requiring linkages between many specializations and agencies, such as science, technology, government, news media, and the public, to name a few.[1] While EWSs have indeed become more people-centered in the development of the warnings themselves, less progress has been made in understanding how to best elicit early preparation, prevention, and mitigation actions from the exposed and vulnerable populations themselves.

> “EWS are only as good as the actions they catalyse; action is an essential part of any warning system. If a warning is sounded, and no one takes the action that the warning was intended to trigger, then the warning system failed.”[2]

In the interest of reducing the impacts of disasters on exposed and vulnerable populations, this paper builds on existing notions of people-centered early warning systems and incorporates social and behavior change theories and experience to propose a new, behaviorally informed EWS framework. Rather than the orthodox starting point for EWS design and development (hazard data and analysis) this new framework proposes to “flip the script” for EWS design and development,

[1] Sorensen (2000)
[2] IFRC (2012)

beginning by identifying the desired early actions of exposed and vulnerable populations and the behavioral determinants that influence decisions to take those actions.

We then propose that EW information that is relevant for prompting action is collected and that the EW messages are communicated through channels that are relevant and accessible for all vulnerable groups. These messages—tailored to behaviors and actions as opposed to the hazard only—address the previously identified behavioral determinants while calling for specific action. This framework is underpinned by continuous, evidence-based social and behavioral change interventions that enhance the likelihood that the EWS evokes early action and that the enabling environment is sufficient to support those actions. As the EWS is used repeatedly, lessons learned are incorporated into not only the technocratic aspects of the system but also into the social and behavioral change activities themselves. We conclude with recommendations to the practitioner and donor communities that support more behaviorally informed EWSs.

INTRODUCTION

The last four decades have seen major advances in our scientific and sociological understandings of disasters. Historical understandings of disasters and the factors that increased or decreased their impacts focused on the physical dynamics and forces associated with hazards themselves.[3] Consequently, many earlier disaster risk reduction (DRR) interventions centered on preventing the physical and natural phenomenon or mitigating its physical impacts. Early warning systems were viewed as one such measure.

Early warning refers to information that enables institutions and individuals to act against an impending hazard to minimize or prevent losses. Historically, early warning systems simply consisted of integrated hazard detection subsystems. The collection, analysis, and management of hazard data, and blanket, standardized communication of warning messages were typically synthesized by scientific, technocratic government and private sector stakeholders. Public and private responses to these messages were considered outside the remit of the EWSs themselves. Any efforts to normalize response behaviors were maintained through preparedness trainings and exercises. Naturally, with the focus on *hazard* monitoring, forecasting, and communication, initial EWS efforts prioritized technological approaches to detecting hazard indicators and precursors through collection of data from the physical environment, analysis of those data points, and communication of the outcome of that analysis and the resulting forecasts via available mass communication technology. While advancements in hazard detection, monitoring, and communication have certainly been useful, several authors note growing dissatisfaction with the purely technocratic, scientific approaches to EWSs for their ineffectiveness in mobilizing early action.[4]

Meanwhile, Wisner et al. in their pivotal work *At Risk: Natural Hazards, People's Vulnerability and Disasters* formulated disaster risk as a function of the hazard and the vulnerabilities of the affected population to that hazard.[5] The resulting focus on human, physical, financial, political, natural, and social vulnerabilities to disasters in research, policy, and practice has given rise to social constructivist approaches to understanding disaster risk. In Tierney's *The Social Roots of Risk: Producing Disasters, Promoting Resilience*, the sociologist Dennis Mileti argues that:

> *"all risks and losses—whether associated with so-called natural perils or technological ones—are the result of decisions that communities, societies, organizations, and political actors make, or fail to make."[6] Tierney goes on to state that "societal values and ingrained practices, ideologies and worldviews, various forms of social cognition (as opposed to individual psychology), belief systems, collective memories, other types of social constructions, and ideas that become influential through forms of collective behavior such as fads and crazes all play a role in the social production of risk."[7]*

[3] Tierney (2014)
[4] Basher (2006); Glantz (2004); Mileti (1999); Davis and Izadkhah (2008)
[5] Wisner et al. (2004)
[6] Tierney (2014)
[7] Tierney (2014)

As this social, and arguably more human, understanding of the formation of our risk and resilience to natural and man-made hazards developed, there has been a corresponding awakening of early warning system practitioners and policymakers to more "people-centered" approaches. This is demonstrated by an emerging body of literature and experience on how "people-centered" approaches to early warning systems can inform strategies for mitigation, resilience building, preparedness, response, and recovery.[8]

Responding to critiques that early warning systems were too technocratic in their approach, the *Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters* report introduced the concept of people-centered early warning systems, proposing to: "[Develop systems] whose warnings are timely and understandable to those at risk, which take into account the demographic, gender, cultural and livelihood characteristics of the target audiences, including guidance on how to act upon warnings, and that support effective operations by disaster managers and other decision makers."[9] Specifically, the Hyogo Framework for Action (HFA) calls for provision of information to "*encourage* [emphasis added] and enable people to take action to reduce risks and build resilience." It goes a step further, calling for the inclusion of "traditional and indigenous knowledge and culture heritage," tailoring the information to target audiences and "taking into account cultural and social factors."[10]

Later, as a part of the movement towards people-centered approaches, the United Nations International Strategy for Disaster Reduction (UNISDR), now known as the United Nations Office for Disaster Risk Reduction (UNDRR), and the German Federal Foreign Office instituted the Platform for the Promotion of Early Warning (PPEW), and it's 3rd International Conference on Early Warning in 2006 took a particular focus on people-centered early warning systems (PC-EWSs). The PPEW clarified the objective of PC-EWSs as the "empowerment of individuals and communities threatened by hazards to act in sufficient time and in an appropriate manner to reduce the possibility of personal injury, loss of life and damage to property and the environment."[11]

In order to accomplish this objective, the PPEW outlined four key aspects of a PC-EWS:

- **Risk Knowledge:** Establish a systematic, standardized process to collect, assess, and share data, maps, and trends on hazards and vulnerabilities.
- **Monitoring & Warning Service:** Establish an effective hazard monitoring and warning service with a sound scientific and technological basis.
- **Dissemination & Communication:** Develop communication and dissemination systems to ensure people and communities are warned in advance of impending natural hazard events and facilitate national and regional coordination and information exchange.
- **Response Capability:** Strengthen the ability of communities to respond to natural disasters through enhanced education of natural hazard risks, community participation, and disaster preparedness.

[8] Nyakeyo (2016); Schilderinck (2009)
[9] UNISDR (2005)
[10] UNISDR (2005)
[11] Wiltshire (2006)

The PPEW then goes on to outline four additional *"cross-cutting" issues*:

- **Effective Governance and Institutional Arrangements:** This is primarily focused on improving the sustainability and institutional support for EWSs.
- **A Multi-Hazard Approach:** All hazard-based systems are linked for economies of scale, sustainability, and efficiency and will likely be activated more often, theoretically enhancing functionality and reliability.
- **Involvement of Local Communities:** A "bottom-up" approach of active participation of those most likely to be exposed to the hazard will theoretically enable collection of more relevant hazard data, dissemination of more relevant and trustworthy warning messages, and more well-informed and multi-dimensional responses to those warnings.
- **Consideration of Gender Perspectives and Cultural Diversity:** Recognition that different groups hold different vulnerabilities to various hazards is critical to data collection, analysis, message formation and dissemination, and early action.[12]

Emphasizing the importance of cultural, social, linguistic, and educational considerations, as well as advocating for community participation and "bottom-up" approaches as part of EWSs, was a marked divergence from the traditional technocratic and institutional concerns of the first EWSs. Furthermore, the last three cross-cutting issues above began to illustrate the potential of a more social constructivist understanding of risk and resilience in PC-EWSs, namely the primacy of the perspectives and experiences of those most likely to be affected and the multitude of differentiations found within that society of affected population.

Despite the shift towards more people-centric EWS, the idea of *encouraging* people to act (found in the HFA) remains conspicuously absent in early warning literature in the years subsequent to the HFA. Early warning literature, policy, and best practices continue to focus on "allowing" or "enabling" those who are at risk of being affected to act by using hazard-sensing technology to collect data and present scientifically accurate warning messages (with the preponderance of work continuing to focus on the role of state-based actors in response).[13]

In 2015, the UN General Assembly endorsed the Sendai Framework for Disaster Risk Reduction (2015-2030) (SFDRR), the successor to the HFA. The SFDRR's seventh and final global target is to "substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to the people by 2030," referring specifically to people-centered elements including traditional knowledge in a participatory process to capture "the needs of users, including social and cultural requirements, in particular gender."[14]

It is important to note that the focus of PC-EWSs is on warning information and *how* that information is communicated and disseminated. Despite this limited focus, the UNDRR does recognize the critical component of preparedness for an effective EWS. They describe an EWS as "an integrated system of hazard monitoring, forecasting and prediction, disaster risk assessment,

[12] Wiltshire (2006)
[13] Basher (2006); Carabine and Jones (2015); Davis and Izadkhah (2008); Glantz (2009); Mileti (1999); Thomalla and Larsen (2010); Twigg (2003); UNEP (2012); Willoughby, et al. (2007); Singh and Zommers (2014); and others
[14] UNISDR (2015)

communication and *preparedness activities, systems, and processes* [emphasis added] that enable individuals, communities, governments, businesses and others *to take timely action* [emphasis added] to reduce disaster risks in advance of hazardous events."[15] This inclusion of preparedness activities is a notable change from initial technocratic EWSs.

Recently, UNDRR further simplified and consolidated PPEW's eight key aspects and crosscutting issues into the following four broad components:

1. "Disaster risk knowledge based on the systematic collection of data and disaster risk assessments;
2. Detection, monitoring, analysis and forecasting of the hazards and possible consequences;
3. Dissemination and communication, by an official source of authoritative, timely, accurate and actionable warnings and associated information on likelihood and impact, and;
4. Preparedness at all levels to respond to the warnings received."[16]

We can further consolidate UNDRR's four components, for purposes of discussion, by combining the two forms of information—(1) disaster risk knowledge and (2) detection, monitoring, analysis, and forecasting—under one heading: "EW Information." This results in the following three key elements of a people-centered early warning system (PC-EWS):

1. **EW Information**: The technical knowledge and understanding around specific disaster risks and the related accuracy of scientific forecasting of the related hazards
2. **EW Messaging**: The communication and dissemination of this information
3. **Preparedness**: Knowledge and capability to translate the information received in a message to practical and appropriate early action and recovery activities in response to those messages

Based on these three key elements, a conceptual framework for PC-EWSs emerges that explains how EWSs contribute to the goal of early action:

People-Centered Early Warning for Early Action (PC-EWEA) Framework

[15] UNDRR (2017)
[16] UNDRR (2017)

In addition to the inclusion of preparedness, PC-EWSs ideally consider the human, social, and cultural factors that influence risk and each of the elements in the system. As will be described further, the literature reviewed indicate that, in many cases, this shift from a technological focus to a people-centered approach has helped make EWSs more effective in prompting early action by end users.[17] However, despite the implementation of the above PC-EWS concepts, the desired impact of EWSs to enable and encourage early action by all stakeholders, particularly by those most vulnerable, continues to be a challenge in many contexts, including the drought EWS in northern Kenya.

In an effort to contribute to the improvement and further development of people-centered early warning systems and approaches, this paper reviews current literature on the role of social-cognitive perspectives, culture, perceptions of risk, and other aspects of individual and social worldviews that influence how we sense, think, and act in relation to early warning information, messages, and preparedness efforts. Based on an analysis of the literature review, this paper also proposes a shift in the existing PC-EWEA framework described above to consider behavior or the desired early action to be taken *as the starting point* that should influence all other elements of the PC-EWS.

This literature review is completed as Phase 1 of a broader research agenda that not only seeks to understand the current state of early warning system thinking, but also to perform formative research in Phase 2 and 3. To do that, this research team chose the pastoralist context of northern Kenya's arid and semi-arid lands (ASALs) as a case study prior to performing the literature review in order to provide some grounding and context for each of the key points found in the literature on EWSs. As such, the reader will encounter context-specific examples and excerpts taken from Kenya's ASALs as illustrations within each thematic section below. Phase 2 of the project will consist of formative research to begin identifying early action behaviors necessary for pastoralists to properly prepare for and mitigate the impacts of impending drought. The third and final phase of the research agenda will focus on developing and testing social and behavioral change (SBC) methodologies and tools for assessing, analyzing, and designing solutions to address the challenges of acting on early warning messages by pastoralists living in Kenya's ASAL region.

SCOPE & METHODS USED

In order to ensure as comprehensive a literature review as possible, the research team chose to access existing literature from peer-reviewed journals, grey literature issued by practitioner organizations, research institutes, UN agencies, and other donor agencies, as well as policy documents from government agencies and published books in print form. The search period was limited to mid-1970 to present for all sources, with a primary geographic focus on low-income countries. However, literature developed in relation to higher income countries was vetted for relevance to the research topic, particularly on subjects of early warning system best practices and social and behavioral change topics concerning risk communication, response, and decision-making. Within the body of literature available on early warning systems, sources addressing drought hazards specific to the East Africa context were prioritized.

[17] Ahsan et al. (2016); Bronfman et al. (2016); Paton et al. (2010); Cordasco et al. (2007); Haynes et al. (2008); Paton (2008); Fakhruddin et al. (2015); Arlikatti et al. (2018); Donovan et al. (2018)

For literature directly relating to pastoral livelihood systems, the scope of the literature review was primarily limited to Kenya, but also considered certain works pertaining to Ethiopia and Somalia since several pastoral tribes live and migrate across the vast, porous borderlands that share similar climatic characteristics. Many of the sources cited also directly engage insights from pastoral communities in this region.

These criteria yielded a wide range of knowledge and the research team reviewed a total of 295 peer-reviewed journal articles, 62 works of grey literature, and five published books in print form. Through analysis of the literature, the research team identified several key cultural, social, and cognitive aspects of PC-EWS, including:

- Participation of end users for increased ownership;
  Perceptions of reliability, credibility, and trust;
- Ability of government to manage communication of hazard information across multiple levels;
- Useful EW information collected and then disseminated;
- Culture, gender, ethnicity, and other differences in EW messaging;
- Participation in preparedness; and
- Influence of worldview, risk perception, and behavior.

The resulting paper has been organized to elaborate how each of these themes relates to and is integrated within the three key elements of the PC-EWEA Framework: 1) EW Information; 2) EW Messaging; and 3) Preparedness. Each of these three factors are discussed in the context of drought and pastoralism in northern Kenya. Based on analysis of the literature, gaps in existing PC-EWSs are then identified, leading to the presentation of an adapted conceptual framework for PC-EWS that emphasizes a focus on behavior (early action) and inclusion of factors that influence and change that behavior across all aspects of PC-EWS. The review shows that literature linking early warning information and pastoralists in Kenya is scarce. Given the limitations of available literature, the adapted PC-EWS conceptual framework needs to be understood as a hypothesis to be further tested empirically.

INTRODUCTION TO THE CASE STUDY: KENYA'S EARLY WARNING SYSTEMS

Kenya's first early warning efforts were developed as part of the Drought Preparedness Intervention and Recovery Programme (DPIRP), a Dutch-funded project spanning 1995-2000. This was later improved upon by the World Bank-funded Arid Lands Resource Management Project (ALRMP) in 1996. The role of ALRMP was to collect early warning data, analyze it, and issue reports for Marsabit County and, more generally, for northern Kenya. These two early projects (along with the Ministry of Livestock's own ASAL-based Livestock and Rural Livelihoods Support (ALLPRO) program) were formative and signaled an increased interest and role in drought management by the Government of Kenya. However, they were limited by grant-funded project life

cycles and incapable of streamlining and unifying the diverse stakeholders involved in responding to the drought.[18]

In response to the devastating 2010-2011 drought crisis in the Horn of Africa, the Government of Kenya (GoK) developed an important shift in policy called "Ending Drought Emergencies (EDE)." This policy builds on Kenya's "National Policy for the Sustainable Development of Northern Kenya and other Arid Lands" and was later approved by the Cabinet, adopted by national and county governments, embedded within the broader national development plan ("Kenya Vision 2030"), and IGAD's regional resilience strategy.[19, 20] It was endorsed as a common framework by international development agencies and donors. The Common Programme Framework (CPF) sets out the six pillars of Kenya's multi-sectoral approach to sustainably accomplishing the objectives of EDE in the ASALs based on the drought cycle management (DCM) model. Pillar 5 of the CPF (Drought Risk Management) lays out several critical issues related to institutional capacity and planning:

> *"The first is the need to ensure adequate capacity for sound people-centred planning at the county level, as well as the establishment of an accountability framework which ensures adherence to constitutional principles of public participation and rights-based development. […] Areas of support may include methodologies for ensuring strong citizen participation, particularly of conventionally excluded groups (such as the poor, women, young people, nomadic households and minority clans) […] The second is that formal planning systems need to be more flexible and attuned to local realities in drylands."*

The EDE's Common Programme Framework goes on to outline additional issues and objectives to address the country's growing vulnerability to drought, not least of which is a well-functioning EWS further discussed below. Most importantly, that Kenya's EDE so heavily features people-centered planning and EWS design, development, and administration illustrates the extent to which people-centered EWS approaches have permeated national disaster management policy. Kenya has even gone so far as to establish its National Drought Management Authority (NDMA), which is a "platform for long-term planning and action, as well as a mechanism for solid coordination across Government and with all other stakeholders" with offices in 23 ASAL counties and committed funding.[21] This is particularly noteworthy given Kenya's historical economic and political marginalization and neglect of those living in the ASALs.[22]

For the current EWS in Kenya, the main objective is "to protect livelihoods based on livestock in the event of a drought-triggered emergency."[23] The system is based on indicators like rainfall, water availability, pasture, and livestock market information. Information to inform these indicators is gathered primarily by non-governmental organizations (NGOs) and through periodic assessments done by the county government. A reading of the EWS currently in place in Marsabit suggests that it is geared towards emergencies in the form of a famine early warning system, rather than a

[18] Hazard et al. (2012); Nyariki et al. (2005)
[19] Hillier (2012)
[20] Catley (2017)
[21] NDMA (2019)
[22] Mosberg et al. (2017); Republic of Kenya (2012)
[23] Hazard et al. (2012)

drought early warning system, given that it seeks to measure the impacts of the hazard, such as losses of livestock. As such, "the system constructs risk as a normal component of pastoralists' livelihoods and assumes that societies are not resilient, or lack the capacity to respond to environmental hazards."[24] The current EWS, based on a logic of compensation following a climatic shock, is also at variance with traditional EWSs, which are based on the logic of risk prediction.[25]

In this regard, Kenya's EDE framework document cites "the need for genuinely integrated planning on both horizontal and vertical scales, which harmonizes the contributions of the national and county governments, the sectors, multiple agencies and drought-prone communities in a single framework."[26] The NDMA is a positive step forward in this regard, particularly at a time of major institutional change as the Government of Kenya undergoes the devolution of power and leadership to the county level. In light of devolution's propensity toward "fragmentation and inefficiency,"[27] the difficulties around coordinating data collection and analysis, communication of warnings across multiple agencies and ministries, and the scope and widespread geographical scale of drought, Kenya's National Drought Management Authority (NDMA) is an example of the kind of "platforms for knowledge sharing" that Thomalla and Larsen suggest are necessary for managing "sometimes conflicting priorities and agendas."[28] Mapped across multiple government ministries, the NDMA's geographically focused and multi-sectoral mandate helps provide the coherence and "inter-agency collaboration and synergy" necessary for effective EWS administration.[29] The EDE CPF goes on to state that "timely and effective response requires that the communication of early warning information and the actions it triggers be managed as a coherent whole […] including their capacity to manage knowledge for evidence-based decision-making and practice."[30]

Photo credit: Food for the Hungry

[24] Hazard et al. (2012)
[25] Hazard et al. (2012)
[26] Republic of Kenya (2015)
[27] Republic of Kenya (2015)
[28] Thomalla and Larsen (2010)
[29] Republic of Kenya (2015)
[30] Republic of Kenya (2015)

While EDE and the NDMA are great starts, it is not without its challenges. According to the International Center for Humanitarian Affairs (ICHA), the "uptake of climate information [from Kenya's Meteorological Department] for early warning in disaster risk management has been hampered by complex methods of presenting climate information, poor public awareness, gaps in understanding between science and policy and resource limitations."31 Furthermore, in Northern Horr, no single actor is responsible for collection of data, nor is it collected in a systematic way or standardized format. Even the collection of the data necessary to make forecasts and communicate warnings requires attention to ensure proper and timely functionality of the EWS.

To improve Kenya's official EWS, practitioners "must be careful not to focus excessively on improving forecast skill or dissemination […] Rather, greater attention needs to be given to what infrastructural and institutional advances are necessary to facilitate the use of climate forecast information within the livelihood strategies prevailing in these fragile systems."32 As we will see, there are several other challenges to the current EWS based on the social-cognitive dynamics of decision-making of pastoralists if they receive the drought warning information.

LITERATURE REVIEW

The following literature review is organized according to the PC-EWEA framework outlined above. Relevant social, cultural, and cognitive themes related to each of the key elements of the framework (i.e., EW information, EW messaging, and preparedness) are then further elaborated within each of those sections. Additionally, a case study is presented describing each element and related themes in the context of the northern Kenya ASALs.

EARLY WARNING INFORMATION: KNOWLEDGE OF DISASTER RISK AND HAZARD DETECTION AND FORECASTING

Traditionally, the chief function of an early warning system is to collect, analyze, and share data, maps, and trends on hazards and vulnerabilities in a comprehensive, systematic, and standardized way.[33] This includes an effective hazard-monitoring and warning service with a sound scientific and technological basis that allows for effective and efficient communication and dissemination of information. Taken as a highly technical process administered by experts, these functions of EWSs are typically viewed as the easiest, most technically straightforward, and are often the strongest aspects of the system. However, difficulty and complexity arise when considering the sociological and cultural issues that influence the practical usefulness of EW information. Endorsement and ownership, trust and perceptions of reliability, and the cultural and contextual relevance of EW information are issues that PC-EWSs attempt to address for improved EWS effectiveness.

Fostering Buy-in Through Participation

The literature is full of examples of benefits from the participation and inclusion of potentially affected populations, not only in the design of EWSs, but also in the data collection, analysis, and forecasting functions of the EWSs. One such example comes from the Philippines. Residents of the

[31] ICHA (2017)
[32] Luseno et al. (2003)
[33] Wiltshire (2006)

Bicol River basin were involved in measuring rainfall using rain gauges installed near their homes. Their main role was to monitor rainfall for the EWS and to send that data in a specific format to a central monitoring station. In 2009, this information was used along with other data to develop a flood model and to issue warnings of impending floods to the residents. The early warning was highly successful in its prediction of the time, location, and severity of flooding in relation to Typhoon Dante. Participation of end users in the administration of the EWS itself, through engagement in data collection, also improved responsiveness to the warnings. While this same rainfall data could have been gathered by automated monitoring stations, involvement of the communities led to their sense of ownership of the EWS and to their improved understanding of floods.[34] As we will see, involvement of end users in generating the data and warning information itself helps foster more trust in what the end users see as a more reliable EWS.

Approaches to Foster Trust and Perceptions of Reliability

The source of data and information is a critical aspect that influences end-user trust and perception of reliability of the EWS. The literature reveals several important aspects of the sources from which people obtain early warning information. The first concerns the generator of the information itself. Official generators of information include government agencies, multilateral agencies, and other regional monitoring services. Unofficial generators of information include traditional or indigenous knowledge experts, local leaders, friends, family members, and spiritual leaders. The role of these unofficial groups as generators of information is distinct from their concurrent and accompanying role of unofficial *propagators* or *circulators* of information.

It is widely established that vulnerable populations are more likely to use the information provided to them to prepare for the hazard (thereby limiting its impact) if high levels of trust exist between information generators and those most vulnerable.[35] To increase levels of trust in EW information, some have called for the integration of traditional, indigenous EWSs with official, more scientific EWSs while bypassing the inherent difficulties involved in integrating these drastically different epistemological approaches and assumptions.[36] Others have called for their integration, but continue to privilege the scientific, technical EWSs over traditional knowledge, in so far as only those traditional, indigenous forecasts that are confirmed by physical and meteorological sciences are considered valid.[37]

Increasing the Utility of Early Warning Information through Localization and Contextualization

Essential to the effectiveness of any EWS is the EW information collected and disseminated. However, not all EW information is useful to all stakeholders and, in the case of community and household level stakeholders, the predominant highly technical information collected may not be the actual information needed to inform and enable early action. Thus, while standardization of EWSs at global and national levels is increasing, effective PC-EWS incorporate local knowledge and expertise as well as the locally contextualized concerns of daily life to render them meaningful to

[34] Abon et al. (2012)
[35] Bronfman et al. (2016); Paton et al. (2010); Cordasco et al. (2007); Haynes et al. (2008); Paton (2008); Fakhruddin et al. (2015)
[36] Dekens (2007); Mercer et al. (2010)
[37] Hiwasaki et al. (2014)

hazard-affected people and useful for early action.[38] Apart from the need for more granular and locally specific forecasts, the ways in which information is presented must be distilled to the most basic and locally relevant and actionable points. Reflecting on the use of EWSs by South African farmers, Wilk et al. argue that "forecasts and EWSs are only useful if farmers can respond to the information and mitigate potential damages."[39] Specifically, Thomalla and Larsen call for more integration of early warning information with local priorities for community development, livelihoods, and natural resource management.[40] For example, Wisner et al. suggest that flood warning information should be an integral part of the water management systems of Honduras and Guatemala.[41] Naturally, this requires a culture of learning from all stakeholders involved in order to be successful.[42]

> "The biggest impediment to fulfilling the potential of forecasts is the transformation of acquired modern information into behavior modification. Information is valuable in so far as people are willing and able to act upon it. If people either cannot or will not change behavior in response to information they receive, then the information has no practical value."[43]

To use a non-weather example to illustrate the problem, how might forecasts of food commodity prices assist with the decision of when, where, and what foods to buy? Does it? Alternatively, how might the performance of the New York Stock Exchange (NYSE) impact mortgage interest rates and, by extension, one's decision of when or if to purchase a home? Historically, stock market performance is negatively correlated to mortgage interest rates. However, expert translation of these dynamics is necessary to inform wise home purchases. Lacking in both of these examples is locally relevant information and knowledge of how these broader dynamics translate to and impact local realities. Returning to the food commodity price example, supply chain logistics between producers and consumers, local demand irregularities, personal priorities, and one's own cash flow concerns may all impact the decision of when, where, and what foods to buy more significantly than the price at which a metric ton of wheat is trading on global or national markets.

Furthermore, the *translation* of highly technical scientific and professional language and information used by EW practitioners, often operating at global, regional, or at best, national levels, to practical and contextually relevant information is critical for facilitating local action of lay end users. The use of probabilistic forecasts by scientists and professional experts can present significant challenges in communication and interpretation for all users, from politicians to emergency managers to households and individuals.[44] Probabilistic statements, particularly regarding probability of precipitation (PoP) are not particularly intuitive. For example, a 50% chance of rain is often interpreted by the recipient as a 50/50 chance of experience rain *at the recipient's location*. However, according the United States' National Weather Service, PoP describes the chance of rain

[38] Garcia and Fearnley (2012)
[39] Wilk et al. (2017)
[40] Thomalla and Larsen (2010)
[41] Wisner et al. 2004
[42] Handmer (2001)
[43] Barrett et al. (2004)
[44] Broad (2000); Roncoli (2006); Willoughby et al. (2007)

occurring *at any point* within a selected area. Furthermore, PoP is a function of (C) the chance of rain occurring anywhere within the forecast area and (A) the percentage of that area that will receive measurable rain (PoP=CxA). Therefore, a 50% chance of rain could simply mean that the forecaster is 100% certain that rain will fall over 50% of the forecast area. Thus, Roncoli argues that probabilistic forecasting "amplifies the risk that the information may be distorted by communicators and intermediaries (Broad 2000, Podesta et al. 2002)" and that all stakeholders, including the media, have a role "in translating probabilistic forecasts into deterministic statements and sensationalistic warnings (Nicholls & Kestin 1998, Pfaff et al. 1999, Broad & Agrawala 2000, Glantz 2002, Lemos et al. 2002)."[45] Furthermore, if the translation of scientific and professional information is critical, then there is added pressure for precision of the original sources of that information. Roncoli explains:

> *"Several researchers have stressed the need for precision about what is being predicted (for example, explicitly referring to 'rainfall' rather than to 'season' or 'yields') and for clarity about the timescale and uncertainty of the forecast (Fischhoff 1994, Hammer et al. 2001, Letson et al. 2001, Hansen 2002, Patt & Gwata 2002, Podesta et al. 2002, Ziervogel 2004). Vague terms such as 'likely' or 'normal' may be interpreted differently than intended (Nicholls & Kestin 1998, O'Brien et al. 2000, Phillips et al. 2002, Tribbia 2002, Patt & Schrag 2003, Hansen et al. 2004)."*[46]

While forecasts *have* progressed in scientific accuracy and precision, emergency managers still "scratch their heads about how to use these forecasts in practice because the predictive context of science is different than their decision context."[47]

Despite recognition that highly technical hazard and forecast information may not be useful in its original form, translating broad technical forecasts in such a way that this information is useful for end-user action continues to be a challenge that needs to be addressed for early warning systems to be effective. Emergency managers well trained in forecast interpretation and who are also well networked with end users are invaluable in preparation for impending hazards.[48] Other PC-EWS approaches such as the Participatory Scenario Planning (PSP) also aim to overcome the challenges of contextualization and making highly technical EW information more useful to end users. PSP is "an approach to collaborative design and delivery of user focused climate information services through working with: national meteorological services; all value-chain stakeholders in agriculture; government ministries/departments in other climate-sensitive sectors (such as water, environment, energy, health, development, disaster risk management); and communities, organisations and institutions."[49]

[45] Roncoli (2006)
[46] Roncoli (2006)
[47] Roberts and Wernstedt (2016)
[48] Roberts and Wernstedt (2016)
[49] CARE International (2017)

KENYA

"Reliance upon the herd for sustenance, dearth of agricultural alternatives, and a notoriously poor infrastructure render pastoralists' livelihoods and behavior particularly vulnerable to climate fluctuations (Sandford 1983, Ellis and Swift 1988). […] Through the timely provision of information on upcoming rains, accurate climate forecasts have the potential to inform pastoralists' stock movement and marketing decisions based upon favorable locations for pasture and water household risks. […] Highly advanced early warning systems are being developed predicated upon the assumption that climate forecasts will assist pastoralists in risk mitigation."[50]

The rangelands of northern Kenya are remote and—due to a history of neglect—somewhat isolated in terms of transportation and communication infrastructure. Though this is slowly improving through mobile communication technology, the primary means of forecasts and early warning messaging is through traditional, indigenous methods. In the context of pastoralists in Kenya, communities have relied upon indigenous knowledge systems for drought forecast and action for centuries.[51] Masinde sums a vast body of work on traditional or indigenous knowledge (IK) by saying, "IK is based on cumulative experience and observation of the environment and normally developed through oral communication and repetitive engagement rather than through formal instruction."[52] Masinde, in her review of IK in relation to drought protection, describes indigenous knowledge as:

"A body of knowledge existing within or acquired by local people over a period of time through accumulation of experiences, society-nature relationships, community practices and institutions, and by passing it down through generations (Brokensha, Warren. et al., 1982; Fernando, Jayawardena, et al., 1998; Sillitoe, 1998; Orlove, Roncoli, et al., 2009). In Steiner (2008) indigenous/traditional knowledge (IK) is described as the knowledge of an indigenous community accumulated over generations of living in a particular environment. It is traditional cultural knowledge that includes intellectual, technological, ecological, and medical knowledge. In IK forecasting, the local weather and climate are assessed, interpreted and predicted by locally observed variables and experiences using combinations of plant, animals, insects and meteorological and astronomical indications (Boef, Kojo et al. 1993)."[53]

Masinde's work on incorporating indigenous knowledge (IK) into drought early warning systems (DEWSs) highlights the importance of pastoralists' contribution of IK in helping them "feel valued and confident to participate in DRR activities."[54] However, Kenya-specific examples in the literature of the participation of pastoralists in drought risk management planning or in the DEWS are sparse, with one exception. In some areas in Kenya, the Participatory Scenario Planning (PSP) process has

[50] Barrett et al. (2004)
[51] Luseno et al. (2003)
[52] Masinde (2012)
[53] Masinde (2012)
[54] Masinde (2012)

been used to help farmers and pastoralists contextualize early warning weather forecasting information to improve its usefulness.[55] Masinde goes on to say, "DEWS that incorporate IK automatically gains acceptability and sense of ownership among the people and the fact that such systems are built on what is known to have worked locally, makes them resilient."[56] According to research performed in Northern Kenya and Southern Ethiopia, more than 90% of respondents received information and messages via traditional forecasting methods, most of whom received these forecasts from multiple sources.[57] They further argue that this highlights the importance of and confidence in these traditional methods, stating that "the average overall confidence in traditional forecasts was 77%, far surpassing confidence in modern forecasts, which registered a mere 23%. Though there existed much site variation, in 10 of the 11 survey locations, confidence in traditional forecasts exceeded that for modern forecasts."[58] Ex post, 98% of their respondents felt that the predictions were accurate in the long rains start date and the amount of rainfall predicted.

The most critical pieces of forecast information for pastoralists are the anticipated start and end dates of both the short and long rain seasons. This particular traditional forecasting method is based on observations of historical weather trends, including fluctuations in temperature, humidity, clouds, moon cycles, livestock and wildlife behavior, and vegetation, making them particularly susceptible to unreliability due to the unpredictability introduced by climate change.[59] While these techniques are more readily accepted and understood by relief and development practitioners, pastoralists also supplement and "triangulate" this information with methods "based on beliefs and on cultural and ritual spiritualists who predict rainfall from divination, visions, and dreams" as well as reading the condition of intestines of slaughtered animals and the arrangements of shoes as they are repeatedly tossed and fall to the ground.[60]

Photo credit: Food for the Hungry

For the pastoralist, all of this traditional knowledge and indigenous information gathering is to inform two key decisions: 1) Whether or not to move the herd; and 2) If the decision is "yes," where to move the herd for the most optimal pasture and water. Most argue that, given the context, pastoralism is the most flexible and resilient livelihood available in the ASALs. The very resilience of pastoralists and pastoralism as a livelihood in this context is rooted in the ability to accurately foresee and respond to changing climatic and natural resource conditions. Naturally, these iterative decisions that take place over the course of the dry season must happen in a timely, predictive manner.

[55] Owoko and Wepukhulu (2016)
[56] Masinde (2012)
[57] Barrett et al. (2004)
[58] Barrett et al. (2004)
[59] Mutua (2011)
[60] Masinde (2012)

However, when the discussion turns to Kenya's "official" EWS, it is interesting to see that it assumes the opposite—that pastoralists are *not* resilient and that they will *not* be able to cope with drought seasons.[61] Therefore, it focuses its full attention on collecting environmental and market data for the sole purpose of timing the release of resources to replace what pastoralists lose as a result of the droughts' impacts.[62] While it is certainly true that climate change is making it increasingly difficult for pastoralists to cope with increasingly severe and frequent drought, the current EWS being "based on an actuarial logic which does not sufficiently measure the effects of adverse factors on societies" does little to support existing coping strategies.[63] Furthermore, the aid programs that rely on the WS may actually negatively influence existing coping capacities by encouraging more risky behavior.[64]

Though Kenyans placed more confidence in official, computer-based forecasts than Ethiopians, they still put considerably less confidence in these official sources.[65] In large part, this is due to the fact that these official forecasts are disseminated primarily through radio, which reaches a very small majority of: 1) Those living in higher population areas with available markets; and 2) Those who are wealthy enough to own a radio and educated enough to understand the technicalities of these forecasts.[66] This reduces the frequency with which people receive information from these sources in general, further reducing the trust in and credibility attributed to these official sources. There is not enough recent research to tell whether this scenario has changed.

MESSAGING: COMMUNICATING AND DISSEMINATING DISASTER RISK AND HAZARD KNOWLEDGE

While EW information is certainly a critical element of the EWS, *how* that information is communicated to end users is equally critical to an effective system. The communication of warnings is a complex process as people obtain multiple messages from multiple sources, both official and informal. Other aspects that influence the effectiveness of EW messaging include socio-cultural dynamics of end users (i.e., culture, ethnicity, socio-economic class, gender, age, and disability), addressing issues of trust and perceptions of reliability and certainty, and the ability of national governments to manage EW communication effectively across multiple levels.

Dissemination of early warning information in culturally sensitive ways so that it is accessible by all social groups (gender, socio-economic class, ethnicity, disability and age) to enable them to act.

Disseminating EW messages in culturally sensitive ways is something quite apart from and additional to the inclusion, involvement, or participation of all stakeholders, including those potentially affected by the hazard. The terms "inclusion," "involvement," and "participation" all refer to varying levels of engagement with stakeholders, but are often relegated to data collection and, occasionally, data

[61] Hazard et al. (2012)
[62] Hazard et al. (2012)
[63] Hazard et al. (2012)
[64] Hazard et al. (2012)
[65] Barrett et al. (2004)
[66] Luseno et al. (2003)

analysis functions for EWSs. Although culture, ethnicity, and gender appear to be critical to the effectiveness of EWSs,[67] warnings often do not account for vulnerabilities and capacities of different social groups to effectively access early warning messages or prepare, prevent, or respond to the hazards. Women and men often have different access to information regarding early warnings due to the roles they play in a given society. Older people, people with disabilities, and members of other vulnerable groups may face barriers in accessing early warning information, limiting their capacity for early action.[68] Successful warning messages (where warning is received, understood, and responded to properly) are those that target specific sub-populations, typically based on age, gender, education levels, and ethnicities or cultural differences.[69] Sub-groups of populations not only experience shocks and stresses differently, but they often access information from different sources.

The recent field study funded as part of this research paper confirmed that membership in all of these sub-groups, particularly gender and wealth ranking, directly influence access to information. Hence, EWSs must also engage diverse end-user information sources and communication mechanisms to be successful.[70] EW communication methods should be developed in consultation with and accessible to all sub-groups within at-risk communities.[71] This can be done by combining technological and traditional methods of communicating warnings, ideally engaging communication mechanisms that are directly controlled by the at-risk community. This approach of PC-EWS is also referred to as "community-centered EWSs" (CBEWS).[72] In fact, Mercy Corps and Practical Action claim that "normally, the term 'People-centered' and 'Community-based' are used as synonymous words."[73] Based on work by Jonathan Lassa, they outline several aspects of CBEWSs that highlight the need for cultural sensitivity, such as ensuring that the message reaches the most vulnerable people, considering the level of understanding of the message by the people and ensuring that the EW message addresses the needs of all community members.[74]

Enabling all social groups to easily act requires examination of *differentiators* of culture so that the message can be crafted and disseminated in culturally sensitive ways. Language is one of the most significant differentiators of cultures and ethnicities and thus often accounts for the failure of some EWSs to reach the most vulnerable. For example, EWSs in the United States function almost exclusively in English, leading to demonstrably higher losses among certain vulnerable groups, particularly Latino and Haitian immigrants for whom English is a second language.[75] Further, many immigrants use non-English speaking radio and TV stations broadcasting exclusively in Spanish and Creole. Accessing information, however, goes beyond wholesale language differences. Arlikatti et al.

[67] UNISDR (2005); UNISDR (2015)
[68] Wiltshire (2006)
[69] Drobot and Parker (2007)
[70] Hayden et al. (2007)
[71] Collins and Kapucu (2008)
[72] Baudoin et al. (2016)
[73] Mercy Corps and Practical Action (2010)
[74] Mercy Corps and Practical Action (2010)
[75] Peacock et al. (1997); Perry and Lindell (2006); Morrow (2009); Benavides and Arlikatti (2010); Benavides (2013)

point out the pitfalls of translating technical jargon, not only into other languages, but also between local idiolects and regional dialects within the same language.[76]

Significant demographic differences were observed in the use of tornado early warning systems in a study focused on Ford County, Kansas in the United States. Stokoe found that Hispanics and younger demographics relied on tornado sirens for early action more than white men and older demographics.[77] Meanwhile, older people relied more on television information while younger groups relied on smartphone apps for early warnings.[78] This confirms the logic of using diverse forms of communication for early warnings to reach as many groups in vulnerable communities as possible, particularly people with physical disabilities (including those who are blind and/or deaf).[79] In an age of rapid technological advancements, it is important to point out that older people may have difficulties accessing newer technology platforms, such as web-based, computers, apps and, hence, warning information.[80]

In relation to floods in Bangladesh, it was found that most people preferred local announcements as the media for early warning dissemination. The sources of these messages were preferably locals, such as schoolteachers, religious leaders (Imam), or the Union Parishad (lowest administrative unit) members informing people in places such as schools, colleges, mosques, or markets.[81] King argues that the "warnings must remain clear and standardised, but the routes to understanding them must be as diverse as the people."[82] In addition to ensuring accessibility of EW messages, the source of the message also directly affects the trust that people place in the warning, how reliable they feel the warning is, and the resulting credibility of the EWS as a whole.

Trust and Perceptions of Reliability and Credibility of Warning Messages

Official warning sources play an important role in perceptions of impacts and response to the hazard.[83] Additionally, people rely on multiple circulators of warning information to triangulate, clarify, and bolster their trust in official generators and circulators of warning information.[84] Unofficial circulators of information include friends and relatives, acquaintances, social networks, and media such as TV, radio, social media, and the internet. Interestingly, in a study of evacuation behaviors in Indonesia, warning information circulated by and received from friends and relatives directly influenced evacuation decisions while information received from official generators had little to no effect, even when coupled with training.[85] New media such as Twitter and even bespoke apps are being used to communicate warnings and modern EWSs must learn to harness this evolving technology.[86] Additionally, social networks are critical resources for ascertaining the personal relevance of a message, especially for women, and for some racially and ethnically marginalized

[76] Arlikatti et al. (2018)
[77] Stokoe (2016)
[78] Stokoe (2016)
[79] Arlikatti et al. (2014); Howard et al. (2017)
[80] Howard et al. (2017); Spence et al. (2007); Akerkar and Bhardwaj (2018)
[81] Fakhruddin et al. (2015)
[82] King (2004)
[83] Huang et al. (2012)
[84] Mileti and Sorensen (1990); Brown et al. (2016)
[85] McCaughey et al. (2017)
[86] Vultee and Vultee (2011)

groups.[87] However, the use of multiple sources of information can lead to confusion over conflicting, distorted, or incomplete information, resulting in distrust or skepticism of one or more sources.[88] The development and administration of EWSs should take this complex context into account.[89]

In her summary of the Social Amplification of Risk Framework (SARF),[90] Tierney explains that "risks (which were assumed to be real and objectively measurable), as well as risk-triggered events, were characterized as generating 'signals' that could be strengthened or weakened as they circulated through information sources and channels and through individual and social 'stations,' leading to subsequent individual, social, and institutional behaviors and policy responses. [...] Owing to processes of social amplification and attenuation, public views on threats and potential disasters could thus differ markedly from their actual likelihood and effects."[91]

Furthermore, research indicates that there is sometimes disparity between how officials perceive the effectiveness of their alerts and how the public actually perceive them.[92] Given how problematic the alterations that occur throughout the transmission of information from source to source can be, early warning information that is generated as close to the end users as possible becomes priority. Unfortunately, most available research refers to formal warning systems and ignores the plethora of informal systems and networks that appear to be more important and influential in many places.[93] Traditional or indigenous knowledge (IK), also referred to as local or folk knowledge,[94] becomes a valuable and often more actionable source of information.[95] EWSs based on indigenous knowledge are widely used by communities in various contexts. For example, in Zimbabwe, a majority of people relied on IK about impending drought because of its suitability and perceived precision by the community as compared to that of radio and television. Early warning information from extension workers was the second most widely used, while radio and television were primarily used by the younger generation.[96] Furthermore, "Phillips, Deane et al. (2002) reported that in both 1997/98 and 1998/99, Zimbabwean farmers' seasonal climate forecasts, elicited in advance of the release of official climate forecasts, corresponded almost exactly with the official meteorological service forecasts."[97] Chisadza et al. provide additional supporting evidence from the Limpopo River Basin in southern Africa that traditional forecasts performed better than meteorological forecasts of drought at the local level during the 2012/2013 season.[98] Generally speaking, IK falls into three main categories: 1) Folk knowledge that is passed down from generation to generation that informs attitudes and behaviors; 2) Methods of interpretation of animal and plant behavior and the information generated from those interpretations; and 3) Information generated

[87] Phillips and Morrow (2007)
[88] Brown et al. (2016); Huang et al. (2016)
[89] Morss et al. (2018); Gladwin et al. (2007); Sadri et al. (2017)
[90] Kasperson et al. (1988)
[91] Tierney (2014)
[92] Stokoe (2016)
[93] Parker and Handmer (1998)
[94] Sillitoe (1998)
[95] Shaw et al. (2009); Steiner (2008); Orlove et al. (2009); Mutua (2011)
[96] Belle et al. (2017)
[97] Masinde (2012)
[98] Chisadza et al. (2014)

by "cultural and ritual spiritualists who predict rainfall from divination, visions, and dreams."[99] Typically more qualitative and geographically precise,[100] IK not only serves to provide early warning information but to also inform coping strategies for those impacted by various natural events. However, the efficacy of indigenous knowledge on weather and climate phenomena is slowly being eroded by two forces: climate change and a growing generation of "younger, urbanised, educated" youth.[101] For now, however, IK certainly appeals to those who are illiterate and who demand localized information on current and near-term weather and environmental conditions.[102] Therefore, there is general agreement that:

> *"Integrating indigenous knowledge into modern science can improve livelihoods (Brokensha, Warren. et al., 1982; Thrupp, 1989; Flora, 1992, Richards, 1993; Virji, Cory et al., 1997; Sillitoe, 1998). Some of the reasons that motivate promotion of IK are: (1) IK is already processed by the community; (2) by recognising and sharing the IK, the community feels valued and therefore confident to participate in risk reduction initiatives. This by extension ensures that they can immediately respond to potential risk and consequently leads to strengthened resilience and self-confidence (Mutua, 2011)."*[103]

This suggests that a demand-driven approach, as opposed to the predominant supply-driven approach of most EWSs, may be more effective.[104]

Warnings are most effective when a credible source provides the threat message with sufficient specificity for recipients to develop a high degree of certainty that they and their loved ones are personally at risk from an immediate and significant threat.[105] This is particularly true for minority or marginalized groups who tend to be socially isolated and lack social capital in the form of reciprocal trust.[106] Mercy Corps and Practical Action advocate that EWS messages must be considered legitimate by end users and must be trusted and accepted for acting upon.[107] They also indicate that inclusion of local/traditional knowledge (discussed in the previous section) within the formal system can influence the sense of legitimacy that the end users have of the EW messages received.[108]

Credibility of the generator of the EW information (discussed above) along with credibility of the circulator of the EW message can influence the credibility of the message itself. The credibility of the message is also influenced by past experiences of false warnings or the timeliness of messages. Warnings received closer to the expected time of impact tend to be more reliable and, therefore,

[99] Masinde (2012); supported elsewhere by Boef et al. (1993); Chisadza et al. (2013); Johnston (2015); Luseno et al. (2003)
[100] Roncoli (2006)
[101] Masinde (2012)
[102] Luseno et al. (2003)
[103] Masinde (2012)
[104] Luseno et al. (2003); Masinde (2012); Roncoli (2006)
[105] Lindell et al. (2007); Handmer (2001); Ahsan et al. (2016)
[106] Lindell and Perry (2004); Mayunga (2007); Folke (2006); Cutter et al. (2008); Norris et al. (2007); Putnam (2000); McCaughey et al. (2017)
[107] Mercy Corps and Practical Action (2010)
[108] Mercy Corps and Practical Action (2010)

build credibility of the source of the warning over time.[109] For example, residents in the coastal areas of Bangladesh rarely follow evacuation orders due to mistrust of the warning messages rooted in the unreliability of the forecasts themselves.[110] Other research on specific disaster events (the Pakistan floods in 2010 and the United Kingdom floods in 2007) suggests that face-to-face warnings are more effective than warnings through media because of the reciprocal trust and credibility inherent in personal relationships with those with whom we have face-to-face contact.[111] For example, in Bangladesh, people tended not to believe forecasts broadcasted via television as they were delivered by the Bangladesh Meteorological Department with whom they had no personal relationship and, therefore, did not trust.[112] However, there is some evidence that warnings from *local* media, such as local radio stations, are considered trustworthy and credible because the voices and programs are simply more familiar to the listeners. These radio stations, since they tend to cover local issues in detail on a regular basis, are considered more knowledgeable and aware of local issues and peculiarities.[113] Although end users may view messages generated by those with whom they have personal relationships as more trustworthy, reliable, and credible, the role of governments in collecting and analyzing information remains a vital capability and responsibility.

Ability of Government to Manage Communication of Hazard Information across Multiple Levels

Any thorough discussion of the social aspects of risk reduction and resilience outcomes include some treatment of the effectiveness of the representative government in relevant sectors and the demographics of the society which it aims to represent. In the case of EWSs, we specifically examine the structural and political aspects of information flow across government departments and ministries from data collection (presuming it is already happening in a robust, people-centered way) to the communication of warnings. It is common to encounter several different government departments with vested interest in EWS administration. As one can imagine, the transition from the making of the forecast (usually by technical experts) to its communication as an early warning (often made by less technically trained people such as provincial and extension workers) to the communities, is not without challenges. The chain of communication can be long and bureaucratic, and there are often gaps in the understanding of the technical information by the officers on the ground disseminating the messages.[114] Improving the timeliness and quality of warnings involves work on the entire information/data chain and the relationships between each set of actors in the chain—from the forecasters to emergency responders to the public responding to the hazard.[115] Critical warning information should be shared as inclusively as possible with all agencies whose remits would be potentially affected by the hazard.[116]

[109] Paul et al. (2010); Mileti (1999); Priest et al. (2011); Islam et al. (2011)
[110] Roy et al. (2015)
[111] Turner et al. (2014); Pitt (2008)
[112] Fakhruddin et al. (2015)
[113] Cohen et al. (2007)
[114] Wilk et al. (2017)
[115] Drobot and Parker (2007)
[116] Oloruntoba (2005); Mat Said et al. (2011)

Each transmission of information along this chain introduces uncertainty into the EW process.[117] Such uncertainty can be reduced by involving all stakeholders at all points along that chain, from design to dissemination.[118] This inclusion helps improve credibility and reliability of the message itself, as well as responses to the message by those potentially impacted by the hazard.[119] EWSs adopted and shared by a range of stakeholders are most likely to be successful when there is a shared understanding of the hazard and opportunities for collective planning to address its risks.[120] Additionally, platforms for knowledge sharing between different stakeholders and communities can help navigate the various, and sometimes conflicting, priorities and agendas.[121] Information flow via feedback mechanisms from end users back up the chain of communication to forecasters, as well as constant dialogue between all government agencies, may lead to better data collection, analysis, forecast development, communication/dissemination, and potentially even action of end users.[122]

Since pastoralists in northern Kenya "worry primarily about variables heavily influenced by climate patterns, such as forage and water availability, livestock prices, and animal and human disease (Smith et al. 2001)," any weather-related forecasts would seem valuable.[123] However, when one considers that the ASALs cover 89% of Kenya's land mass[124] (or approximately 506,535km2), the prevailing micro variability in climate, and that the "spatial resolution of the forecasts remains fairly course," the meaningfulness of broad-scale weather and climate forecasts to a single pastoralist trying to decide when and where to move his animals becomes difficult to ascertain.[125] Furthermore, Luseno et al. state that "forecast skill with respect to seasonal climate patterns is generally weak but the ability to forecast impacts on variables of direct interest to decision makers is weaker still (Barrett 1998)."[126] The remainder of this section is devoted to understanding pastoralists' abilities to make use of EW information, regardless of its accuracy or precision, for three reasons: 1) Accuracy and precision of weather and climate forecasting has rapidly improved over the past two decades; and is expected to do so with 2) Technological advancements and improvements in understanding of meteorological science; and 3) Luseno et al. found that "pastoralists offer their own probabilistic forecasts, underscoring the fact that they acknowledge and accept forecasts of less-than-perfect skill."[127] Generally, the usefulness of EW information for pastoralists is determined by two factors: content and timing.[128]

[117] Garcia and Fearnley (2012)
[118] Glantz (2004)
[119] Twigg (2003); Davis and Izadkhah (2008)
[120] Edgeley and Paveglio (2016)
[121] Thomalla and Larsen (2010)
[122] Golden and Adams (2000); Kgakatsi and Rautenbach (2014); Kox et al. (2018); Lindell and Prater (2010)
[123] Luseno et al. (2003)
[124] Republic of Kenya (2012)
[125] Luseno et al. (2003)
[126] Luseno et al. (2003)
[127] Luseno et al. (2003)
[128] Abraham et al. (2017); Nyakeyo (2016)

Content

One aspect of content is, of course, the language in which the information is conveyed. To explore the issue of probabilistic forecasting and language, Luseno et al. gave each study respondent twelve stones and asked them to indicate their expectations of "above normal," "normal," and/or "below normal" rainfall for the upcoming long rain season.[129] Respondents, most of whom had never attended any school and were illiterate, then placed their stones in a trinomial distribution of probability, demonstrating clearly that pastoralists readily and regularly think and operate in probabilistic terms, even if they weren't using technical, probabilistic language. This was then confirmed in further follow-up discussions with respondents.

Two prominent studies have demonstrated that the *onset date of the long rains* was the *most useful* type of forecast to pastoralists.[130] At the time of these studies, this type of forecast was unavailable from meteorological agencies anywhere in the Horn of Africa, underscoring pastoralists' reliance on traditional forecasting methods. Interestingly, the forecast variable deemed least useful by pastoralists was the volume of rainfall expected outside the vicinity of respondents, an area to which they might migrate in search of pasture and water when/if their vicinity proved insufficient because of their strong preference for sending scouts for direct observation of the quality of pasture and water. Furthermore, research has indicated that livestock producers in developing countries "understood forecasts for a rainy season that is drier than usual to mean that the season would be shorter than usual rather than one that produced less rainfall (Roncoli et al. 2004, 2005)" and that they "think about rainfall as a process rather than as a quantity. Yet, climate forecasts continue to be formulated in terms of quantity rather than temporal parameters, as currently available tools and models cannot reliably predict duration and distribution of rainfall."[131] Finally, no official feedback mechanisms exist to-date for determining if or how stakeholders utilize information shared through the EWS, making it essentially impossible to assess the usefulness of the disseminated EWS content.

Timing

Typically, pastoralists in the ASALs move not based on forecasts but by sending scouts out in advance to establish where water and pasture may be found and to negotiate access to it, if necessary. Furthermore, the Gabra in northern Kenya have a cyclical conceptualization of time, one based reasonably repetitive returns of rainy and dry seasons:

> *"The cyclical nature of weather patterns was the basis of Gabra rangeland management strategies to cope with drought situations. This conception of the calendar provided the basis for prediction of events by considering the possibility of repetition of a past event in the present or the future."*[132]

[129] Luseno et al. (2003)
[130] Luseno et al. (2003); Barrett et al. (2004)
[131] Roncoli (2006)
[132] Hazard et al. (2012)

Climate change, naturally, makes this traditional method increasingly less accurate and, by extension, less useful. Additionally, "there are difficulties in linking the timing of individual warning events, places where the risky event might occur, and the uncertainty of potential victims of risks such as livestock raiding. Such challenges limit the usefulness of traditional early warning indicators among pastoral communities."[133] In response to this growing unreliability of traditional EW methods, the work of Luseno et al. and the authors' own experience indicate that pastoralists typically seek out early warning type information a full one to two months in advance of the expected long rains (late January or early February) rather than late February when the official forecast is issued.[134] They argue that "the information most likely of value to people who generally migrate in response to emerging opportunities and pressures would be real time, spatially explicit weather and forage condition reporting (e.g., through finer resolution maps of recent rainfall and current range conditions), not long-lead forecasts."[135] Such detailed information is not available to the pastoralists through official forecasts, and communication of broad-scale climate forecasts is often at variance with the micro-local needs of pastoralists.

> *"[…] the spatial resolution of the forecasts remains fairly coarse, while extensive grazing systems depend heavily on spatial information necessary to manage herd migrations" and "the ability to forecast impact variables of direct interest to decision makers [pastoralists] is significantly weaker"*[136]

Barrett et al., as part of a broader research project studying pastoralist livestock marketing behaviors in northern Kenya and Ethiopia and the constraints limiting off-take rates, fielded household surveys to better understand the utilization of climate forecast information.[137] The study randomly sampled 330 households from 11 sites across northern Kenya and Ethiopia covering roughly 124,000km^2, strategically chosen to capture variations including ethnic diversity between seven major tribes, livestock mobility, market access, and others. The study took place in 2001 immediately following the severe drought event of 1999-2000. The results are enlightening. Only 20% of surveyed households even received seasonal forecasts from the Drought Monitoring Centre (DMC), most of which were accessed via radio.[138] This was primarily attributed to material constraints, with only 23% of Kenyan households in the survey owning a functioning radio. "In seven of the ten sites, a majority of those sampled either did not have access to a radio or were not aware that forecasts were available on the radio."[139] The recent field study funded as part of this research paper confirmed that this largely remains the case even today. Furthermore, "forecasts based on meteorological science appear to be reaching a relative elite that has sedentarized and enjoys good market access and non-pastoral income within the drylands of northern Kenya and southern Ethiopia."[140] Therefore, the most vulnerable pastoralists who would benefit the most from

[133] Hazard et al. (2012)
[134] Luseno et al. (2003)
[135] Luseno et al. (2003)
[136] Luseno et al. (2003)
[137] Barrett et al. (2004)
[138] Barrett et al. (2004)
[139] Barrett et al. (2004)
[140] Barrett et al. (2004)

drought early warning information (i.e., those with relatively small herd sizes and less social access to information on available pasture and the status of water points[141]) are the very ones unable to access the messages being disseminated.

On the other hand, over 90% of respondents accessed traditional forecasts, more readily available from multiple sources through typical social channels and from personal observation of traditional methods "ranging from animal and wildlife behavior observation to intestine interpretation."[142] Luseno et al. point out that pastoralists' confidence in traditional, indigenous forecasting methods was primarily due to "their familiarity and accessibility, both in terms of having the forecasters personally present forecasts in the community and in terms of the language used."[143] Barrett et al. ominously point out that:

> *"Despite the stated confidence in traditional forecasts, surprisingly few respondents altered their behavior after receiving forecasts. Only about one quarter of our respondents changed their behavior on the basis of the forecast start dates for the 2001 long rains, while fewer than ten percent of those who received external forecasts of rainfall volumes in their own locations adjusted behavior in response."*[144]

PREPAREDNESS: HAVING THE KNOWLEDGE AND CAPACITY TO RESPOND EFFECTIVELY TO EARLY WARNING MESSAGES TO MITIGATE NEGATIVE IMPACT AND RECOVER

A key point upon which many scholars and practitioners of disaster reduction agree is that "strategies must extend beyond information provision to engage community members in ways that facilitate their adoption of protective actions (Paton, 2006)."[145] Preparedness, the third element of the PC-EWEA framework, aims to help transform EW information and messages into action.

Preparedness encompasses what actors at every level—government, organizations, communities, and households—do to transform the information communicated in EW messages into practical actions to mitigate the negative impact of or recover from an impending or current hazard event. The UNDRR defines preparedness as the necessary knowledge and capacity to take this action. While many actors are involved or responsible for preparedness actions, if the most affected by the hazard are to take action, then preparedness must engage those specific end users. PC-EWSs recognize that participation in preparedness actions to ensure communities and households have the necessary knowledge and capacity to act is an essential aspect of the preparedness element.

Participation in Preparedness Actions

Mercy Corps and Practical Action emphasize the importance of community participation EWSs to ensure that the specific needs of vulnerable communities be addressed:

[141] Catley. (2017)
[142] Barrett et al. (2004)
[143] Luseno et al. (2003)
[144] Barrett et al. (2004)
[145] Mercy Corps and Practical Action (2010)

> *"The community based approaches for establishment of the early warning systems recognise the fact that the first response to a disaster always comes from the community itself. It also recognises the fact that in many cases, top down and highly technical approaches may fail to address the specific needs of vulnerable communities, ignoring the potentials of local resources and capacities. Community based early warning systems seek ways to help communities use local resources and capacities effectively to better prepare for and respond to disasters and adopt measures to reduce their vulnerability."*[146]

Participation is important to ensure the EWS considers the needs of all, because not all households and communities face the same needs. Differentiated vulnerabilities linked to socio-economic factors significantly influence people's capacity to prepare and act early.[147]

One example of how participation improves translation of the EW message into action comes from Bangladesh. In relation to Cyclone Alia, it was found that those who participated in preparedness activities had acted on the early warning messages more than those who had not participated.[148] Programs that focused on behavior change (actions to be taken after warnings) were also found to elicit better responses.[149]

The need for participation in preparedness activities can also be seen by the lack of action by end users in top-down approaches. In the case of the Uttarakhand floods of 2013 in India, the top-down approach to preparedness planning and communication resulted in unnecessary loss of life and property as communities failed to receive timely information about the flash flood hazard. Involving villagers in the design and implementation of early warning criteria and utilizing their understanding of the local terrain and environmental cues, would have improved rates of early action.[150] Furthermore, research from the Zao region of Japan on EWSs for volcanic eruptions suggests that sustained public engagement with an emphasis on dialogue with the public rather than top-down education would be more effective in preparedness and response.[151]

Despite the recognition that preparedness actions of EWSs must address differentiated needs of vulnerable populations and that community engagement and participation are essential for addressing these needs, the literature reviewed was mostly silent on any other factors that influence the effectiveness of preparedness. Mercy Corps and Practical Action mention that for PC-EWSs to be effective, they must affect preparedness and response.[152] However, how PC-EWSs should do this is less clear. Is participation in preparedness efforts the only recommendation? Preparedness requires both knowledge and capacity, but what knowledge and capacities are needed for early action? Are there any factors other than knowledge and capacity that might influence the transformation of EW information and messages into useful early action? In the following section, this paper looks at some of the weaknesses of the existing PC-EWS framework and considers other important factors the literature revealed as influencers of the end goal of early action to mitigate and recover.

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[146] Mercy Corps and Practical Action (2010)
[147] UNESCAP (2019)
[148] Ahsan et al. (2016)
[149] Hoekstra et al. (2014); Paul et al. (2010); Priest et al. (2011)
[150] Arlikatti et al. (2018)
[151] Donovan et al. (2018)
[152] Mercy Corps and Practical Action (2010)

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In *An Assessment of Pastoralist Management of Drought As A Strategy of Disaster Risk Reduction: A Case of Mandera County*, Ibrahim reported that, out of 111 survey respondents, 60.4% either agreed or strongly agreed that "there is very little link between preparedness, early warning and early action/response," with 34.4% remaining neutral on the question.[153] Furthermore, 61.4% of respondents agreed or strongly agreed that "drought contingency plans are response oriented with little emphasis on mitigation," again with 34.4% remaining neutral on the question. This and other evidence in the report indicates a significant gap in the execution of the EWS in northern Kenya and corresponding preparedness activities by pastoralists. The literature reviewed indicates an overall limited number of true traditional preparedness activities from pastoralists.

These include:

1) The identification, mapping, and management of drought fallback/reserve grazing areas by elders through clan/tribe structures;

2) The drilling of contingency boreholes and capping them during rainy seasons in order for the pasture around those boreholes to replenish in preparation for the next drought season; and

3) Vaccinations of livestock to disease outbreaks common during dry seasons. Worsening rainfall variability and ethnic-based conflicts and competition make reserve grazing areas as a preparedness strategy less effective.

To a much more limited degree, some women of pastoralist households report harvesting grasses and storing them at the household level in preparation for impending drought to ensure the health of lactating animals left behind when the men migrate with the other livestock. As has been discussed in previous sections of this paper, pastoralists primarily rely on coping strategies and activities to mitigate the impacts of drought, as opposed to preparedness activities *ex ante*[154]. More research is needed to 1) Identify potential preparedness activities that could be promoted by early warning; and 2) Better understand how early warning systems and the information provide can support coping strategies and activities in this context.

Photo credit: Food for the Hungry

[153] Ibrahim (2016)
[154] Aklilu and Wekesa (2002)

A CASE FOR A BEHAVIOR CHANGE INFLUENCED PC-EWEA FRAMEWORK

GAPS AND WEAKNESSES OF THE EXISTING PC-EWEA FRAMEWORK

Despite PC-EWS approaches to ensure that EW information, communicated through EW messaging, is transformed into early action/mitigating behaviors through preparedness activities, evidence from the literature and research carried out by Food for the Hungry (FH) indicates that what is currently being done is rarely enough to result in end users taking early action measures. One such example is described by Barrett et al. who explain that, despite utilizing a PC-EWS approach of including traditional forecasts in EW messaging, few end users actually changed their behavior based on the information received:

> "The biggest impediment to fulfilling the potential of forecasts is the transformation of acquired modern information into behavior modification. Information is valuable in so far as people are willing and able to act upon it. If people either cannot or will not change behavior in response to information they receive, then the information has no practical value."[155]

> *"Despite the stated confidence in traditional forecasts, surprisingly few respondents altered their behavior after receiving forecasts. Only about one quarter of our respondents changed their behavior on the basis of the forecast start dates for the 2001 long rains, while fewer than ten percent of those who received external forecasts of rainfall volumes in their own locations adjusted behavior in response."*[156]

Barrett et al. go on to explain that:

> *"Our evidence suggests that climate information is not a particularly limiting factor to pastoralists' livestock marketing behavior. Though few respondents received modern forecasts, confidence in traditional forecasts outweighed confidence in modern forecasts by a three to one factor, and despite the high degree of confidence in traditional forecasts, few respondents changed their behavior in response to the additional information garnered. This evidence calls into question arguments that improved production and dissemination of climate forecasts should be a high priority investment as donors and governments strive to reduce pastoralists' vulnerability to climate-related shocks. Rather, greater attention needs to be given to what infrastructural and institutional advances are necessary to facilitate the use of climate information within the livelihood strategies prevailing in these fragile systems."*[157]

[155] Barrett et al. (2004)
[156] Barrett et al. (2004)
[157] Barrett et al. (2004)

Recent research carried out by Food for the Hungry Kenya indicated that while only 17% of the households received early warning information during the 2016/2017 drought, still only 4.1% of the households did something to prepare for the drought.[158]

What factors are contributing to this dynamic of inaction even in light of a PC-EWS? Upon analysis of the literature, several factors related to world-view, and the influence of risk perception and behavior shed some light on this question and indicate a possible way forward through an adapted PC-EWS framework focusing on behavior and factors that influence behavior.

WORLDVIEW, RISK PERCEPTION, AND BEHAVIOR

The Sendai Framework for Action (2015-2030) recognizes the importance of understanding social and cultural perspectives of communities for effective EWSs. However, there is hardly any guidance on how to gain that understanding. Furthermore, while the UNISDR policy literature has called for people-centered EWSs, issues of engagement with the worldviews and perspectives of the end users and their indigenous knowledge and forecasting methods is weak. This is important to note since the end users' worldviews are often based on their local contexts, and indigenous knowledge about the hazard can mediate the interpretation of the hazard and be at variance with that of the scientific community. According to Tierney:

> *"Societal values and ingrained practices, ideologies and worldviews, various forms of social cognition (as opposed to individual psychology), belief systems, collective memories, other types of social constructions, and ideas that become influential through forms of collective behavior such as fads and crazes all play a role in the social production of risk. […] The key insight of social constructionism is that both perceptions and social activity are based not on our direct apprehension of 'objective reality' (in our case, risk) but rather on systems of meaning that are provided by culture, developed through social interaction, and produced through claims-making activities that advance particular views of the world."*[159]

A worldview is a "complex set of perceptions, attitudes, values and motivations that characterise an individual or group," which mediates the interpretation of events in the world.[160] These worldviews can be shaped by everything from religion, beliefs about god and fate, and response efficacy, to previous experiences with hazards. They can also be shaped by social backgrounds rooted in gender, education, and social position. People's worldviews help to organize perceptions, events, experiences, and situations in ways that render them meaningful.[161] Different worldviews exist about early warning systems. These can be roughly categorized into two camps: 1) The worldviews of professional experts who privilege scientific knowledge and high self-efficacy/response efficacy; and 2) Those of vulnerable communities who rely upon and privilege traditional knowledge systems and forecasting methods and tend to hold more external loci of control. This division is highlighted by the fact that, while advocating for more people-centered approaches to EWSs, its proponents

[158] FH/TF (unpublished)
[159] Tierney (2014)
[160] Waring & Glendon (1998)
[161] Goffman (1974)

often work with the discursive assumption that the worldviews of the affected people must undergo a radical change. Wilk et al., for example, contend that:

> *"Transformations in the personal sphere such as changed beliefs, values, worldviews and paradigms are an important part of this [EWS] process and could be triggered by, e.g., increased awareness, knowledge and understanding about what SFs [Seasonal Forecasts] are and the potential benefits of responding to the information."*[162]

However, others contend that designers of EWSs should attempt to understand these worldviews and adapt systems to respond to them.[163]

The need to understand community perceptions and worldviews is underscored in the UNISDR 2006 global survey of early warning systems, in which experts found that of the four components of people-centered EWSs, the weakest links were dissemination of understandable warnings and effective response.[164] Carabine and Jones advocate for EWSs that are "end-to-end," and focus not only on risk knowledge but also on public "capability to act on warnings received."[165] Such a focus requires more than just the conveyance of information about an impending hazard. The relationship between forecasts and its value to people at risk must not be taken for granted. Warning is a social process and thus much more complex than an improved forecast.[166]

Even when researchers and developers of EWSs have attempted to understand the worldviews of vulnerable populations, they have focused largely on the issue of risk perception, assuming that information about risk plays the primary role in behavioral choices.[167] While interventions that aim to improve people's perception of their risk have had some limited success, they have largely been disappointing, as noted in the UNISDR survey.[168]

Complexities of Risk Perception

One of the reasons the focus on risk perception has not been entirely successful is that it involves complicated social and psychological processes that developers of EWSs struggle to uncover. In his foundational paper, *The Human Factor in Early Warnings*, Twigg notes that it is extremely challenging for an outsider to understand a population's perception of risk.[169] Factors such as religion, beliefs in god(s) and fate and the perceived ability to cope, previous experiences with the hazard, and social backgrounds of persons such as gender, education, and position also influence people's perceptions of risks.[170]

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[162] Wilk et al. (2017)
[163] Twigg (2003)
[164] UNISDR (2006)
[165] Carabine and Jones (2015)
[166] Dash and Gladwin (2007)
[167] Bostrom et al. (2018); Chipangura et al. (2016); Slovic et al. (1979); Twigg (2003); Hayden et al. (2007)
[168] UNISDR (2006)
[169] Twigg (2003)
[170] Bormudoi and Nagai (2017); Bempah and Øyhus (2017); Drobot and Parker (2007); Sun et al. (2018); Mustafa et al. (2015); Kasperson and Kasperson (1996)

Many researchers have found the striking distinction between the experts' objective assessment of risk and the public's perception of risk.[171] Of particular interest has been the phenomenon of *social amplification of risk*, in which risk is socially constructed through cultural, institutional, and psychological processes that affect responses.[172] These processes are highly complex and based in a specific social and cultural environment that shares worldview, beliefs, and practices. Even within a population, risk perception is not homogenous and varies greatly by sub-groups such as wealth, class, gender, and livelihood.[173] Furthermore, researchers have discovered several heuristics that are socially based, including framing, continuity (status quo bias), and positive asymmetry that directly influence a population's perception of risk,[174] reinforcing Twigg's argument that an outsider's understanding of a community's perception of risk is limited at best.

> "Individual risk perceptions are shaped by cultural behaviors, local traditions, education, knowledge and beliefs. Risk awareness varies among those who have previously experienced a similar disaster and/or have engaged in risk education and community preparedness programs."[175]

Perceived risk itself includes two separate assessments: 1) People's assessment of the severity of the risk (how bad is the potential hazard); and 2) Their assessment of their own susceptibility to the risk[176] (how likely is it that this hazard will affect me). Both of these must be addressed to increase response. The example of Hurricane Katrina in the United States demonstrates the potential pitfalls of failing to be alert to the presence of these two processes. Officials miscalculated on their messaging by neglecting to address risk severity in their communications, which resulted in high perceived susceptibility (people knew the hurricane was coming) but low perceived severity (few people knew how badly it would affect them).[177] This error is not an isolated one; in studying flood risk perception, a recent meta-analysis found that the majority of research neglected to apply social science theoretical frameworks, such that "a methodological standardization in measuring and analyzing people's flood risk perceptions and their adaptive behaviors is hardly present."[178]

The process of perceiving risk itself involves multiple steps, all of which need to be well understood by risk communicators. Mileti's work found that people hearing warnings proceed through five separate stages: 1) Hearing; 2) Understanding; 3) Believing; 4) Personalizing; and 5) Deciding on Action.[179] Any efforts to increase risk perception and prompt action must pay attention to each of these steps. Psychologists have also discovered a multitude of heuristics that affect how a person assesses risk within each of these steps, identifying three of these as primary: 1) Availability (how easily can a person retrieve an occurrence from memory); 2) Anchoring (the tendency to establish

[171] Barrett et al. (2001); Sjöberg (1999)
[172] Kasperson et al. (1988); Martin et al. (2007); Kim and Kang (2010); Sullivan-Wiley and Short Gianotti (2017)
[173] Barrett et al. (2001); Sullivan-Wiley and Short Gianotti (2017)
[174] Tierney (2014)
[175] UNESCAP (2019)
[176] Pennings and Grossman refer to perceived severity as "risk attitude," and perceived susceptibility as "risk perception."
[177] Pennings and Grossman (2008); Sullivan-Wiley and Short Gianotti (2017)
[178] Kellens et al. (2013)
[179] Mileti (1995)

a starting point that affects information like risk-related probabilities); and 3) Representativeness (relating a risk to a previously known or experienced event).[180] Other heuristics to note include optimism bias ("others are more at risk than I am"), myopia (short-term thinking), and the affect heuristic ("fast, instinctive, and intuitive reactions to danger").[181]

The affect heuristic has received particular attention from researchers who study risk, as it demonstrates that risk assessment is frequently *not* a deliberate, cognitive process,[182] which may explain some of the failure to increase risk perception through provision of information like statistical probabilities.[183] Instead, studies show that "emotional reactions to risk situations often diverge from cognitive assessments" and that "emotional reactions often drive behavior."[184] Risk-related data is nearly useless unless coupled with something that will trigger an emotional response.[185]

Risk Perception Paradox and a Focus on Behavior

Many studies have found that risk perception is not the most influential factor in determining response to a potential hazard and that, even when the perceived risk is high, risk-mitigating behavior may remain low, creating a "risk perception paradox." Several reasons exist to explain this paradox (why people who recognize the risk do not take action): 1) The perceived negative consequences of the behavior outweigh the perceived benefit; 2) Lack of agency/self-efficacy and/or lack of perceived responsibility; and 3) Lack of resources to act.[186] These reasons are supported by Lindell's research, along with others' research, showing that attitude towards the protective action is more predictive of behavior than attitude towards the hazard itself.[187]

> "[A] substantial discontinuity between people's risk beliefs and their level of preparation suggests that adoption decisions are influenced by additional motivational and interpretive processes."[188]

Analysis of hazard response in various contexts demonstrates the need to focus on desired behaviors rather than just risk perceptions:

- Responses of people to early warning are dependent upon the protective action available to them.[189] For example, in the case of Typhoon Alia and Sidr in Bangladesh, accessibility of the protective remedy (such as evacuation shelters), both for themselves as well as their livestock, was an important determinant of whether people acted on the warning.[190]

[180] Tversky and Kahneman (1974)
[181] Tierney (2014); Slovic et al. (2005)
[182] Slovic et al. (2004); Loewenstein et al. (2001)
[183] Chandler et al. (1999); Loewenstein et al. (2001)
[184] Loewenstein et al. (2001)
[185] Slovic et al. (2004)
[186] Wachinger et al. (2013)
[187] Lindell and Perry (2012); Weinstein (1993); Rogers and Prentice-Dunn (1997); Chandler et al. (1999); Paton (2003); Grothmann and Reusswig (2006)
[188] Paton (2003)
[189] Liu et al. (1996)
[190] Ahsan et al. (2016); Paul et al. (2010); Saha and James (2017); Islam et al. (2011).

- In the context of the United Kingdom (UK) floods, advice on both the forecast and appropriate response was more effective than forecast messages alone in achieving desired response from the potentially affected.[191]
- Maps communicating wildfire warning information with location names and addresses of safe shelters were found to be useful for action in simulated wild fire scenario with residents from wild fire areas in Australia.[192]

This focus on response is a key component in many behavioral models (see section on theories below) but is frequently absent in systems that heavily emphasize risk perception. In fact, in many cases the risk communication does not promote or encourage any particular behavior for preparedness or risk mitigation, assuming that the population themselves will identify a course of action.[193] This absence of a behavioral focus could be one of the reasons why effective response has been found to be a weak component of many EW systems.[194] By exclusively emphasizing risk, designers of EWSs do not achieve a deep understanding of the potential risk-mitigating actions (and their potential impact), the feasibility of those actions from the community members' point of view, and the particular beliefs, attitudes, and environmental supports that may be determinants of the behaviors. In light of this gap, many are calling for communication efforts to focus more on the appropriate behaviors rather than on the risk itself.[195]

Other Important Factors

Although some EWSs do identify and promote a specific action to take in preparation or mitigation, many still primarily emphasize the risk in order to prompt populations to take those actions. Research has highlighted a number of additional factors found to be influential in increasing behavioral response. Even in models where risk perception is central, researchers acknowledge that other determinants may be as (or even more) important. Sjöberg notes that "it is simplistic just to assume that a high level of perceived risk carries with it demands for risk mitigation."[196]

> "It is not enough to relay to people that something is a risk – they need help understanding what they can do about it, and to feel empowered to take those actions. High perceptions of risk can thus be taken as a necessary, but not sufficient condition for response."[197]

Many of these other factors have been identified using behavioral theories from other fields of study and applying them to emergency preparedness and mitigation response. While some evidence shows that researchers fail to systematically apply social science frameworks to disaster risk reduction efforts,[198] a handful of studies have attempted to explain a population's response using a select number of theories. Most

[191] Parker et al. (1995)
[192] Cao et al. (2016)
[193] Demeritt and Nobert (2014)
[194] UNISDR (2006)
[195] Wood et al. (2012)
[196] Sjöberg (1999)
[197] Brown et al. (2016)
[198] Kellens et al. (2013)

application of behavioral models has been done in a rich-world context, with limited research taking place in lower- or middle-income countries.[199] Models were often studied very narrowly and/or the models failed to explain the majority of the observed response.

The most commonly applied behavioral theories were:

- Protection Motivation Theory (PMT);[200,201]
- Protective Action Decision Model (PAMD);[202,203]
- Theory of Planned Behavior;[204]
- Health Belief Model (HBM);[205, 206]
- Extended Parallel Process Model (EPPM);[207, 208] and
- Social Cognitive Theory.[209]

These theories, along with other research, have identified several factors influencing behaviors related to disaster preparedness or mitigation, including:

- Perceived benefits/attitude (of the protective action)[210]
- Trust[211]
- Self-efficacy/locus of control[212]
- Perceived barriers to action/lack of resources[213]
- Social norms[214]
- Response/action efficacy[215]
- Social (or place) belonging[216]

[199] Ejeta et al. (2015)
[200] PMT also includes factors related to threat appraisal (perceived risk).
[201] Rogers and Prentice-Dunn (1997)
[202] PAMD includes threat perceptions, but research has found that attitude towards the behavior is more predictive than attitude towards the hazard.
[203] Lindell and Perry (2012).
[204] Ajzen (1985)
[205] The HBM also includes perceived susceptibility and perceived severity, components of perceived risk.
[206] Rosenstock (1974)
[207] The EPPM also includes perceived threat, but studies found that perceived efficacy to be a stronger influence that perceived threat.
[208] Witte (1992)
[209] Bandura (1997); Glanz et al. (2002)
[210] Teitler-Regev et al. (2011); Yang (2015); Nexøe et al. (1999); Najafi et al. (2017); Myers and Goodwin (2012)
[211] Sjöberg (1999); Starr (1969); Pennings and Grossman (2008); Stokoe (2016); Sullivan-Wiley and Short Gianotti (2017); Becker et al. (2015), Paton (2003)
[212] Martin et al. (2007); Weinstein (1993); Rogers and Prentice-Dunn (1997); Chandler et al. (1999); Baytiyeh and Naja (2016); Yang (2015); Myers and Goodwin (2012); Najafi et al. (2017)
[213] Wachinger (2013); Pennings and Grossman (2008); Sullivan-Wiley and Short Gianotti (2017); Teitler-Regev et al. (2011); Yang et al. (2015); Nexøe et al. (1999)
[214] Martin et al. (2007); McCaughey et al. (2017); Becker et al. (2015); Wood et al. (2012); Yang et al. (2015), Myers and Goodwin (2012); Najafi et al. (2017)
[215] Lindell and Perry (2012); Weinstein (1993); Rogers and Prentice-Dunn (1997); Chandler et al. (1999); Paton (2003); Grothmann (2006); Barnett et al. (2009), Balicer et al. (2010); Erret et al. (2012)
[216] Martin et al. (2007); Kim and Kang (2010); Paton (2003); Becker et al. (2015)

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In the context of northern Kenya, perceived risk seems to have little effect on behaviors. Pastoralists believe risks such as droughts originate from God (*Waaq'a*) and, therefore, humans have no control over their occurrences or their devastating consequences.[217]

Respondents in a study undertaken by Luseno et al. did not make appreciable change in the management of their herds after hearing the forecasts.[218] The main response was in terms of prayers and ceremonial rituals. Luseno et al. argue that to respond, the pastoralists must have means to undertake strategic alternative protective actions.[219] If they have limited capacity, then they may not be able to act. Further, their livelihood strategy based on mobility does not benefit from the ex ante response. It is based on post ante response—responding to drought through search for better pastures. Poorer pastoralists found it difficult to move, as the minimum critical herd size required for mobility was estimated to six to ten cattle. The recent field study funded as part of this research paper confirmed that this largely remains the case.

CONCLUSIONS AND RECOMMENDATIONS

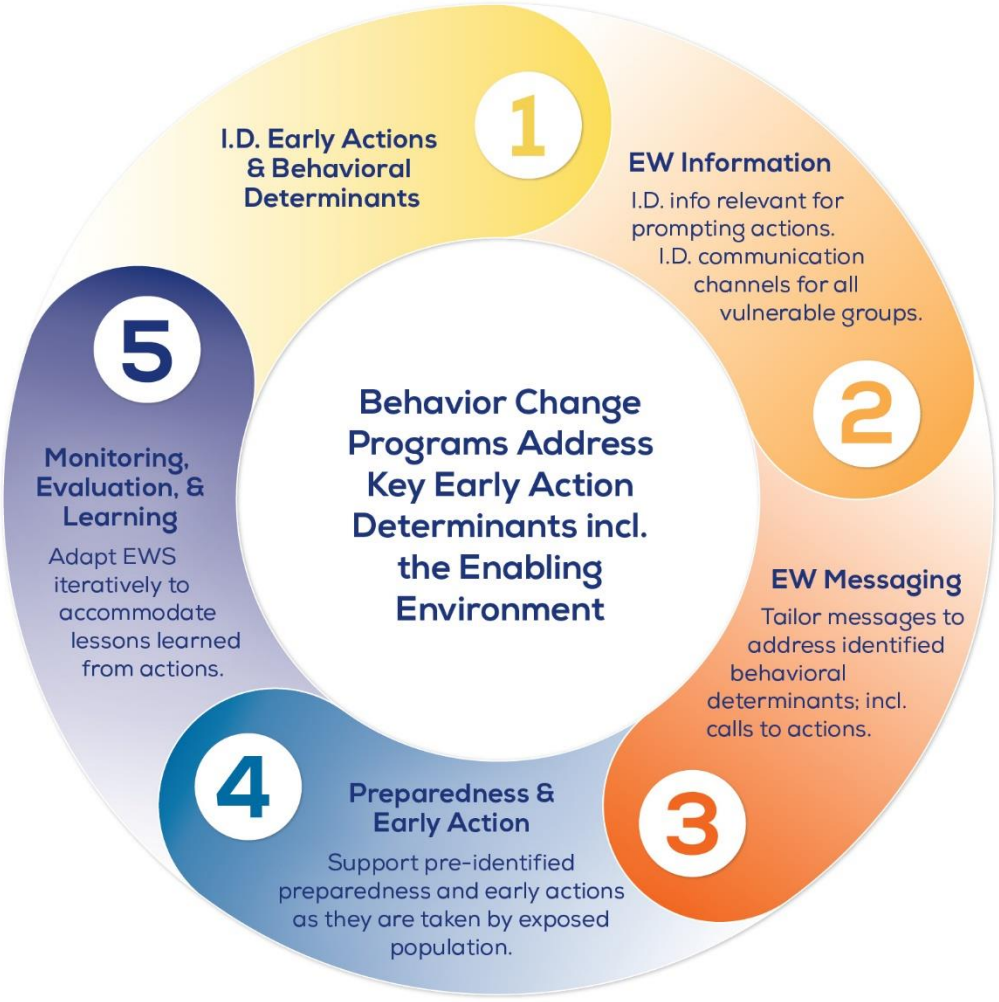
Early Warning Systems have traditionally focused on the technology of forecasting, with the assumption that communities will act simply after receiving a message of an impending hazard. If these systems have had an action emphasis, it has been primarily on the government and donor community to respond to crises early by committing funds and positioning relief supplies. In recent years, many have called for systems that are responsive to specific needs of the affected population, involve affected populations in the design or data collection, or adapt messages to different segments within the communities. These calls for people-centered early warning systems have identified the failure of previous EWSs to stimulate effective action from the populations most vulnerable to the hazard in question. The literature on people-centered early warning includes a variety of recommendations based on evidence for how to best tailor these systems so that they are more culturally relevant, useful, accurate, equitable, and credible.

While designing early warning systems to be more people-centered shows promise, the behavioral science literature on early warning suggests that these efforts may still be insufficient to elicit the necessary early action behavior change. Here the evidence, albeit limited, indicates that, in order to achieve vital changes in behavior, systems must go beyond the warning and begin to emphasize the action itself. Such an emphasis requires much more than predictive information about a potential hazard and must examine a variety of other factors, including a careful consideration of actions available to vulnerable populations, barriers, and motivators people face in adopting such actions—be they financial, societal, gender-based, or motivational—and the perceived consequences of those actions, both positive and negative.

[217] Hazard et al. (2012)
[218] Luseno et al. (2003)
[219] Luseno et al. (2003)

While affirming the current efforts of the PC-EWEA framework, we recommend that governments, donors, and relief and development practitioners incorporate a specific behavioral approach to the design of early warning systems with the following proposed framework:

The Behavior Change for Early Warning & Early Action Framework (BC-EWEA)



RECOMMENDATIONS

- **Encourage actions from the population at risk:** EWSs should take a more explicit and intentional approach to encouraging communities and households to take early action. The primary purpose of many, if not most, EWSs is to prompt action from the government or donor communities, while the population at risk is often a secondary audience (if recognized at all). The government in particular has a key role to play in promoting and supporting preparedness early action of the exposed communities. However, preparedness must go beyond knowledge or skills and consider specific behaviors and the determinants of those behaviors. These types of activities should take place well before a hazard warning is issued, especially in contexts of cyclical events like droughts in the ASALs or northern Kenya.

- **Start by identifying appropriate behaviors:** In order to effectively encourage communities to act, designers and managers of EWSs need to identify the behaviors most effective for the population to prepare, prevent, and/or mitigate the harm from a potential hazard event. Because these behaviors may vary widely based on vulnerabilities (livelihood, gender, age, and geographic location), implementers should actively engage the at-risk population using participatory formative research. This research should explore previous events to identify which actions would be most beneficial for which vulnerable groups. Methodologies useful for such formative research include Participatory Learning and Action/Participatory Rural Appraisal, positive deviance, Trials of Improved Practices, focus group discussions, and key informant interviews.
- **Conduct formative research on determinants of the identified behaviors:** Using established behavior change theory and practice, research the key barriers and motivators of the behaviors—not simply perceptions of the hazard. Because of the lack of consensus on the most effective behavioral theory, we recommend not limiting research to one particular theory, but approaching determinants broadly and within the specific context of the desired actions. Potential methodologies to use include the qualitative methods mentioned above and doer/non-doer analysis, vignettes, and gamification.
- **Consider the enabling environment:** Possible determinants of any particular behavior could include structural issues around services, access to resources, leadership and governance, gender norms, and policies. EWSs should intentionally connect with development efforts in these areas to facilitate the preparedness and early action behaviors they are promoting. Social and behavior change generally requires a much broader focus than simple messaging. In the case of Kenya, this also requires that the EWS be embedded in the overall context of a disaster risk reduction and resilience framework that reflects the pastoral livelihood systems and their worldviews[220]. The role of EWSs must be that of assisting all stakeholders in developing better and more effective responses, namely enabling reduction of risks (livestock loss), preserving herds, and building viable herd size for pastoralists that are more vulnerable[221]. This means engaging with behavioral change in all stakeholders, to enable such proactive responses, rather than just instantiating reactive response in terms of food aid/water or emergency response from governments, NGOs, and policy communities, or responses which focus on market-related strategies.
- **Focus on the call to action:** When messaging early warnings, EWSs need to focus on the call to action—what people should do—not on the hazard. As mentioned in this literature review, much research has found that behavior change is more dependent on determinants of the action itself (e.g., action efficacy and access to resources) than on perception of the hazard (perceived risk). This focus on action is especially critical in contexts where community members feel the situation is beyond their control (fatalism).
- **Engage the at-risk population as much as possible:** Both people-centered and community-based EW principles espouse participation of the affected population, but the relief and development communities variably define "participation" as anything from

[220] Aklilu and Wekesa. (2002)
[221] Catley. (2017)

extracting information from interviews to complete ownership of a program by the population. We recommend that practitioners clearly define the level of participation in early warning and early action programs and attempt to move towards ownership over time. Increasing the quality of participation will improve efforts towards identifying effective behaviors and their determinants, developing appropriate messages and ensuring equity in both behavior change and early warning programming. Such participation is invaluable not only in initial design of a behavior-centered EWS, but for the feedback and adjustments necessary for refinement and improvement as part of a monitoring, evaluation, and learning cycle.

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