BRACC

BUILDING RESILIENCE AND ADAPTING TO CLIMATE CHANGE

Sustainability of early warning systems

Discussion Paper

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About this paper

This paper is one of a three-part series of discussion papers produced under the Building Resilience and Adapting to Climate Change (BRACC) programme in Malawi. The papers aim to synthesise existing evidence on nature-based solutions for flood control, watershed management, and early warning systems in Malawi. They also highlight existing knowledge and policy gaps, and identify potential areas for further research on the three topics.

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Acronyms

ACPC	Area Civil Protection Committees
AfDB	African Development Bank
AWS	Automated Weather System
BRACC	Building Resilience and Adapting to Climate Change
CBEWS	Community-Based Early Warning Systems
CBO	Community-Based Organisation
CCA	Climate Change Adaptation
CPC	Civil Protection Committee
CSO	Civil Society Organisation
DCCMS	Department of Climate Change and Meteorological Services
DCPC	District Civil Protection Committees
DoDMA	Department of Disaster Management Affairs
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
DWR	Department of Water Resources
EWS	Early Warning Systems
FbA	Forecast-based Action
FEWSNet	Famine Early Warning Systems Network
GoM	Government of Malawi
GSM	Global System for Mobile Communications
ICT	Information and Communication technology
IFRC	International Federation of Red Cross
INGO	International Non-Governmental Organisation
LDCF	Least Developed Countries Fund
MVAC	Malawi Vulnerability Assessment Committee
NGO	Non-Governmental Organisation
NMHS	National Meteorological and Hydrological Services
NRS	National Resilience Strategy
O&M	Operations and Maintenance
PICSA	Participatory Integrated Climate Services for Agriculture
PSP	Participatory Scenario Planning
SARCOF	Southern African Regional Climate Outlook Forum
SMS	Short Message Services
UNDP	United Nations Development Programme
UNDRR	United Nations Office for Disaster Risk Reduction
VCPC	Village Civil Protection Committees
WMO	World Meteorological Organization

1. Introduction

This paper has been commissioned by the BRACC Knowledge and Policy Hub (the Hub) to synthesise evidence on the sustainability of early warning systems (EWS) globally, and in Malawi in particular. Demand for research on this topic emerged from dialogue between the Hub and BRACC's wider stakeholder network – government partners, donors and programme implementing partners.

The paper draws on a wide range of literature – published and grey – from Malawi and globally. It covers global frameworks and definitions of EWS (Section 2); a summary of global thinking and writing on the sustainability of EWS (Section 3); an overview of policies and institutions with relevance to EWS and their sustainability in Malawi (Section 4); and a synthesis of the main challenges and opportunities to sustainable EWS in Malawi (Section 5).

The desk-based literature review was based on online literature searches, searches in project databases and input from BRACC partners and external experts. Background conversations with members of BRACC also informed this report, though have been kept anonymous.

This is a Discussion Paper, not a comprehensive critique or appraisal of early warning systems in Malawi. The views expressed are the author's own. The paper builds on a Hub background briefing note on disaster risk reduction (DRR) experience in Malawi.[1]

2. Global frameworks and definitions of EWS

"To properly work, the system also becomes not simply a technical problem, but one of cooperation between government, relief agencies, and the communities to create, maintain, and use the system. These more social and political problems define the success of the system, and ensuring their solutions involves a different approach than the technical issues." [2]

The importance of climate services and EWS is noted in the three major global development frameworks:

- **Sustainable Development Goals, Target 13.1:** "Improve education, awareness raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction, and early warning."
- **Paris Agreement, Article 7(7a):** "Parties should strengthen their cooperation on enhancing action on adaptation, taking into account the Cancun Adaptation Framework, including with regard to: Strengthening scientific knowledge on climate, including research, systematic observation of the climate system and early warning systems, in a manner that informs climate services and supports decision making."
- **Sendai Framework for Disaster Risk Reduction, Priority 1(25.a):** "Enhance the development and dissemination of science-based methodologies and tools to record and share disaster losses and relevant disaggregated data and statistics, as well as to strengthen disaster risk modelling, assessment, mapping, monitoring and multi-hazard early warning systems."

The United Nations Office for Disaster Risk Reduction (UNDRR) describes an EWS as an "integrated system of hazard monitoring, forecasting and prediction, disaster risk assessment, communication and preparedness activities systems and processes that enables individuals, communities, governments, businesses and others to take timely action to reduce disaster risks in advance of hazardous events".[3] An EWS was previously defined by the UNDRR in more linear terms as "the provision of timely and effective information, through identified institutions, that allows individuals exposed to a hazard to take action to avoid or reduce their risk and prepare for effective response". This is sometimes referred to as a 'linear paradigm', or more commonly, an 'end-to-end' system.

EWS are often configured and perceived as linear connections that begin with hazard monitoring and continue through to probabilistic forecasts, generating warnings and transmitting these to users. System reliability is enhanced when all the relevant links in the early warning chain are in place and systematically connected.[4] From a systems thinking perspective, a 'system' comprises entities that are linked through flows and interactions, with inputs and outputs. For EWS, this includes monitoring, forecasting, warning generation, communication, emergency response and feed-back systems, as well as the system's legal and institutional basis, and the people involved in designing and maintaining it.[5]

The widely used but simplified 'linear paradigm' of EWS has been largely superseded since the 2000s by the UNDRR's systems-based framework, with four interrelated elements:

1. Risk knowledge of the relevant hazards, and of the vulnerabilities of people and society to

these hazards, based on systematic collection of data and disaster risk assessments.

2. Monitoring and warning capacity to detect, monitor and analyse hazard precursors, forecast the hazard evolution, and issue forecasts and warnings of hazards and possible consequences.
3. Dissemination and communication of authoritative, timely, accurate and actionable warnings and associated information on hazard likelihood and impact, and providing preparedness information to those at risk.
4. Response capability knowledge, plans and capacities for timely and appropriate action by authorities and those at risk.[4]

Some have since argued for the addition of a fifth element: the governance arrangements and institutional relationships that shape EWS.[6] This is critical because in practice, there is often no consistent agreement about what is meant by 'EWS' and its individual terms ('early', 'warning' or 'system'). Interpretations are highly contextual, depending on social settings and the hazards themselves.[5] Khankeh et al. (2019) go so far as to maintain that, although a number of different EWS models have been developed at various levels, these may focus on different issues; there is no consensus on the most appropriate models and their essentials; and a model rarely includes all the necessary elements.[7]

The interrelated elements need to be coordinated within and across sectors and multiple levels for the system to work effectively, with feedback mechanisms in place for continuous improvement.[5] Failure of individual components or their interactions can lead to failure of the whole system[4], while multiple EWS may lead to division of responsibilities, duplication of effort, and provision of contradictory and inconsistent information to decision-makers.[8]

Garcia and Fearnley (2012) examined the links between the four EWS components introduced earlier in this chapter, recognising missing linkages as the most common factor in system failure.[9] Arguing for flexibility and taking local context into account, rather than seeking increased EWS standardisation, they identified four areas for improvement:

1. Establishing effective communication networks to put scientific research into practice;
2. Developing effective decision-making processes that define accountability and responsibility;
3. Acknowledging the importance of risk perception and trust for effective reaction;
4. Considering differences among technocratic and participatory approaches.

Within a systems-based framework, National Meteorological and Hydrological Services (NMHS) have a critical role across the four interrelated elements of the system. This role comprises:

- risk identification: systematic observation and monitoring of hydro-meteorological parameters; provision of quality-assured archived and real-time- data; hazard analysis and mapping; hazard forecasts;
- risk reduction: provision of hazard forecasts and early warnings to support emergency preparedness and response; climate data and forecasts to support medium- and long-term sectoral planning;
- risk transfer: provision of historical and real-time hazard data and analysis to support catastrophe insurance, bonds and weather-indexed risk transfer.[10]

EWS are also sometimes viewed as social networks with nodes comprising individuals (e.g. scientists, officials and people) or organisations (e.g. meteorological services, government ministries and administrative offices). These nodes are connected by systems of values, visions, mandates,

technological instruments, governance, and rules.[11]

There is widespread support for ‘multi-hazard’ or ‘all-hazard’ approaches which create coordination, synergies and efficiencies across systems, building on a combination of relevant technical and institutional capacities. One of the seven global DRR targets of the Sendai Framework, Target (g), aims to “substantially increase the availability of and access to multi-hazard early warning systems [MHEWS] and disaster risk information and assessments to people by 2030”.[12] MHEWS increase the efficiency and consistency of warnings through coordinated and compatible mechanisms and capacities, involving multiple disciplines for hazards’ identification and monitoring.[13]

3. Sustainability of EWS

'Sustainability' or 'sustainable business models' are rarely discussed directly in EWS literature and there is little clarity or definition about what the terms mean in this context. A recent online discussion on the subject[A] raised a number of issues relevant to EWS sustainability, including hardware maintenance, training and refresher courses for personnel, costs, funding and volunteer motivation.

In summary, synthesising findings from the following sub-chapters, the key factors that have been found to contribute to EWS sustainability include:

- strong political commitment;
- durable institutions and their capacities;
- effective governance and institutional arrangements, good communications;
- involvement and coordination of a broad range of actors (individuals and institutions) with responsibility and accountability for their functions;
- strong inter-linkages between different EWS elements and stakeholders – communities, local and national governments, regional and international organisations and institutions, non-governmental organisations (NGOs) and the private sector – and between DRR and sustainable development agendas;
- high levels of public awareness and appreciation of the benefits of EWS.

Multi-stakeholder partnerships and processes require clarity about mandates, roles and responsibilities – hence the repeated emphasis in EWS guidance on the need for standard operating procedures.[14] For example, private sector providers may be able to deliver readily available, good-quality climate information services at a reasonable cost to other actors such as NGOs, but in doing so may bypass NMHS. Where multiple and conflicting sources of information reach citizens, this may erode the authority and mandate of NMHS, leading to confusion and distrust in official information. There are also questions about the continuity of private sector involvement and public-private sector partnerships when EWS engagement is no longer profitable.[15]

Sustainable EWS are able to monitor and provide early warning not only of short-term hazard threats but also longer-term factors, including environmental degradation and unsustainable and risk-creating development practices. At the same time, experience of disasters can strengthen support for effective and sustainable EWS[4,16] in the short term, given their potential to reduce disaster loss.

User satisfaction and perceived effectiveness of EWS services are said to be significant factors in stimulating uptake and response.[17] Yet, "few countries measure their own capacity to generate and communicate effective, impact-based, multi-hazard early warnings; and they lack tools and metrics to support such efforts. Metrics to measure early warning access and effectiveness can guide investments and improve programming, institutional capacity development, resource allocation".[18]

Finally, it is noteworthy that the cost of setting up and maintaining EWS is not discussed in the literature at any length; yet this is clearly a fundamental element in system design, installation and operation. EWS have been shown to reduce losses from hydro-meteorological and other hazards; and to produce positive cost-benefit ratios (in terms of losses avoided against installation and operating costs) in different contexts.[19]

[A] Natural-hazards-disasters listserv www.jiscmail.ac.uk/natural-hazards-disasters

Contributors and challenges to the sustainability of EWS

Relatively little research, evaluation and learning to date has focused on the sustainability of effective EWS. The following paragraphs summarise highlights from the existing literature with regards to the main contributors and barriers to EWS sustainability that have been identified to date.

Looking more widely at sustainable climate services delivery, Dupar et al. (2021) focus on necessary elements to sustain capacity; how sustainability can best be incorporated into project design and implementation; enablers and barriers to creating sustainable capacity; and how barriers can be overcome. Drawing on a review of literature on the sustainability of climate services and experiences from the WISER TRANSFORM project, they argue that climate services projects are likely to sustain their effectiveness if they invest in human skills and capacity (individual and organisational) in addition to infrastructure investments; establish high-level buy-in and accountability from government (and NMHS in particular); secure partnerships, protocols and processes; ensure equal voice for women and socially marginalised groups; develop and execute sustainable business models; develop sustainability plans from the beginning; provide sufficient time and money; address institutional reforms where necessary; and engage political leaders as champions for climate services.[20]

Lassa (2008) appears to be the only researcher to have addressed EWS sustainability directly, observing that although EWS may claim to be based on systems thinking, most of them adopt a sequential approach that does not reflect systems' complexity.[11] He uses Adger et al.'s (2003) principles of effectiveness, efficiency, equity and legitimacy[21] for assessing EWS sustainability, arguing that discussions of EWS have given too much attention to effectiveness and not enough to the other three principles (see Box 1). An understanding of DRR governance is required to achieve the sustainability of EWS (in this context, governance comprises politics, policy and polity).[11]

In addition to this focused analysis of EWS sustainability, several studies have identified barriers, challenges and opportunities relating to the sustainability of EWS, often in connection with assessing the effectiveness of these systems. Basher (2006) identified structural weaknesses in many EWS that may affect sustainability, particularly: a focus on the hazard (i.e. emphasis on vulnerabilities, risks and response capacities); lack of synergy across different technical institutions focusing on different hazards; the dominance of technical experts, with limited engagement of people at risk in EWS design and operation (and hence lack of user 'ownership' of the system and mistrust of experts and authorities); and weak feedback loops for incorporation of users' knowledge and experience. Limited public engagement and recognition is likely to lead to weak political and budgetary support for EWS. Sustainable EWS need "strong political commitment and durable institutional capacities", which in turn depend on "public awareness and an appreciation of the benefits of EWS".[4]

Box 1: Effectiveness, efficiency, equity and legitimacy principles in assessing EWS sustainability[11]

1. Effectiveness: relates to the capability of a decision or policy alternative to achieve its expressed objectives.
2. Efficiency: refers to added value, reducing costs and losses, time saving for problem solving.
3. Equity: focuses on the consequences of EWS decisions on different people's welfare, recognising equity issues in the spatial distribution of risk.

4. Legitimacy: the 'rightfulness' of decisions about EWS, or the extent to which these are accepted.

Luther et al (2017) have identified a number of gaps and challenges with regard to EWS effectiveness and sustainability:[5]

- **Risk knowledge:** There is a need for quality-controlled historical time series of extreme hazard events and disaster occurrences in terms of intensity or magnitude, location, duration, timing and impacts. Risk and impact information are often not integrated into EWS, or insufficiently integrated, often due to lack of cooperation (between technical agencies responsible for collecting hazard data and stakeholders collecting vulnerability and exposure data) as well as a lack of availability or access to reliable loss and impact information. Even if risk knowledge is incorporated, it is often still an inadequate representation of all dimensions of vulnerability.
- **Monitoring and warning services:** Many regions lack modern monitoring and communication systems. More research and development is needed to improve observations, monitoring, data processing, modelling, forecasting and prediction, and related applications. There is a lack of policy and legal frameworks to ascertain authority and accountability, and of resources for sustainable operations by agencies; and there is insufficient transboundary information sharing.
- **Warning dissemination and communication:** Not enough focus on the uptake and use of warning messages, including the capacity to use information for longer-term interventions. There is a proliferation of information and communication technologies (ICTs), leading to the loss of a single authoritative voice and to use of warning messages from unofficial sources (also due to ineffective engagement with the media and private sector). Warning messages are sometimes unclear and incomplete, due to a lack of standardised nomenclature and non-technical, actionable language, and because uncertainties are often not well specified and explained. Communication networks break down during disasters (often with a lack of back-up systems). New technologies and support for dissemination and communication of warnings are often not available in least developed countries. There are challenges in promoting public-private partnerships, market access and incorporation of indigenous knowledge.
- **Response capability:** Response capabilities vary between countries and depending on the hazard. There is insufficient education and training for response. The role of non-governmental responders is not reflected in policies and legislation, missing opportunities for partnerships that do not rely on central government. The public and local emergency management agencies do not have sufficient opportunities for participation in the development of response plans.

Case studies collected for the Science for Humanitarian Emergencies and Resilience programme highlight a number of challenges to the effectiveness, scale up and sustainability of EWS, relating to: financing, integration, responsibilities, community interpretation, politics, dissemination, accuracy, capacity, and focus.[22] They also outline seven priority areas for EWS research, including how best to sustain effective EWS between hazard events, and climate proofing current EWS. These priorities thus reflect the gaps in the current evidence base on the sustainability of EWS.

IFRC et al.'s (2014) report on early warning/early action in the Horn of Africa identified a wide range of complementary policies and practices required to create an enabling environment for more effective and sustainable EWS (particularly in the context of drought and food insecurity, although these are also applicable in other hazard contexts).[23] These include:

- A legal basis for the EWS and coordination framework.
- Transferring decision-making and ownership of programmes from humanitarian actors to national

government and local partners; putting affected communities at the heart of decision-making. National platforms, and equivalent bodies at the operational level, should work with all stakeholders to build consensus on key indicators.

- EWS systems located within government structures and operating within a clear legal framework, at a range of levels (from community to regional) that are integrated and communicate effectively. EWS should seek to preserve and include local and traditional knowledge and strengthen community ownership.
- Transparency and trust between stakeholders, developing from a shared vision, a strengthened evidence base and a common commitment to open communication; prioritising common goals, valuing openness and transparency; and emphasising evidence over opinion. EWS must be accountable and measured in terms of their predictive/warning capacity. The information, analysis and direction they provide must have the confidence of end users.
- Jointly owned indicators, produced by national EWS and with the confidence of development and humanitarian actors (investment in parallel systems should be a last resort). The results of monitoring should be available in the public domain.
- Open dialogue between partners/actors with different perspectives and priorities.
- A legally based national platform (and local platforms) for EWS dialogue and decision-making involving all stakeholder groups, formally linked to existing coordination architecture and supported by a legal framework, with an early action agenda formally included in its mandate.
- Flexible funding: increased availability of multi-year and decentralised funding, greater flexibility within agreed programmes (linked to government budgets at national and local levels, with mutually agreed trigger mechanisms for releasing funds agreed in advance), transparency and accountability about resources and access to them.
- Contingency plans for early action, agreed in advance, including ‘surge’ strategies to increase capacities, ideally linked to existing programmes or activities operating at scale; fast-track procedures, creative use of contingency funds, setting predetermined thresholds.
- Information products that are appropriate and accessible to diverse target audiences, in terms of the frequency of messages, the level of detail, timeliness and the means of communication.

Involvement of diverse stakeholders to support effectiveness and sustainability of EWS

Effective multi-hazard EWS require national, regional and local governments, vulnerable groups and many other relevant stakeholders to take actions to minimise the threat of loss or damage, be actively involved in the establishment and operation of EWS (and take ownership of these systems as appropriate) and create integrated and comprehensive frameworks that clarify stakeholders’ roles, responsibilities and relationships within the system. EWS stakeholders are many and varied: they include disaster management authorities (at national, regional and local levels); scientific and technical agencies responsible for issuing hazard warnings or advisories (e.g. NMHS, health authorities, geological services); humanitarian and relief organisations (e.g. National Red Cross/Red Crescent Societies); local governments (with support from national governments), public and private communication providers; and agencies in other sectors (including transportation, agriculture and food security, energy, health, water resource management, telecommunications and education). Communities are fundamental to EWS. They should take local ownership of systems where possible and should be involved in all aspects of their establishment and operation.[13]

National governments are responsible for policies and frameworks and for the technical systems that predict and issue hazard warnings. They interact with regional and international governments and agencies to strengthen capacities, ensure that warnings and responses are directed towards vulnerable populations, and provide support to local communities and governments to develop operational capabilities. Regional institutions and organisations can play a supporting role in providing specialised knowledge and advice to support national efforts and facilitating linkages with international organisations and adjacent countries. International bodies, particularly the World Meteorological Organization (WMO) as well as other UN agencies, facilitate international coordination, standardisation and support for national early warning activities and foster the exchange of data and knowledge between countries and regions. This support may include providing advisory information, technical assistance, and policy and organisational support to national authorities or agencies.[13] In many lower-income countries, NMHS have few resources and are critically understaffed and overstretched. Although increased demand for localised data may encourage stakeholder payment for access to climate information, providing vital finance to NMHS, paywalls are a barrier to free public access to climate information.[24]

NGOs can raise awareness among individuals, communities and organisations involved in early warning, particularly at the community level. They can assist with implementing EWS and preparing communities for disasters. They can also play an important advocacy role to ensure that early warning stays on governments' and policymakers' agendas.

Climate services continue to be inaccessible to large numbers of vulnerable people. NGOs are increasingly taking on intermediary roles, helping users to acquire, understand and use climate information within their decision-making processes. NGOs' contributions can be maximised by improving knowledge sharing, greater collaboration and coordination across systems and scales; knowledge co-production; and supporting learning processes. NGOs perform several roles and functions in climate information services and EWS. These include translating information into accessible language and formats, and communicating it to beneficiaries; facilitating co-production of knowledge by information producers and users; and acting as policy advocates and brokers between governments and citizens. As weather forecasts develop and are combined with social and economic information to estimate potential impacts ('impact-based forecasting'), NGOs can help to improve understanding of impacts and identify actions to avoid or mitigate these.[24]

The private sector's roles in early warning (including the development of early warning capabilities by private organisations) need further investigation, but it has significant potential to provide skilled services (e.g. technical personnel and know-how, donations of goods or services). The media plays a vital role in improving disaster awareness among the population and disseminating warnings. Some communication channels are designed to reach users directly, via sirens, mobile phones and websites, but disaster information is still disseminated mostly via the mass media, enabling fast transmission to large numbers of people.[13]

The academic community (from global to national) provides specialised scientific and technical inputs to help governments and communities develop and improve EWS. Its expertise is essential for analysing hazards, vulnerabilities, exposure and risks, supporting the design of monitoring and warning services, contributing to data exchange, translating scientific or technical information into comprehensible messages, enhancing messages with additional information on potential impacts, and disseminating warnings to those at risk.[13] At a global level, the International Network for Multi-Hazard Early Warning Systems (established in 2015), a multi-stakeholder partnership of international, regional and national institutions, facilitates sharing of expertise and good practice on strengthening MHEWS as an integral component of national strategies for DRR, climate change adaptation (CCA) and building resilience. It aims to guide and advocate the implementation and/or

improvement of MHEWS, share lessons learned regarding early warning and increase the efficiency of investments in such systems for enhanced societal resilience.[5]

EWS can also be viewed as a social process with technical components embedded in their social context. This leads to a preference for a 'first mile' approach for developing EWS: i.e. involving community and societal stakeholders from the beginning of the design process, instead of a top-down, technical process where 'expert' information is handed down to community level. Emphasising the social process includes understanding decision-making authorities and their processes, and placing technical aspects in their social contexts, to ensure that EWS remain an active part of the community at all times (through public education, training, mapping and other forms of data gathering). Viewed from this perspective, key elements in EWS include: transparency; integration (into community, society and everyday life); human capacity (sufficient staffing capacity with relevant expertise); flexibility; continuity; and timeliness.[25]

Community (or end-user) engagement in EWS has often been described as essential for effective and sustainable service delivery. Such engagement includes a wide range of approaches and activities across the four components of early warning systems (see Section 2). These approaches and activities include: identifying and interacting with target populations; involving communities in exploring and mapping risks and planning responses; supporting community/local monitoring and warning systems; disseminating public information materials; establishing benchmarks and performance standards for technical warning services; developing formal mechanisms for monitoring warning system design and performance; surveying public awareness; supporting public memory and learning (e.g. through monuments, publications, commemorative events); conducting research on human understanding and response to warnings; and organising exercises and simulations. These call for the coordinated participation of many different types of organisations, committed to an integrated, people-centred EWS.[4,16]

An EWS can be considered people-centred if individuals, communities and organisations that are threatened by hazards participate in the generation of early warning information and have access to timely and meaningful information that enables them to act appropriately.

Community-based EWS (CBEWS) are widely endorsed and encouraged as a means of facilitating end-user participation and ownership of systems – and hence contributing to the efficiency and durability of 'last-mile' actions. There is a degree of ambiguity about what 'community-based' means or consists of in practice, which echoes wider discussions about the meaning and practice of 'community-based' DRR; but it is usually taken to mean that communities develop, manage and maintain their own EWS instead of simply responding to warnings.[26] Essential features of CBEWS are said to include: all community members, especially vulnerable groups, have meaningful participation in EWS decision-making and are involved at all stages from designing to operating the system, receiving warning messages and responding to warnings; measures taken should be based on the needs of everyone in the community including the most vulnerable; community members should own the process and system.[27]

Facilitating linkages across the different levels of stakeholders, a UN global survey of EWS from 2006 set out a 10-point plan for establishing national people-centred EWS[16] (see Box 2). Although this does not identify sustainability explicitly as a goal, the proposed actions develop a robust and comprehensive structure to support this.

Box 2: 10-point plan for establishing national people-centred EWS

1. Adopt the guiding principle that the country's early warning systems must be people-centred in addition to being technically sound.
2. Establish (or strengthen) a multi-party early warning roundtable, such as a subcommittee of the national platform for disaster reduction, to ensure coordination among the key actors and the integrated implementation of early warning capabilities across all hazards and all user needs.
3. Ensure at national level that the authority and political responsibility for issuing warnings are established in law and are appropriately assumed, and that the chains of command for the dissemination of warnings are clearly established.
4. Undertake a systematic national survey of all early warning system needs, covering hazards and vulnerabilities, institutional and social factors, and existing system capacities, performance and gaps.
5. Develop a long-term national plan for the systematic strengthening of early warning systems, covering technical and social elements, seeking synergies among the different hazard components, and with clear definitions of the targeted populations and the expected performance of the systems.
6. Where appropriate, request the support of the UN Resident Coordinator and the World Bank to support project identification and resourcing, in partnership with other donors, United Nations Development Programme (UNDP), relevant UN technical agencies and programmes, and non-governmental organisations.
7. Establish a national strategy and standards for warning dissemination that target stakeholders' needs and interests and reach to local level, and engage both the public and private sectors, especially the media, in their development.
8. Stimulate community-based risk assessment and early warning systems through the assignment of specific responsibilities for risk reduction and emergency management to local bodies, the support of local training and information needs, and the use of traditional knowledge and experience in warning system design.
9. Develop necessary curricula and institute a public education programme that reaches all the population at least once each year to enable them to understand the risks they face, the nature and meaning of warnings, and the appropriate responses to take.
10. Undertake a well-publicised exercise annually to demonstrate and test national EWS, evacuation plans and public response, preferably involving all or large fractions of the at-risk population.

4. Policies and institutions with relevance to EWS in Malawi

Malawi has endorsed the Hyogo and Sendai frameworks, which emphasise preparedness and resilience building among local communities, and people-centred-approaches to disaster risk reduction. Development of an effective warning communication and dissemination process (principally for floods and drought/food security) is recognised by the government as a major challenge that must be addressed to encourage the uptake of warning information.

Policies relevant to EWS

Many national policies and strategies relating to weather, climate variability, climate change, climate information and EWS have been introduced or revised in recent years, to create a more robust policy architecture for disaster risk management (DRM).[B]

Three policies are particularly relevant to EWS: National Disaster Risk Management Policy (2015); National Climate Change Management Policy (2016); and National Meteorological Policy (2019). These all support the National Resilience Strategy (2018-30).

National Disaster Risk Management Policy 2015.[28] This is the government's top-line policy document in the area of disaster risk, relying on other legislation and programmes for its implementation. It aims to move from a culture of disaster response towards mainstreaming DRM into development planning and policies across sectors, enhancing coordination and generating adequate budgetary allocations. The policy is regarded as a major step towards integrating DRM into planning and facilitating effective programme coordination. It identifies priorities and strategies, provides direction on DRM implementation to government, NGOs, private sector organisations, media and development partners at national and local levels; and seeks to ensure that all EWS are comprehensive, effective, people-centred, and integrated. The policy identifies six priority areas:

1. Mainstreaming DRM into sustainable development;
2. Establishment of a comprehensive system for disaster risk identification, assessment and monitoring;
3. Development and strengthening of a people-centred EWS;
4. Promotion of a culture of safety, and adoption of resilience-enhancing interventions;
5. Reduction of underlying risks;
6. Strengthening preparedness capacity for effective response and recovery.

All of these (particularly priorities 2 and 3) have implications for the development, effectiveness, reliability and sustainability of EWS.

Establishment of an effective system to identify, assess, monitor and map disaster risks at all levels is an essential step towards evidence-based sustainable development and planning. Such a system

[B] They include: National Meteorological Policy (2019), Malawi Growth and Development Strategy III (2017), National Climate Change Policy (2017); National Agricultural Policy (2016); National Disaster Risk Management Policy (2015); National Wildlife Policy (2018); National Forest Policy (2017) and National Irrigation Policy (2016). Older strategies and policies still in place include the National Environmental Policy, 2004; Water Policy, 2005; Land Resources Management Policy, 2000; Energy Policy, 2003.

must have the capacity to monitor and track hazards, regularly update, document and disseminate risk assessment information, and develop integrated risk maps; but the policy acknowledges that Malawi does not yet have such a system in place. Barriers that must be overcome to establish effective EWS in Malawi include: limited financial resources; limited human and technical forecasting capacity; and inefficient coordination of weather and climate information dissemination, including early warning preparedness, response, and risk management.[28–30]

National Climate Change Management Policy 2016.[31] This seeks to consolidate the implementation and management of climate change related programmes by (inter alia) providing direction for the development, strengthening and institutionalisation of meteorological observation and prediction. It provides limited guidance on growth and development of weather and climate services, leaving the meteorological sector without a clearly defined mandate, authority and legal framework to discharge its functions effectively. The absence of a meteorological policy is also said to have adversely affected the credibility, reliability and dissemination of meteorological services, thereby contributing to reduced demand from relevant sectors and the public. Other challenges and constraints include restricted financing of meteorological infrastructure and human resource capacity for data capture, processing, archiving and management.

National Meteorological Policy 2019.[32] This is an overarching guide on generating and providing meteorological services and products for various users. It is intended to complement and strengthen operationalisation of the National Climate Change Management Policy (2016) through stronger sector linkages and coordination. It aims to enhance meteorological services to support socio-economic development, through a broad-based approach addressing seven priorities: monitoring and predicting weather and climate; managing meteorological data and information; meteorological engineering and information technology development; meteorological research services; financing the climate change and meteorological sector; capacity building and awareness; and cross-cutting issues. While forecasting services are widely used, there has been concern among the public and specialist users about forecast accuracy and reliability. There is an acknowledged need to replace old equipment and instruments and to conduct refresher courses for weather observers and forecasters. Specifically, the policy aims to: improve planning, programming, and implementation of weather and climate activities; enable generation of reliable, responsive, high quality, timely and up-to-date weather and climate services; ensure timely dissemination of accurate and reliable sector relevant information for early preparedness; provide a framework for monitoring, evaluation, and reporting on interventions for the meteorological sector; and provide a platform for stakeholder engagement in the meteorological sector.

National Resilience Strategy 2018-30.[33] The ambitious National Resilience Strategy (NRS) 2018-30 is regarded as a pivotal shift in the way Malawi will address poverty reduction, food and nutrition security and inclusive resilient growth. There is a recognised need for coordinated investments in effective DRM and response systems, particularly in flood control, drought mitigation, EWS and shock-sensitive social protection. The NRS aims to accelerate Malawi's transition from the cycle of annual humanitarian appeals for food and other emergency assistance, by reorienting existing and planned programmes under four thematic pillars: (1) resilient agricultural growth; (2) risk reduction, drought mitigation, flood control and early warning and response systems; (3) human capacity, livelihoods and social protection; and (4) catchment protection and management.

The NRS is intended as a platform to convene all stakeholders in establishing a multi-sectoral programme of complementary interventions, targeting different population groups, to strengthen resilience to shocks and promote graduation pathways out of chronic poverty. It focuses on mainstreaming DRM across all technical sectors and administrative levels, through initiatives to strengthen flood control, EWS and preparedness, response, and recovery (prioritising drought and

flood). Mainstreaming activities include technical training and conducting risk and multi-hazard assessments (supported by improved data collection and analysis of risk information) to guide development planning, map risk exposure and improve community access to risk information. The NRS supports inter-ministerial and community level coordination and operational protocols regarding EWS between the Department of Disaster Management Affairs (DoDMA) and other departments, ministries and government institutions; the Malawi Defence Force; district councils; Area Civil Protection Committees (ACPC) and Village Civil Protection Committees (VCPC); as well as international NGOs (INGOs), and NGOs supporting community-based EWS.

Institutions and organisations working on disaster management in Malawi

National early warning information is provided by the Department of Climate Change and Meteorological Services (DCCMS) and the Department of Water Services in Malawi. Warning communication in Malawi works through a largely top-down system, designed by national authorities, disseminating warning information from national to local levels.[34] The main national government institutions involved in generating, communicating and using EWS messages and warnings are:

- DoDMA, formerly under the Office of the President but now moved to the Ministry of Home Affairs and Internal Security in the Office of the President and Cabinet;
- DCCMS in the Ministry of Forestry and Natural Resources;
- Department of Water Resources (DWR) in the Ministry of Irrigation and Water Development.

Lack of integration between community- and national-level EWS presents a challenge to CBEWS sustainability and effectiveness in Malawi. This includes a lack of clarity about where different government institutions' responsibilities lie for coordination and dissemination of flood warnings.[1]

A key challenge to scaling up, institutionalising and making community-level pilots sustainable is ensuring that DRR is an integral part of district development planning and budgeting. The lack of funding to cover recurring EWS costs at local levels has been a key constraint to enhancing risk and EWS.[22] The UNDP (2013) noted the need for ownership of projects by government structures (in particular, DCCMS, DWR and DoDMA) and for involvement of relevant government departments and local communities in design and implementation of project interventions.[30]

DoDMA, established in 1994, is the cornerstone government agency for DRM in Malawi, mandated to coordinate responses to disasters, and to disseminate warnings. It coordinates with other ministries and international partners through the National Disaster Preparedness and Relief Committee, and the UN cluster system. At district level, depending on the size of response, clusters are also established, led and supported by their District Civil Protection Committees (DCPC). DoDMA also houses the National Emergency Operations Centre whose responsibilities include monitoring hazards and risks, preparing and coordinating disaster management plans and activities, ensuring other agencies are informed, and issuing daily situation reports. DoDMA is understaffed, has limited capacity and resources to respond to floods, is heavily dependent on donor and INGO assistance (as revealed during the 2015 floods) and has weak outreach at local levels. It has sometimes suffered from institutional instability: in 2018 it was moved from the Office of the Vice-President to the newly created Ministry of Homeland Security, but moved back after the May 2019 elections. It has customarily relied on district councils, which have limited human resource capacity, to plan, implement and evaluate local early warning and disaster management activities.[30,35]

DCCMS is responsible for weather and climate monitoring and forecasting, collection and management of weather data, and providing forecasts, seasonal outlooks and long-term climate change planning to national partners and different sectors. It oversees the National Forecasting

Observatory and manages the national weather and climate observation network. In 2015 these comprised full synoptic meteorological stations, aviation synoptic stations, automated weather systems (AWSs), rainfall logging gauges, volunteer observing stations, a satellite receiving station and stations at Chileka and Lilongwe International Airports. At that time, it was said to have a number of qualified staff, but lacked the infrastructure and technology to fully realise its mandate.[36] Forecast information from DCCMS is generally valued, widely accepted and trusted, but said to require higher spatial resolution (at a minimum: district level). Radio and extension officers are the most trusted communicators. There are two main forecast sources for smallholder farmers: forecasts based on local knowledge and forecast based on scientific models made by DCCMS.[37]

DWR is responsible for development and management of ground and surface water resources, water quality, administration of the Water Resources Act, and implementing regional and international agreements and obligations on transboundary water courses. It has previously received support through investment programmes funded by the African Development Bank (AfDB) and the World Bank to address capacity and infrastructural constraints.[36]

Several parts of government, particularly DoDMA and DCCMS, are involved in the annual production and distribution of seasonal forecasts from national to district levels. Forecasts are disseminated by DCCMS and DoDMA staff to district councils, which take the information to ACPCs and VCPCs for further dissemination. Agricultural extension services play an important role in translating seasonal forecast information into agricultural advice for farmers.[37]

The **Malawi Vulnerability Assessment Committee** (MVAC) is a multi-stakeholder committee (with members from government, UN organisations, NGOs and civil society) mandated to assess annually food and nutrition insecurity and needs for lean season programming and response (usually by the Government of Malawi Z GoM, an INGO consortium, and the World Food Programme and its NGO partners). MVAC provides regular drought vulnerability updates and early warning information relating to food security, which is used to assign funds, identify priority areas for disaster reduction and food aid dissemination, and develop national policy. It uses indicators from partner organisations, the DCCMS, the Famine Early Warning Systems Network (FEWSNet) and NGO structures. Historically, most responses have been in-kind (i.e. food), but use of cash is growing.[29,36]

NGOs and civil society organisations (CSOs) tend to be more involved in localised EWS activities, particularly working with communities. CSOs play an important role in CCA and DRM programmes and activities. Their entry point to communities is primarily through vulnerability assessments: vulnerability is conceptualised here in relation to specified outcomes (chronic poverty, malnutrition) mediated by household responses (coping strategies) and policy interventions (risk reduction, risk mitigation, risk coping).

Many NGOs have experience in leading and implementing DRM and CCA projects and activities, such as implementing CBEWS and capacity building of Civil Protection Committees (CPCs).[37] For example, GOAL Malawi provides food and non-food items to flood-affected families, supports food-insecure households through food and cash distributions in the lean season, works with DoDMA to build CPCs' capacity, and supports community hazard mapping and warning system development.[38] It has also subsidised the costs of mobile phone access to weather and climate information and crop advisories for smallholder farmers.[36] NGOs were involved in the design of the UNDP's Least Developed Countries Fund (LDCF) project (2013-17) through a DIPECHO consortium led by Christian Aid, and the DISCOVER consortium led by Concern Universal.[30]

Local institutions play an important role in flood risk management at local level. **Village and Area Civil Protection Committees**, religious institutions and community-based organisations (CBOs) are frontline decentralised institutions, disseminating early warning information, providing community-

level coordination and carrying out preliminary disaster impact assessments. VCPCs and ACPCs are prominent in flood risk management, mediating between communities, NGOs, and government stakeholders. While the committees provide a structure for facilitating local-level DRM, they function only in areas with NGO projects, and they may not be sustainable after projects come to an end. Most VCPCs have limited capacity, do not have trained personnel and in some cases exist only on paper. Most ACPC and DCPC members in district councils have not been trained in disaster management, climate change and how to use climate risk/early warning information. An assessment in 2015 recommended regular training of DCPC members and community members involved in response and using climate risk/early warning information, by DoDMA in collaboration with DCCMS and DWR.[36] District assistance is often provided too late to save assets; and local risk assessments and EWS are upgraded and updated infrequently.[30]

Community participation in consultation, design and implementation of flood management projects is often limited mostly to working with VCPCs, predominantly in areas where NGOs have active projects; but these often cease to function after the project ends, and they may suffer from 'elite capture' by influential individuals such as traditional leaders and chiefs.[39,40]

NGO-assisted **community-based approaches** contribute to sustainable, locally accepted and locally owned interventions. For example, a partnership of the Evangelical Association of Malawi, Christian Aid and the Chikwawa District Assembly, with DIPECHO funding, implemented a community-based disaster preparedness and response project to develop a people-centred EWS that was understood, used and maintained by communities. The project established rainfall and river water data collection systems and a community information dissemination system in 12 villages, targeting 1,289 households. This protected 6,660 people and their assets in Chikwawa, although lack of funding prevented it from being extended to other rivers.[37] NGOs may also fund projects that include dissemination of forecast information: usually only a few districts are targeted due to capacity limitations, but in 2018/19, NGO funding was said to have enabled distribution of a seasonal forecast to all districts.[37] The Malawi Red Cross Society, with 33 divisions and a network of 76,000 volunteers, is a major actor in response and is present in all 28 districts of Malawi. It works with DCCMS to disseminate early warning messages.[41]

The **private sector** is a potentially important partner in EWS, principally through risk transfer mechanisms such as insurance relating to floods or droughts. There is a need for further research on how the private sector does and can support CBEWS and the national EWS system through engagement in monitoring and dissemination of risk information (e.g. by mobile service operators and agro-dealers), which is not yet well documented for Malawi.

Social networks also play a role in community-level DRM: for example, community members helping each other to strengthen houses, moving livestock to relatives and friends in safer locations, borrowing canoes from neighbouring villages, helping one another during evacuations, and seeking shelter with relatives or other community members.[39] Platforms and networks such as Weather Chasers and the Civil Society Network on Climate Change are important platforms for exchange and dissemination, including for early warnings. **Local, informal and indigenous knowledge** of coping and adaptation strategies in flood and drought EWS, early action and DRR appears to be largely overlooked and underutilised in Malawi. It does not receive much attention in the 2015 National DRM Policy and is not apparently integrated into local government contingency planning.[39]

5. Challenges and opportunities to sustainable EWS in Malawi

Challenges

Lack of continued domestic funding for EWS

Arguably the most significant challenge to sustainable EWS, which is consistently identified in various reports and documents over time, is the GoM's high level of dependence on international development funding. This is because GoM does not have capacity to facilitate and deliver DRM widely at local scales, primarily due to lack of financial resources.[35] For example, a $14.9 million programme for strengthening climate information and EWS (2013-17), executed by DoDMA, in partnership with a number of ministries and departments,[C] was funded by the UNDP[30].[D] The Green Climate Fund has funded improvement and scaling up of weather and climate agricultural advisory services in 21 districts during the six-year, $16 million M-CLIMES programme.[42] The DWR has received support from the AfDB and the World Bank to address capacity and infrastructural constraints. The Department For International Development (now FCDO) provided 82% of the funding for the Enhancing Community Resilience Project; FEWSNet (funded by USAID) provides information on drought impacts and famine risk. The World Bank has invested in the Shire River Basin Management Project and Integrated Flood Risk Management Strategy, and is funding the Malawi Flood Emergency Recovery Programme (2015-19) and the Malawi Drought Emergency Recovery Programme (2017-21).[43] Human Network International and Catholic Relief Services have paid for telecommunication services to small-scale farmers. Private sponsorship is said to be more likely where the private entity has a commercial interest (the Bank of Malawi wanting to help farmers who have taken out loans). Many CBEWS are implemented through NGOs and CSOs.[36]

The GoM's 'heavy reliance' on donors and emergency response (with relatively limited resources dedicated to government agencies for DRM) and the limited capacities for ongoing operation and maintenance of installations such as AWS and automated EWS, has implications for the sustainability of the structures and systems concerned.[1]

Gaps in technical and operational capacities

Malawi's climate information and EWS infrastructure and technical capacities currently have limited ability to monitor and forecast weather conditions, communicate warnings, respond to disasters and plan for long-term transformational changes in socio-economic development. Improving management of climate-related hazards requires: enhancing the capacity of hydro-meteorological services and networks to understand and predict climatic events and associated risks; developing more effective and targeted delivery of climate information (including early warnings); and supporting improved and timely responses.[33]

[C] Ministry of Environment and Climate Change Management (Department of Climate Change and Meteorological Services, Environment Affairs Department, Department of Forestry, Department of Surveys), Ministry of Water Development and Irrigation (Department of Water Resources), and Ministry of Agriculture and Food Security.

[D] This aimed to establish a functional network of meteorological and hydrological monitoring stations and associated infrastructure to better understand climatic changes; develop and disseminate tailored weather and climate information (including early warnings) to meet the needs of end-users in seven disaster-prone districts; integrate weather and climate information and early warning systems into national sector-specific policies and district development plans in at least seven districts; and establish cooperation agreements with national hydro-meteorological counterparts in Mozambique to improve warnings.

An integrated, people-centred EWS is central to effective disaster preparedness and response. The need for national guidelines for developing and implementing EWS projects in Malawi has long been noted.[30] Many EWS projects have been implemented by state and civil society organisations in response to drought and flood crises, but often with limited horizontal or vertical coordination between projects and actors.[30] EWS are not fully integrated or comprehensive. Equipment and processes for gathering data are insufficient, outdated or do not work adequately. Flood EWS mostly cover major rivers, dissemination of early warning information to communities is challenging, and there is a lack of knowledge and capacity at community level to take action.[28]

There is a history of significant capacity limitations in Malawi's climate change and meteorological sector regarding infrastructure, availability of trained personnel, prediction, technology usage, data processing, and information dissemination. A 2015 report stated that DCCMS was unable to carry out numerical modelling due to limited availability of forecasting equipment, including modern meteorological facilities and human resources; and DCCMS did not have the technical capacity to conduct accurate and fine-scale short-, medium- and long-term forecasting, particularly for droughts.[36] There are many gaps in the observation network; communication and dissemination of meteorological information does not always meet WMO standards; and use of cutting-edge meteorological technologies is limited. Most DCCMS stations (manual and automatic) need rehabilitation and lack the full complement of equipment and sensors needed to function efficiently. AWS capacity is reduced by vandalism, shortage of spare parts, inefficient maintenance and inaccurate calibration. Reporting of information from manual stations is frequently inaccurate or does not happen, due to lack of diligence or technical capacity to collect and transmit readings via mobile phone, telephone or radio. Data collection and transmission from AWS and rainfall logging stations is hindered by limited airtime availability and expired software licenses. Manual systems are often used for data processing. There is continued vandalism of meteorological equipment (implying a need for community sensitisation to instil a sense of ownership of the equipment). There is little or no redundancy in monitoring and data communications networks.[36]

Development of mobile communications systems for EWS requires considerable technical resources, including programmers, servers, computers, GSM modems, internet access and airtime. Mobile phone networks, though extremely useful generally for disseminating warnings to community members, may struggle to operate in all conditions (e.g. where there is intermittent or no coverage, or electricity shortages prevent recharging). Short message service (SMS) texting is often too expensive for low-income end-users. Gauge readers have to work in sometimes hazardous conditions, and receive very little remuneration.[36] Investments are planned to modernise early warning communications mechanisms using ICT, such as SMS, at no cost to users.[33]

The drought EWS involves institutional stakeholders at different levels to provide a seasonal forecast, agreed at the Southern African Regional Climate Outlook Forum (SARCOF)[E] and by DCCMS in Malawi. Seasonal rainfall forecasts are downscaled to national level and disseminated by DCCMS to local communities through agricultural and disaster management departments. A range of dissemination methods are used to ensure maximum outreach to farmers, but access to warnings is affected by lack of staff capacity and availability of mobile phones, radio sets or internet connections. Timely release of seasonal forecasts, tailoring and timing of drought warning content to agricultural practices and decision-making, and use of multiple dissemination channels are said to enhance trust and improve farmers' uptake of warning information.[34]

The UNDP's LDCF project (2013-17) aimed to generate improved climate information at a national

[E] SARCOF is an annual conference organised by the WMO for Southern African Development Community countries to provide the seasonal outlook for the year.

level, and activate communication channels and procedures for issuing alerts at national and local levels, through radio and mobile-based alert platforms in 15 priority districts. It included technical capacity building for government departments, engaging local communities in EWS development and operation, and creating sustainable revenue streams for DCCMS through the provision of climate services and products. Involvement of government institutions and departments (in particular, DCCMS, DWR and DoDMA) was said to provide potential for future incorporation of the project's approaches into ongoing planning and strategies, while capacity building of key government stakeholders would enable mainstreaming of climate information and early warning into sectoral planning and decision-making.[30] It is not clear how far these aims have been realised.

There is relatively little information on human resources and skills for developing tailored products and scaling up EWS. Skills and staff shortages have often been identified as a challenge. However, there appear to be high levels of enthusiasm to learn new skills, particularly for programming and producing tailored information products. The GoM's 2015 report on scaling up EWS called for DoDMA, the Ministry of Agriculture, DWR and DCCMS to work together more to share data and information.[36]

Limited integration of EWS across community, district and national levels

An EWS can be based in a community without being owned or driven by that community. However, the most lasting impact occurs when a community has a strong understanding of the EWS. Lack of integration between community- and national-level EWS in Malawi poses a challenge to effective CBEWS. A significant challenge to scaling up, institutionalising and raising the sustainability of community level pilots is ensuring that DRM is an integral part of district development planning and budgeting. The absence of funding to cover recurring EWS costs at local government and community level has been a key constraint to enhancing EWS. Other areas that might help overcome some of these challenges, but are yet to be explored, include the potential role for the private sector to support early warning and for telecommunication networks and mobile phones to be used in EWS communications and flood warning.[22,36] Exploration of such issues needs to be underpinned by a solid understanding of how people interpret, understand and act on warnings, based not only on risk perception but also belief systems, cultural attitudes towards risk, livelihood activities and experiences, and the degree of household involvement in DRM and EWS initiatives.[1]

Opportunities

Participatory tools and approaches

Participatory Scenario Planning (PSP) has been used in some districts in Malawi since 2015-16 to produce sectoral and livelihood advisories for decision-makers, based on locally downscaled weather forecasts. PSP is effective in generating usable weather information that users trust. It is inclusive and accessible, and enables dialogue and knowledge sharing between communities and technical experts, and different scientific and local knowledges. So far, scaling up and sustainability of PSP in Malawi face technical, financial, and institutional barriers and it gets relatively little attention in the 2019 National Meteorological Policy and its use tends to be confined to individual projects. Nonetheless, there are opportunities to reinforce participatory tools and approaches in Malawi through integration in planning frameworks and being embedded in formal governance structures.[45]

The Participatory Integrated Climate Services for Agriculture (PICSA) approach supports informed decision-making by farmers based on accurate, location-specific, climate and weather information; collective analysis of information on crop, livestock and livelihood options and their risks; and participatory planning and decision-making. It is effective and trusted, but only available in certain regions of Malawi.[46] Evidence from Senegal and Mali shows that PICSA enables farmers to make

strategic plans and stimulates adaptive farming practices, with positive impacts on income and food security, wellbeing and confidence in ability to address climate change and variability.[47,48] Uptake and sustainability of PICSA by farmers in Malawi is likely to face constraints relating to availability both of (donor) funding and (government) extension officers, and may require development of more innovative approaches to service provision (e.g. involving private sector partnerships).

Ensuring early warnings result in anticipatory action

The World Food Programme, the government and external partners are seeking to integrate forecast-based action (FbA) into social assistance programmes and humanitarian response.[F] Work has begun on building an FbA system and working with partners to establish criteria to trigger different actions. FbA can link scalable social assistance programmes to climate forecasting, and define triggers to respond to shocks in advance. Ensuring financial sustainability is challenging. Ad hoc humanitarian funding is likely to be unsustainable, due to donor conditionality and uncertainty regarding availability of resources. Combining funding from different sources (i.e. contingent funding from regular programmes, aligned with humanitarian funding for unpredictable shocks) may be more effective in terms of public financial management, reporting, timeliness and accountability.[29,44]

Public private partnerships to support operations and financial viability of EWS

The GoM's report for the Green Climate Fund on scaling up EWS and use of climate information in Malawi, from 2015, pointed out that a sustainable EWS/weather and climate forecasting infrastructure requires sustained operations and maintenance (O&M) capacities, including technologies, human resources and financing.[36] In turn, these require leveraging of domestic as well as external technical and financial resources, training and other forms of capacity building for sustained O&M, and exploring partnership opportunities. Capacity-building activities that have been recommended, based on operational experience, include technical training on O&M equipment and techniques. Training of trainer approaches (for staff and communities) should reduce reliance on external technical consultants over the medium to long term. O&M costs for EWS are mostly provided by DCCMS, DWR and DoDMA through their budget allocations, but it seems to be generally agreed that additional resource streams are needed. Public-private partnerships could potentially support the operations and financial viability of EWS, critical infrastructure, and national hydro-meteorological services. This will require appropriate policy, institutional and financial arrangements.

[F] FbA is "the use of climate or other forecasts to trigger funding and action prior to a shock or before acute impacts are felt".[44]

6. Conclusions

Development of an effective and sustainable warning communication and dissemination process (principally for floods and drought/food insecurity) is recognised as a major challenge by the GoM and its development and humanitarian partners. Many national policies and strategies relating to weather, climate variability, climate change, climate information and early warning systems (EWS) have been introduced or revised by GoM in recent years, to create a more robust policy architecture for DRM, including EWS.

However, there are barriers that must be overcome to establish effective EWS that are sustainable over time. These include: limited financial resources, technological forecasting capacity; skills and staff shortages; and inefficient coordination of weather and climate information dissemination, including early warning preparedness and response. The lack of funding to cover EWS operating costs, particularly at local levels, has been a key constraint. The government is heavily dependent on international donors and emergency response; and lacks capacity to facilitate and deliver DRM widely at local levels. The limited capacity for ongoing operation and maintenance of EWS equipment and installations has implications for the sustainability of these structures and systems.

Warning communication is largely top-down in Malawi. There is limited horizontal or vertical coordination across different levels and actors. Equipment and processes for data gathering and sharing are insufficient, outdated or do not work adequately. Flood EWS mostly cover major rivers, dissemination of early warning information to communities is challenging, and there is a lack of knowledge and capacity at community level to drive effective action. Local institutions (VCPCs, ACPCs), religious institutions, and CBOs play an important role in local-level flood risk management but have limited capacity and training. Community participation in consultation, design and implementation of flood management projects often ceases after the project ends.

The private sector is a potentially important partner in EWS, for instance through the development and operation of risk transfer mechanisms such as flood or drought insurance. There is a need for further research on how the private sector can support local and national EWS through engagement in monitoring and dissemination of risk information.

Future research on EWS in Malawi should examine how sustainability principles and practices can be incorporated more thoroughly and effectively into EWS design and operation. This can build on the challenges and opportunities for EWS sustainability identified in this discussion paper on the basis of global experience and past research (Section 3), as well as Malawi more specifically (Section 5). Relevant sub-questions for further research are listed in Box 3.

Box 3: Proposed questions for further research on the sustainability of EWS in Malawi

Overarching research question: How can sustainability principles and practices be incorporated more thoroughly and effectively into EWS design and operation in Malawi?

Sub-questions:

1. What are the main elements (resources, actions, capacities, etc.) needed to make EWS sustainable in Malawi? What are the main opportunities and barriers to achieving sustainability and reliability?

2. What legislation, strategies/plans, business models, protocols, memoranda of understanding, standard operating procedures (at national and sub-national levels) exist that can support and strengthen EWS sustainability? How effective are they?
3. Is human, technological, institutional and political capacity sufficiently reliable, adaptive and effective to support sustainable EWS? What are the main capacity strengths, weaknesses and gaps? What resources and investments (institutional, human, political, financial, etc.) are needed to create and sustain capacities for effective EWS in Malawi?
4. Are EWS supported by sustainable, multi-year funding streams (public and private sector)? What is done/could be done to address funding gaps?
5. How can EWS be linked or aligned more efficiently with other climate services?
6. How strong are EWS links with private sector actors and what opportunities are there to promote long-term partnerships?
7. How can hydro-meteorological data collected, analysed, stored and shared more effectively with different end users? How can EWS data be better used or integrated into other decision-making structures (e.g. social protection, wider risk management)?
8. How can EWS data be used more effectively to support public communication of risks and issuing of warnings? What training in public communication and engagement could be given to scientists and technical staff?
9. What M&E mechanisms and systems are needed to strengthen accountability for the sustainability of EWS in Malawi?

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