

# EARLY WARNING SYSTEM TOOLKIT

A guide for practitioners in Mangochi and Salima Districts



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# ACRONYMS AND ABBREVIATIONS

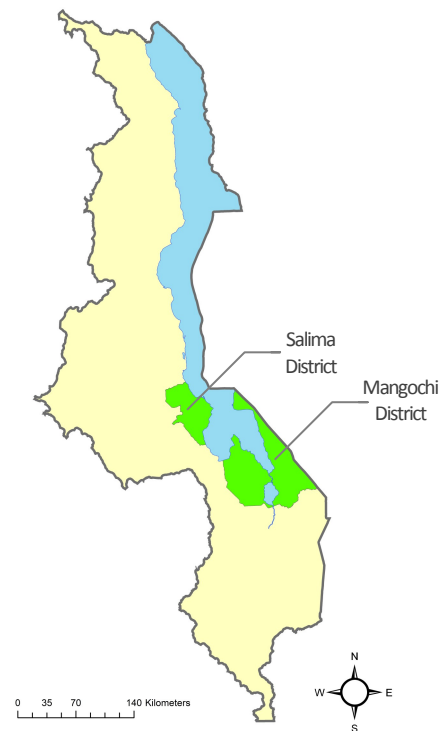
ACPC	Area Civil Protection Committee	DRR	Disaster Risk Reduction
APES	Agricultural Production Estimates Survey	EPD	Extension Planning Division
COOPI	Cooperazione Internazionale	EWS	Early Warning System
DCCMS	Department of Climate Change and Meteorological services	MVAC	Malawi Vulnerability Assessment Committee
DCPC	District Civil Protection Committee	NSO	National Statistics Office
DEC	District Executive Committee	RATS	Response Across Time Scales
DODMA	Department of Disaster Management Affairs	UNDP	United Nations Development Programme
DRM	Disaster Risk Management	VCPC	Village Civil Protection Committee
		WMO	World Meteorology Organisation



# PURPOSE OF THE TOOLKIT AND ITS USE

This toolkit is designed to support the hazard and vulnerability mapping of Mangochi and Salima Districts. It aims to provide an introduction and practical guide to implementing and utilising existing vulnerability integrated, multi-hazard early warning systems at district and community levels. The hazards covered include: Drought, Floods, Army Worms, Cholera and Wildlife/ Human Conflict.

The toolkit is aimed at Disaster Risk Reduction (DRR) stakeholders and practitioners. All information has been prepared in line with principles outlined in the Disaster Risk Management (DRM) training manual issued by DODMA (2016), the National Disaster Risk Management Policy (2015), The Disaster Risk Management Operational Guidelines (2016), along with international best practices.



# INTRODUCTION TO THE DRM CYCLE

## Mitigation

Public Education  
Improved Infrastructure

## Preparedness

Early Warning Systems

Emergency Response & Contingency Plans

Training & Drills

EVENT

## Recovery

Economic Recovery  
Housing  
Health and Social Services  
Psycho-Social Support

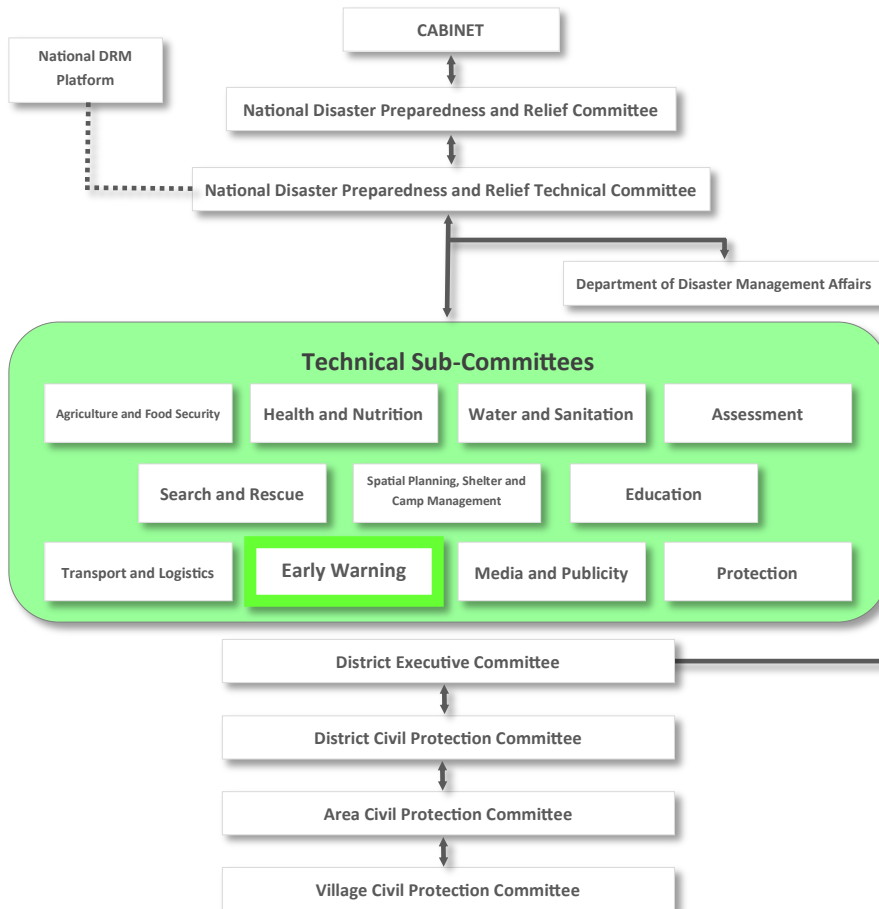
## Response

Life Safety  
Evacuation Shelter & Registration  
Research & rescue  
Distribution of Basic Needs  
Mass Care  
Incident Stabilisation

The DRM Cycle is established in 4 phases which happen before, during, and after the 'event' of a disaster.

EWS are part of the 'preparedness' phase, and can play a significant role in limiting the negative impacts of a disaster.

# NATIONAL DRR FRAMEWORK



Nationally, DRR stakeholders and structure are set up as per the diagram indicated left. This framework is laid out in the *'Government of Malawi Disaster Risk Management Operational Guidelines'* (2016).

Note that this framework includes committees and stakeholders that relate to all sections of the DRM Cycle (page 5). Early warning is indicated as being one of the overall DRR framework yet its role in risk reduction and management is critical.

Within the structure, the Civil Protection Committees (DCPCs, ACPCs & VPCs) have an important function in both Disaster prevention and response.



# WHAT IS AN EARLY WARNING SYSTEM?

An EWS represents the set of capacities needed to **generate** and **disseminate timely** and **meaningful** warning **information** that enables at-risk individuals, communities and organizations to **prepare and act appropriately** and in **sufficient time to reduce harm or loss** (IFRC 2014).

According the WMO: “The primary objective of a warning system is to **empower** individuals and communities to **respond timely** and **appropriately** to the **hazards** in order to **reduce** the **risk** of death, injury, property loss and damage. Warnings need to get the message across and stimulate those at risk to take **action**.” (Benchwick 2016)

## The Key Elements Are:

- A system involving monitoring, generation and communication of information
- Multiple actors, stakeholders and communication mediums
- Should result in action to reduce risk and loss



**EARLY WARNING**

# COMPONENTS OF AN EARLY WARNING SYSTEM

An EWS is usually made up of the following components:



**Risk Knowledge:** Risk is a combination of both hazards and vulnerability. This entails an understanding of risk by all stakeholders at all levels. This includes:

a) Natural Hazards: a process or a natural phenomenon that can cause death, injury or other negative impacts on health, property, livelihoods and services and other social and economic problems, as well as environmental damage (UN/ISDR 2009)

b) Vulnerability: the set of factors contributing to the fragility of essential elements of a territory including the population, such as the weakness of institutions, structural and economic problems of accessibility (UN/ISDR 2009). This includes exposure to hazards, as well as aspects that can generate a better resistance to a disaster, such as the existence of alternative energy supplies or disaster preparedness plans.



**Monitoring:** Once risks are understood, the hazards and vulnerability levels need to be monitored and measured in order to detect possible changes that may need to be communicated. Monitoring of hazards entails a combination of instruments, knowledge and systems.

It is important to also monitor changing vulnerability levels as these can result in communities being in need of assistance despite relatively 'normal' hazard conditions.



**Dissemination & Communication:** Information gained through monitoring needs to be communicated to relevant stakeholders and communities in an accessible format. Staged warning can be a useful tool in this regard, using a grading scale (green, yellow, red) depending on the level of risk.

# COMPONENTS OF AN EARLY WARNING SYSTEM



**Response Capability:** This represents the ability of stakeholders and communities to take action based on information received. Early warning

systems are only considered successful if action is taken based on the information received.

Importantly, response in this case refers to actions taken in response to a warning (as opposed to responding to the disaster itself). Recipients of information need to be primed for this with the understanding, systems and capability to make decisions based on the information communicated. As such, response capability is important for both district level stakeholders and communities.





# HAZARD BASED EWS AT DISTRICT LEVEL



## Army Worms

Army worms are a regularly experienced hazard in Mangochi and Salima. Potential consequences of army worm invasions can be devastating. In light of this, the Army Worm Early Warning System is one of the most active and functional systems in place.

**Risk Knowledge:** The system is embedded within the department of Agriculture who, along with farmers, are

well versed with the risks and manifestations of the pest.

**Monitoring:** Monitoring is conducted through the agricultural extension services who have traps set in every EPD and regularly monitor levels of infestation. Indigenous warning signs include higher concentrations of butterflies (Annex A).

**Communication & Dissemination:** When levels of infestation are increasing, warnings are communicated by extension officers closest to the infestation. Communication occurs upwards to district level, to locally affected farmers, and extension officers in adjacent areas.

**Response Capability:** District officials respond by applying pesticides to prevent or contain any outbreak. Mobilisation time between receipt of warnings and application of pesticides is usually less than 48hrs.

# HAZARD BASED EWS AT DISTRICT LEVEL



## Floods

Mangochi and Salima are prone to regular flooding during the rainy season, particularly in low land areas. Systems feature a mixture of weather updates and river gauges. When considering early warning systems and flooding, it is useful to take a catchment or watershed approach.

**Risk Knowledge:** Flood risks and regularly affected areas are well known by stakeholders and affected

communities. These are clearly demarcated in the hazard and vulnerability maps for Mangochi and Salima Districts (See Annex 2 for link to maps).

**Monitoring:** Weather forecasts by DCCMS. Flow Rates by the Department of Water. River gauges by VCPCs.

**Communication & Dissemination:** Weather forecasts featuring heavy rainfall events are broadcast on local radio & communicated to DCPC members directly. River gauges readings and flood warnings are communicated from upstream to downstream VCPCs via phone, and vocal.

**Response Capability:** Community members need to stay clear from flood prone areas and use safe routes. High danger alerts may require temporary relocation to safe havens. Response by district officials includes mobilisation of activities and resources indicated in the district contingency plan.

# HAZARD BASED EWS AT DISTRICT LEVEL



**Drought**

Drought and dry spells represent slow onset hazards and are hence approached in a different manner to fast onset hazards.

**Risk Knowledge:** Agriculture is the major livelihoods source in the districts. District stakeholders and communities are therefore well acquainted with the risks associated. There is also a growing awareness of climate change which is projected to result in higher frequencies

and magnitudes of drought and dry spells.

**Monitoring:** Longer term seasonal forecasts and short term weather forecasts are produced by the DCCMS. Indigenous warning signs include weaver bird nests facing up, and heavy fruit bearing of mango trees (seasonal) (Annex A).

**Communication & Dissemination:** Seasonal forecasts pamphlet produced by DCMMS and distributed to DCPCs and ACPCs. Radio announcements of seasonal forecasts. Extension services communication of seasonal forecasts via community meetings. Electronic updates via the 3.2.1. system.

**Response Capability:** If warnings are received in time to adjust agricultural practices options open to farmers include: change of crop types, investment into irrigation, use of early maturing varieties, implementation of water conservation techniques, mulching, alternative livelihoods strategies (Income generating activities).



# HAZARD BASED EWS AT DISTRICT LEVEL



## Wildlife/Human Conflict

Wildlife in direct conflict with humans includes: elephants, warthogs, hippos and crocodiles. Given the unpredictability of the occurrence and challenges in response capability, effective early warning systems have posed a challenge.

**Risk Knowledge:** Dangerous areas are well known, yet unavoidable. The Lake and rivers are water sources while

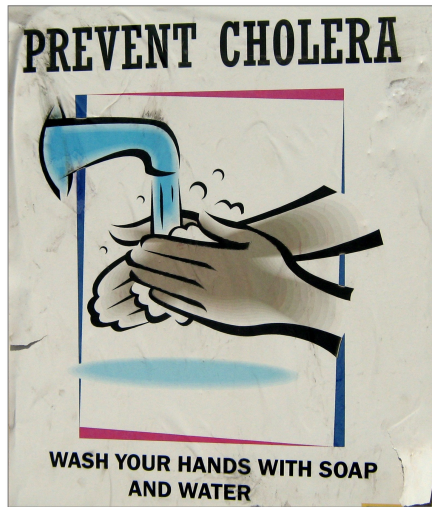
the forest and hill sides are required for resources and farmlands.

**Monitoring:** Mostly on an ad-hoc basis based on sightings by community members and local government officers.

**Communication:** Rangers are called by phone, often by one of the local extension officers from forestry, agriculture or health. Rangers are responsible for a huge catchment area and can take a long time to respond. Localised warning of communities is done through village criers and messengers.

**Response Capability:** Armed rangers deal with threats from dangerous wildlife.

# HAZARD BASED EWS AT DISTRICT LEVEL



## Cholera

Cholera is a hazard experienced primarily in the rainy season. Prone areas are often those that are also prone to regular flooding. Given the potential for spreading in rural areas, early warning systems are effective and functional.

**Risk Knowledge:** Cholera is a water borne disease with symptoms and causes that are well known.

**Monitoring:** Reports of possible cases in rural areas and confirmed cases at health centres, conducted by hospital and clinic staff.

**Dissemination and Communication:** Conducted by hospitals and the department of health to surrounding areas, hospitals and AEHOs.

**Response Capability:** Origin is established and teams mobilised by hospitals, clinics and the department to contain the spread of the disease. Mass vaccination campaigns can be deployed if mandated at central level.

# VULNERABILITY MONITORING AT DISTRICT LEVEL

The spatial index applies the IPCC conceptual framework, used to generate the vulnerability map on page 17 separates vulnerability into 3 components and incorporates 14 indicators: 6 related to **exposure** to hazards, 4 related to **sensitivity** to hazard impacts, and 4 related to **adaptive capacity** of communities to overcome the impacts. Each of the components is based on physical, environmental and socioeconomic indicators (see Annex 4).

Having a current understanding of vulnerability is important when considering EWS. In times when a more immediate and basic indication of vulnerability is required, information can also be obtained from the sources listed in Annex 2.

Component	Indicators
<b>Exposure:</b> The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected	flood frequency drought frequency precipitation wildlife incursions pests & cholera incidence wind & landslides
<b>Sensitivity:</b> The degree to which a system or species is affected directly or indirectly by climate variability or change. (e.g. directly: a change in crop yield in response to a change in the mean, range, or variability of temperature; indirectly: damages caused by an increase in the frequency of flooding)	population density poverty (<2 USD/day) soil organic carbon house building material
<b>Adaptive Capacity:</b> The ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences	anthropogenic biomes health centre access literacy school proximity
Definitions source: IPCC (2014)	



# USING HAZARD AND VULNERABILITY MAPS TO IMPROVE RISK KNOWLEDGE

When devising an effective EWS, it is essential that both the hazard maps and vulnerability maps (see pages 17 & 18) are used in conjunction:

- Hazard maps should be used to verify and locate areas which are prone to experiencing specific hazards for which a warning system and action plan needs to be developed and implemented.
- Vulnerability Maps can be utilised as a general overview to identify and prioritise target areas and populations that are would be severely impacted by hazards.

**Priority should be given to hazard prone areas of high vulnerability.**

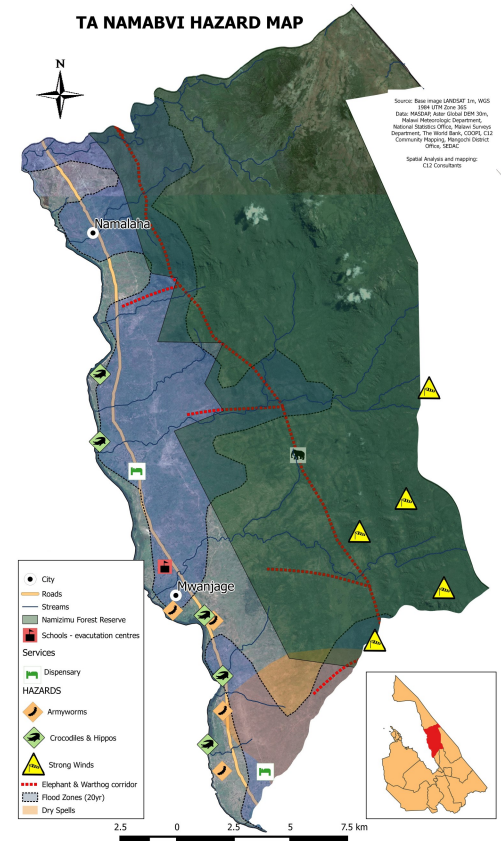


# HAZARD MAPS

**Hazard maps** are created by identifying and delineating locations of natural phenomena that represent a threat to communities. These locations can be georeferenced directly through field collection and input from communities (community-drawn hazard maps) or by computer modelling of hazards. The newly processed data is then plotted on the map.

As can be seen with TA Namabvi, hazard maps help identify the locations frequently susceptible to various natural hazard impacts (floodplains, wildlife corridors, areas prone to drought, places where cholera was reported, and others). They should be examined to review the types of hazards the area is facing and where each of the hazards is commonly present.

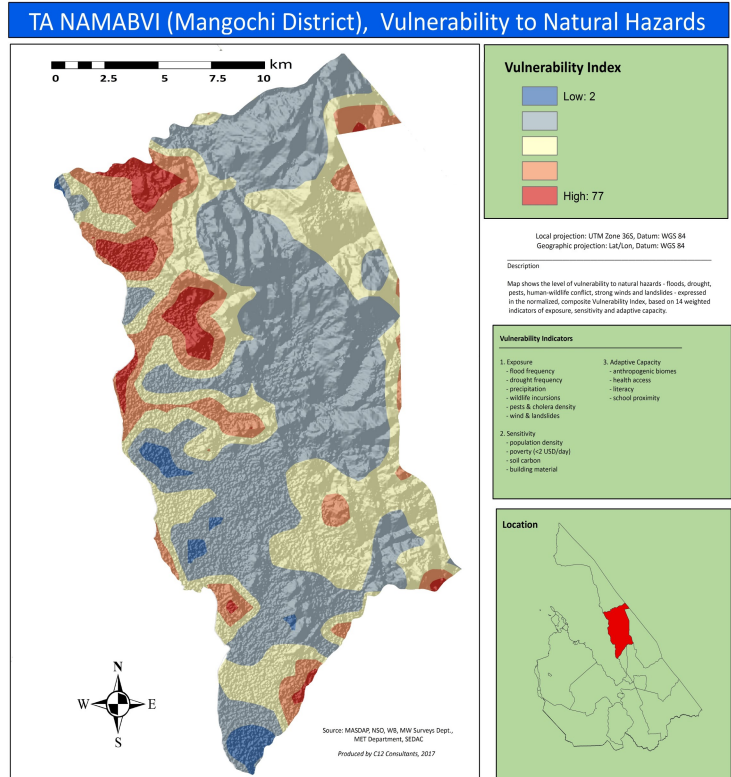
The main hazards experienced in Mangochi & Salima are: *Army Worms, Floods, Drought, Cholera, Human-Wildlife Conflict*, with occasional *Strong Wind* and *Landslides*.



# VULNERABILITY MAPS

**Vulnerability maps** are created through collection of published data (by various stakeholders) and field collected data (from communities) reflecting the chosen indicators. The data is spatially analysed and integrated to develop a composite Vulnerability Index which combines **EXPOSURE**, **SENSITIVITY** and **ADAPTIVE CAPACITY** of communities to hazards. (See Annex 4 for further details).

Vulnerability maps show how well different areas across the districts and TAs can withstand the onset of a natural hazard. The higher the index, the more vulnerable the community is. These maps should be examined not for specific hazards, but to identify hotspots of impact across the district. They can be used by district planners to pinpoint those areas that are most susceptible which can help in targeting early warning service needs and response interventions



# PREPARING COMMUNITIES FOR IMPLEMENTATION OF EWS: RISK KNOWLEDGE

Risk knowledge is the first component of an effective early warning system. Hence, preparing communities with the understanding of hazards, building capacities and organising community information is essential towards implementing localised EWS.

Key steps include:

- Explain the concepts of Hazards, Vulnerability and Community Capacity and identify local examples of each.
- Develop a hazard and vulnerability map of the area surrounding the community including: hazards, vulnerable areas/HHs, Safe zones, evacuation routes and sites.
- Together with the community, establish a list of resources that are available to the community, these can include existing communication systems,



organisational structures , infrastructure and local capacities.

- Conduct a risk prioritisation exercise. Taking into consideration likelihood (what are the chances an event will occur), and severity (how bad it is when it does occur). Rank risks in terms of priority.
- Outline an action plan for the establishment of early warning systems that ascribes clear roles and responsibilities for monitoring, communicating and responding.

# PREPARING COMMUNITIES FOR IMPLEMENTATION OF EWS: MONITORING

Monitoring requires the collection and measurement of information about hazards and vulnerability levels from multiple sources both within and external to the community. Key aspects of effective monitoring systems at community level include:

- Use locally appropriate, and hazard appropriate technologies for monitoring of information.
- Build the capacity of communities to monitor hazards and trends.
- Establish scenarios involving different timeframes for different hazards from 'real time' (flash floods, strong winds, wildlife), 'short term' (floods, Army worms, Cholera) to 'medium term' (drought & dry spells).
- Encourage public displays of monitoring, to motivate communities.
- Include and explore indigenous warning signs (see annex A) .
- Consider monitoring over a 24hr period.

Hazard	Monitoring Tool/Source
Floods	River Gauges
	Rain Gauges
	Flood Stage Markers
	Radio (weekly forecast)
Drought	Rain Gauges
	Groundwater levels
	Radio (seasonal forecast)
	3-2-1 Phone Platform (forecast)
Army Worms	Army Worm Traps
	Butterfly Populations
Cholera	Radio (Health Update)
Human/Wildlife Conflict	Watch rotas on exposed fields and common wildlife routes/habitat.



# PREPARING COMMUNITIES FOR IMPLEMENTATION OF EWS: COMMUNICATING

Warning communication is a key link between monitoring and response capability. It often involves three actors (with clearly assigned roles) for successful communication to take place:

- **The Author** (creates or assembles the contents of the alert message).
- **The Mediator**, transmitter or 'first receiver' (receives, reformulates and redistributes alert messages among at-risk recipients to suit local sensitivities).
- **The Recipient** or audience of the delivered alert message.

Information can be communicated in many ways, but it is important to remember fit the means of communication to the local context and hazard. With more immediate hazards such as floods this may entail use of whistles, drums and cell phones to alert

downstream communities. Regarding more long term hazards such as drought, community meetings can be called to explain and discuss the latest climate forecasts.

## A good early warning message must contain the following six elements:

1. **Timing:** When is the hazard due to strike?
2. **Location:** Which areas are going to be affected?
3. **Scale:** What is the magnitude of the hazard? (e.g., yellow/red)
4. **Impact:** What will be the effect on the communities and environment?
5. **Probability:** What are the chances of this happening?
6. **Response:** What should at-risk populations do to protect themselves?

# PREPARING COMMUNITIES FOR IMPLEMENTATION OF EWS: RESPONDING

Early warning systems are only considered successful if action is taken based on the information received. This requires a clearly defined community response plan as to what happens in any given situation; and importantly, who is responsible for which action. Key steps include:

- Ensure that action plans align with broader district policies and contingency plans. Include ACPD stakeholders input into the action plan to enable better coordination of response.
- Establish standard hazard based response options once warnings are received, including evacuation routes signalled by local signs.
- Conduct a scenario planning Respond Across Time Scales (RATS) exercise (e.g. Table to the right), to explore the various time-scales for which EWS must be poised to respond. This requires asking questions like: *‘what could you and those around you do today if you heard that a flood would strike next year, next season, next week, in eight hours or in 15 minutes?’*.

Simple **mitigation actions** that can be conducted at the community level may include: reinforcing river-banks with sand bags (for flooding), or clearing debris from channels and inhabited areas (limiting risk of flood and fire), temporary evacuation (flood and wildlife), or adopting drought tolerant crop species such as sorghum and millet for the upcoming season (drought).

RATS Exercise Template			
HAZARD:	(FLOODS)		
Lead Time of Message	Early Warning Message Says	Appropriate Actions that are feasible today	Early actions that could be possible with support
Years			
Months			
Weeks			
Days			
Minutes (Now)			

# OVERARCHING PRINCIPLES

Early Warning Systems are a critical component of disaster risk management. Investing in effective early warning can have a hugely positive impact on limiting the negative effects of disasters and building long term resilience of communities. In this respect, building capacity and motivation within communities to manage their own systems is essential. Some overall principles of community level EWS include:

- Keep it simple.
- Clearly define roles and responsibilities for monitoring, communication and actions.
- Convince community leaders of the value of EWS and obtain their support in implementing systems.
- Use locally appropriate technologies, systems and examples.
- Establish the concept of uncertainty in monitoring (one can rarely predict events to 100% certainty). Uncertainty does not mean that the information is of poor quality. It is better to be safe than sorry.
- Create threat levels and types of alerts. For instance, yellow, orange and red.
- Identify champions. Make sure village leaders, regional leaders receive early warnings and can activate local response and further distribution of messages.
- Include indigenous knowledge and systems.
- Ensure that activities are in line with district and national policies and systems.
- Take care to establish communication systems or chains across different levels (community to district).



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# ANNEX 1: INDIGENOUS EARLY WARNING SIGNS



Livelihoods in rural Malawi predominantly centre around rain fed agriculture, and have done so for generations. Within the communities natural signs and patterns are monitored which provide indications of weather trends from seasonal to short term time frames. A summary of these are indicated on pages 28-30, for more information please consult the Adapting to climate change: Indigenous knowledge booklet available at: (<http://www.coopi.org/category/paese/malawi/>)

# ANNEX 1: INDIGENOUS EARLY WARNING SIGNS

Timeframe	Sign	Description
Variable	Prevailing winds (direction)	<p>Local communities often have knowledge associating wind direction with particular rainfall patterns. For example, violent thunderstorms will usually come from a certain direction, or wind from a certain direction does not bring rain.</p> <p>Additionally, seasonal rainfall quantity and patterns can change if the prevailing wind direction is different. The implications of one direction over another differs depending on locality.</p>
Seasonal (months)	Bird nests woven with the hole facing up, down, or to the sides. Birds that do this are the black sunbird, scarlet sunbird, and the masked weaver	Birds building their nests will reflect the upcoming rainy season. If the hole faces up, the season will be dry. If the hole faces downward, it will be a very wet season. If the hole is to the side of the nest, it faces away from the prevailing wind (link to above point on direction).
	Termite hills with the hole facing in different directions	Similar to the nests above, the main entrance to the hill faces the opposite direction as that of the rainfall.

# ANNEX 1: INDIGENOUS EARLY WARNING SIGNS

Timeframe	Sign	Description
Seasonal (months)	Mango trees fruiting, the abundance of fruit	Mango trees fruit before the rainy season. If trees feature a bumper yield, it is likely that the upcoming season will feature poor rainfall.
	Grasses (Local name - Ndungo)	When this grass appears, the rainy season will start within the month.
	Swallows in flight	The rains usually start within the month after the first appearance of Swallows (birds)
Medium (weeks)	Appearance of Swallows (bird)	Swallows are migratory birds, the appearance of which heralds the imminent start of the rainy season. Once swallows appear, the rains are not far behind.
	Trees species sprouting leaves after the dry season.	Tree species sprout leaves when the rains are only weeks away. This is used to monitor the timing of the season. Trees include: Malambe (Baobab), Nthundu ( <i>Ficus Capensis</i> ), Mtondo ( <i>Cordia Africana</i> ), Mtumbu ( <i>Kirkia Acuminata</i> ), Mgoza ( <i>Sterculia Africana</i> ), Masau ( <i>Ziziphus Mauritiana</i> ), Kachere ( <i>Ficus Natalensis</i> )
	Very hot temperatures at night	Excessively hot temperatures at night are associated with the end of the dry season. The rains usually follow in the coming weeks.

# ANNEX 1: INDIGENOUS EARLY WARNING SIGNS

Timeframe	Sign	Description
Short Term (days, hours)	Termites storing food.	When there is a break in rainfall of a couple of days, these termites emerge from their holes to gather food . Once the rain is about to come, the termites disappear deep into their holes again. Sighting these termites gathering means there is no rain expected within the day.
	Egrets (cattle birds) flying away from the water sources	Egrets, also known as cattle birds are water birds. When heavy rain is likely, these birds leave the waterside and fly to upland areas.
	The cry of the Vulawe bird	The Vulawe bird is known to herald the coming of a rainfall event by loudly sounding its cry.



# ANNEX 2: USEFUL RESOURCES

MALAWI SPATIAL DATA PLATFORM (MASDAP)

<http://www.masdap.mw/>

DEPARTMENT OF CLIMATE CHANGE AND METEOROLOGICAL SERVICES

[www.metmalawi.com](http://www.metmalawi.com)

FAMININE EARLY WARNING NETWORK

[www.fews.net](http://www.fews.net)

RELIEFWEB

[www.reliefweb.int](http://www.reliefweb.int)

OPEN STREETMAP

[www.openstreetmap.org](http://www.openstreetmap.org)

COOPERAZIONE INTERNAZIONALE

[www.coopi.org/en](http://www.coopi.org/en)

HAZARD AND VULNERABILITY MAPS FOR MANGOCHI AND SALIMA DISTRICTS

<http://www.coopi.org/en/category/sectors/environment-and-disaster-risk-reduction-en/>

BOOKLET

<http://www.coopi.org/category/paese/malawi/>

WORLD METEOROLOGY ORGANISATION

[www.wmo.int](http://www.wmo.int)

THE INTERNATIONAL RESEARCH INSTITUTE FOR CLIMATE AND SOCIETY (EL NINO & LA NINA PROJECTIONS)

<http://iri.columbia.edu/our-expertise/climate/enso/>

NATIONAL STATISTICS OFFICE OF MALAWI

<http://www.nsomalawi.mw/>

REGIONAL CENTRE FOR MAPPING OF RESOURCES FOR DEVELOPMENT

[www.rcmrd.org](http://www.rcmrd.org)

District Vulnerability Data

Malawi Vulnerability Assessment Committee (MVAC)

Agricultural Production Estimates (APES)

National Statistics Office (NSO)

Department of Meteorology and Climate Change Seasonal Forecast (DCCMS)

Department of Disaster Management Affairs (DODMA)

# ANNEX 3: DISTRICT STAKEHOLDER ROLES AND RESPONSIBILITIES

Institution	Primary Hazard Early Warning Responsibility	Description	EWS Roles and Responsibilities
<b>Department of Agriculture</b>	Army Worms	Has a key role to play in terms of its penetration into communities through the extension system.	Monitoring: Army worm traps, crop yield estimates. (vulnerability) Communicating: seasonal climate information and extension messaging, army worm alerts. Responding: Application of chemicals, containment of armyworm outbreaks.
<b>Department of Climate Change and Meteorological Services</b>	Drought, Floods, Storms	Collects information on rainfall, temperature and wind speed and sends to the head office. Seasonal climate and short term weather forecasts are disseminated to all stakeholders.	Monitoring: Daily measurements of rainfall, temp wind and humidity. Regional and global climate patterns. Communicating: Short term weather forecasts, seasonal forecasts, extreme weather alerts.
<b>Department of Disaster Management Affairs</b>	Coordination on all hazards	Coordinates both risk reduction and disaster response. Focal point in times of emergency.	Monitoring: Vulnerability levels of communities. Communicating: Information on all hazards to stakeholders. Responding: Coordination of reaction to warnings.
<b>Department of Water</b>	Floods	Monitors water flow and quality in rivers and the lake.	Monitoring and communicating: flow rates and water quality.


# ANNEX 3: DISTRICT STAKEHOLDER ROLES AND RESPONSIBILITIES

Institution	Primary Hazard Early Warning Responsibility	Description	EWS Roles and Responsibilities
<b>Department of Health</b>	Cholera	Responsible for hospitals and health care.	Monitoring, communicating and responding to cholera incidence and treatment.
<b>Department of Education</b>	n/a	Schools and curriculum. Schools are often used as safe evacuation sites in times of crisis.	Communicating: Early warning alerts to learners and communities.
<b>Department of National Parks and Wildlife</b>	Wildlife/Human Conflict	Rangers are expected cover a wide area within the districts.	Monitoring: Wildlife conflict Communicating: Danger alerts to adjacent communities Responding: Reacting to incidents of wildlife/human conflict. Rangers often respond with lethal force.
<b>District Civil Protection Committee</b>	Coordination on all hazards	District level stakeholder coordination body on disasters made up of representatives from various departments.	Monitoring, communicating and responding to all hazards.
<b>Area Civil Protection Committee</b>	Coordination on all hazards	Area level stakeholder coordination body on disasters made up of representatives from various departments.	Monitoring, communicating and responding to all hazards.
<b>Village Civil Protection Committee</b>	Coordination on all hazards	Village level stakeholder coordination body on disasters made up of dedicated and respected community members.	Monitoring, communicating and responding to all hazards.

# ANNEX 4: VULNERABILITY INDEX

Component	INDICATOR	DATA SET (original data format)	SOURCE
<b>EXPOSURE</b>			RS*, Surveys Dept., C12 flood modelling, community mapping, Regional Center for Mapping of Resources for Development (RCMRD), Malawi Department of Disaster Management Affairs (DoDMA)
	Flood exposure 1999-2016	FLOOD_norm (raster, vector)	
	Drought exposure 1999-2016	DRGHT_norm (raster, vector)	RS*, community mapping, UNEP GRID, RCMRD, DoDMA
	Coefficient of Variation in Precipitation (October-March)	PRECIP_norm (raster, tabular)	Famine Early Warning Systems Network (FEWSNET), Climate Hazard Group InfraRed Precipitation with Station (CHIRPS) data, Malawi MET Dept.
	Crop pest exposure Human-wildlife conflict zones Strong winds and landslides	PEST (vector) WILDLF (vector) WIND_LDSL (vector)	Community mapping, district office
<b>SENSITIVITY</b>	Population density 2008	POPDENS_norm (vector)	NSO (Census) by EA
	Poverty level 2015	POV_norm (raster, vector)	RCMRD, WB microdata (Integrated Household Panel Survey - IHS 2010/11 and 2013)
	Building materials 2015	BMAT_norm (raster)	RS*, RCMRD
	Cholera incidence 2012-2016	VBD_norm (vector)	Community mapping, district health office
	Soil organic carbon 1950-2005	SOILCARB_norm (raster)	RS* RCMRD MASDAP
<b>ADAPTIVE CAPACITY</b>	Health infrastructure accessibility	HEALTH_norm (raster with point inputs)	MASDAP, RCMRD
	Anthropogenic biomes 2006	ANTHBMX_norm (raster)	RS* RCMRD
	School proximity	SCHOOL_norm (raster with point inputs)	District office, OSM, C12 spatial analysis
	Education level	LIT_norm (vector)	NSO, WB microdata

Each indicator was represented spatially and transformed to a common scale 0–100 (where 100 indicates high vulnerability). For the overall vulnerability index, the scores were averaged first by component and then by aggregated vulnerability index. (Based on the IPCC Conceptual Framework: IPCC 2014)



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