MEASURING VULNERABILITY TO ASSESS HOUSEHOLDS RESILIENCE TO FLOOD RISKS IN KARONGA DISTRICT, MALAWI

2023 Engineering Conference

Theme "Building Back Better"

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ACTIONS AND OPTIONS FOR BUILDING BACK BETTER

Presentation Outline

- **Background/problem/justification**
- **Methods**
- **Results**
- **Remaining gaps and urgent needs**
- **Conclusion, Recommendations and policy implications**

Background Information

Measuring vulnerability??

To build back better- WHAT WE NEED TO COUNT?

- Basis for resilience building (Hossain 2020; Munthali et al. 2022).
- Guide planners, engineers and contractors (resilient structures).
- Improve planning & community connectedness & risk ranking.
- Tool for disaster risk reduction (DRR) (mitigation, preparedness & advocacy), including resource availability and allocation.

- But-in Malawi **measuring vulnerability** is limited (NDRMP,2015) (basis of study gap). Impacting on planning for **decision making process.**

Vulnerability: complex conditions that interact with hazards (i.e. floods) to turn into a disaster **(Disaster Risk=Hazard x Vulnerability** (Wisner et al., 2004).

- Vulnerability is inherent in structural characteristics i.e. physical, economic, social, environmental elements and components (exposure, susceptibility and resilience).

METHODS

❖Quantitative study.

Vulnerability variables:

- **Vulnerability components (VCs)**
  - E = Exposure (vulnerability as inherent in locations)
  - S = Susceptibility (vulnerability DRR e.g. preparedness)
  - R = Resilience (vulnerability inherent in households activities)

Underlying Vulnerability factors (UVFs)

Physical environmental

social, economic conditions

Engineering/technocentric solutions-vulnerability conditions

Methods

Agglomeration to Derived Relationships in Regression Model as checked by VIF

Analysis Category	Model & interpretation
Binomial logistical regression	$$y_j = \sum_{i=1}^{i=n} \beta_i \, \delta_i^{O_i} + \epsilon_j \qquad (1)$$ y_j = (predictor from VCs), β_i (intercept generated in model); δ_i (response from UVFs); O_i (operator from scale); ϵ_j (error).
Relationships: (after VIF check-Multicollinearity)	$S_{ca} = \sum [\beta_i + (-)HR_{int} + (-)HS_{vint}]$ (link social & susceptibility: SSFs) (2)
	$E_{hmt} = \sum [\beta_i + (-)PC_{int} + (-)CM_{vint}]$ (link physical & exposure: PEFs) (3)
	$E_{ge} = \sum [\beta_i + (-)CL_{int} + (-)PML_{vint}]$ (link environmental & exposure: EEFs (4)
	$R_{ihh} = \sum [\beta_i + (-)PV_{int} + (-)AL_{vint}]$ (link economic & resilience=eco-resilience) (5)

Methods

Final Determination of Household Flood Vulnerability

Scale	FVI interpretation
Flood Vulnerability Index (FVI) (Balica et al., 2012; Kalaban et al., 2019).	0.32-0.40 =Very low vulnerability (VLV) 0.41-0.49 = Low vulnerability (LV) 0.50-0.59 = Moderate vulnerability (MV) 0.60-0.79 = High vulnerability (HV) 0.80-1.00 = Very highly vulnerability (VHV)

RESULTS

1. Physical Vulnerability

	Outcome % from participants views for physical vulnerability							
Measurement scale	**Construction of infrastructural facilities (roads, bridges etc)**		**Construction materials (burnt bricks with cement, burnt bricks with mud, sun dried bricks)**		**Knowledge on resilient structures (building typologies)**		**Location of built infrastructure (houses, toilets, schools)**	
	%	FVI	KD	FVI	KD	KD	KD	FVI
Less important	**6**	0.06	**10**	0.10	**3**	0.03	**7**	0.07
Important	**26**	0.26	**20**	0.20	**25**	0.25	**27**	0.27
Very important	**66**	**0.66**	**70**	**0.70**	**72**	**0.72**	**64**	**0.64**
Total Percentage	**100**	1	**100**	1	1	100	100	1

RESULTS

2. Environmental Vulnerability

	Outcome % from participants views for environmental vulnerability							
Measurement scale	**Pressure on cultivated land**		**Environmental mismanagement**	**Poor land management**		**Inappropriate use of resources**		
	%	FVI	KD	FVI	KD	FVI	KD	FVI
Less important	**12**	0.12	**3**	0.03	**4**	0.04	**7**	0.07
Important	**18**	0.18	**35**	0.35	**41**	0.41	**28**	0.28
Very important	**70**	0.70	**62**	**0.62**	**55**	**0.55**	**64**	**0.64**
Total Percentage	**100**	1	**100**	1	100	1	100	1

RESULTS

3. Social Vulnerability Factors

Measurement scale	Outcome % from participants views for Social vulnerability							
	Capacity to cope and anticipate floods		Social security		Human rights issues		Access to health services, water and sanitation	
	%	FVI	KD	FVI	KD	KD	KD	FVI
Less important	**1**	0.01	**6**	0.06	**4**	0.04	**1**	0.01
Important	**35**	0.35	**25**	0.25	**30**	0.30	**26**	0.26
Very important	64	**0.64**	**69**	**0.69**	**66**	**0.66**	**73**	**0.73**
Total Percentage	**100**	1	**100**	1	1	100	100	1

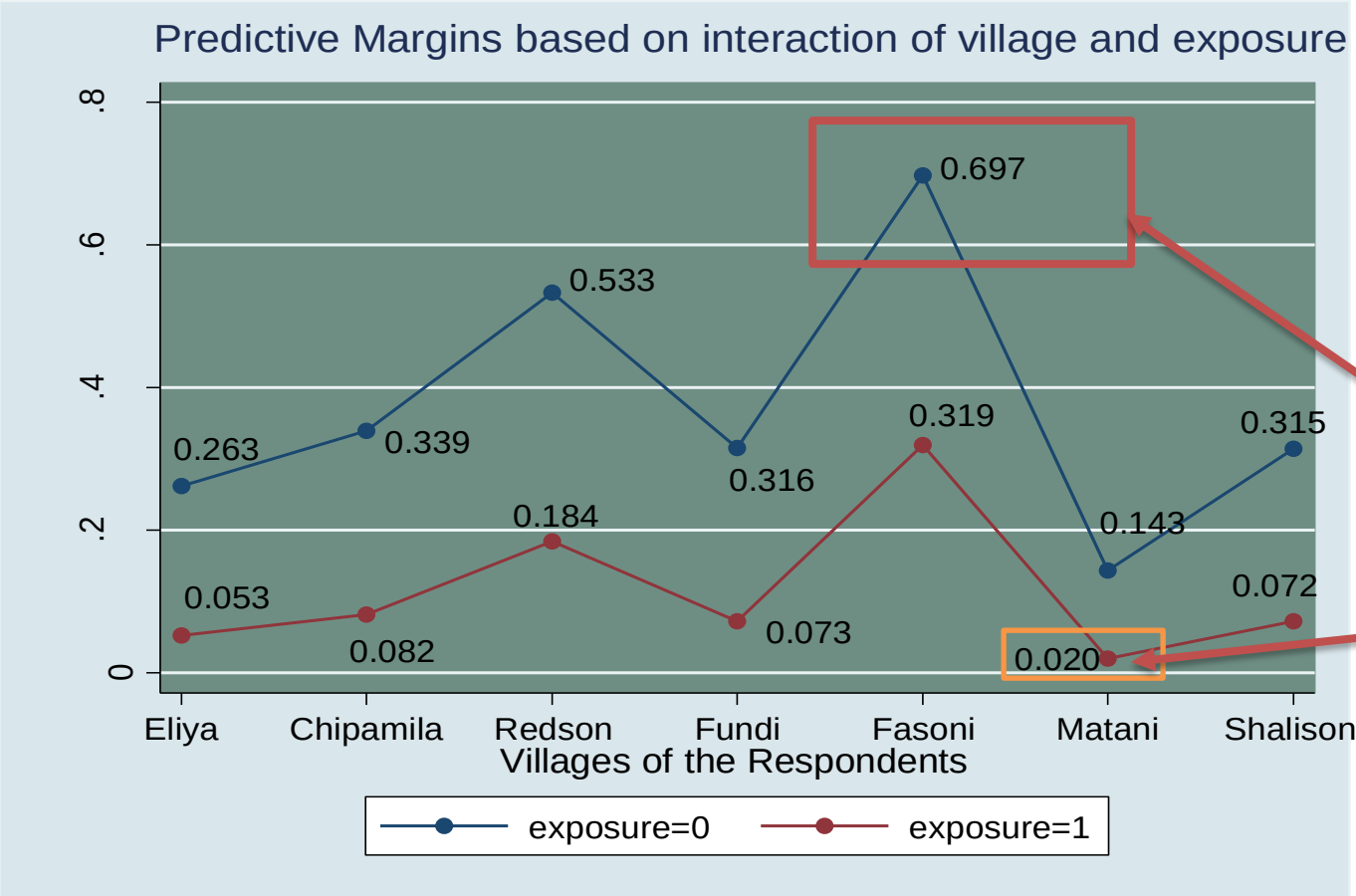
RESULTS

4. Economic Vulnerability Vulnerability

	Outcome % from participants views for economic vulnerability							
Measurement scale	**No credit unions/financial support**		**Income generating activities**	**Poverty**		**Lack of alternative livelihoods/crop diversification**		
	%	FVI	KD	FVI	KD	FVI	KD	FVI
Less important	20	0.2	34	0.34	3	0.03	4	0.04
Important	37	0.37	40	0.40	29	0.29	25	0.25
Very important	43	0.43	26	0.26	**68**	**0.68**	**71**	**0.71**
Total Percentage	100	1	100	1	100	1	100	1

RESULTS

Prediction Margins of villages based on Exposure.



Key Results :

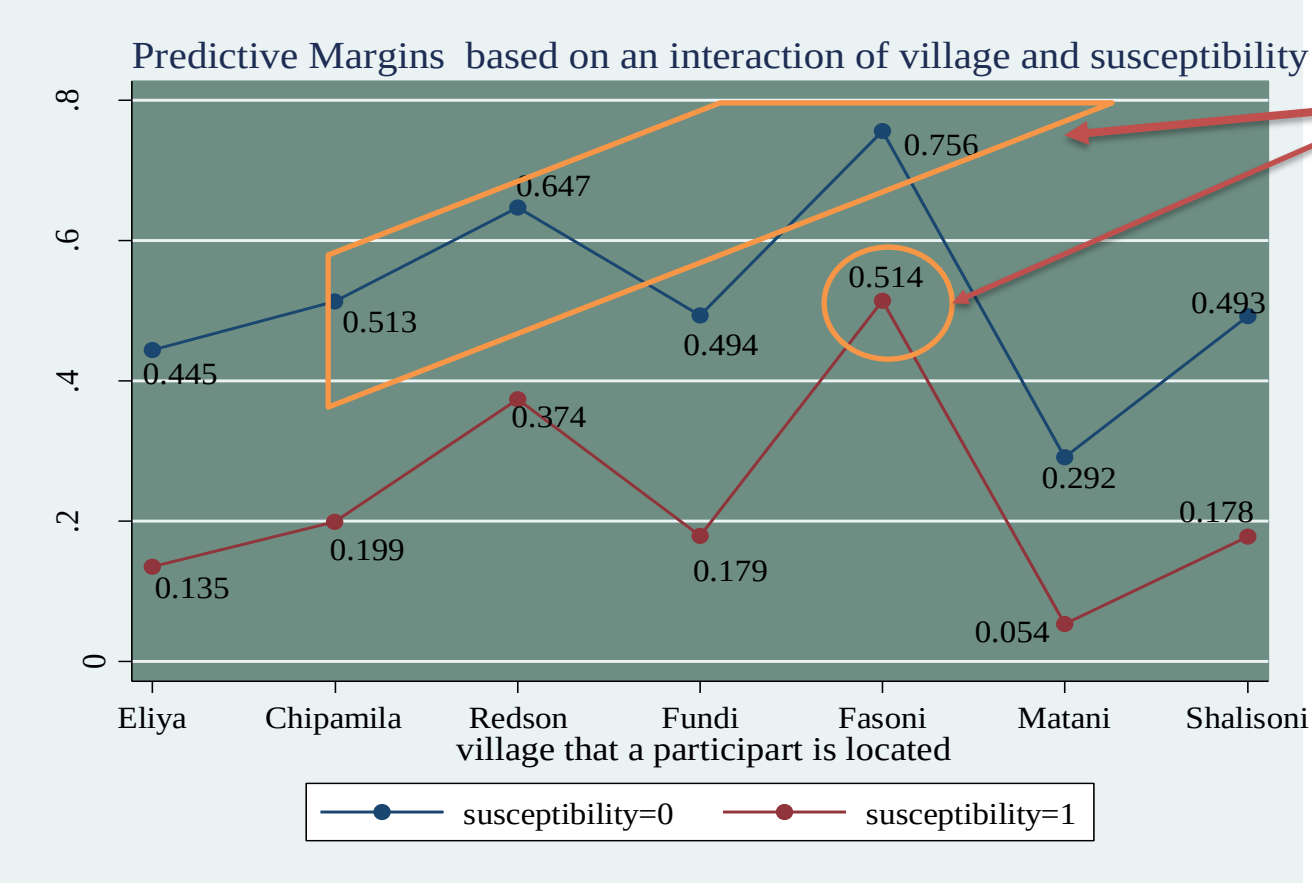
- Some villages revelaed high vulnerability (0.71) based on building locations & surrounding characteristics:

Significant factors were:

Proxy to rivers (0.001), elevation type (0.003)

RESULTS

Prediction Margins of villages based on Susceptibility.

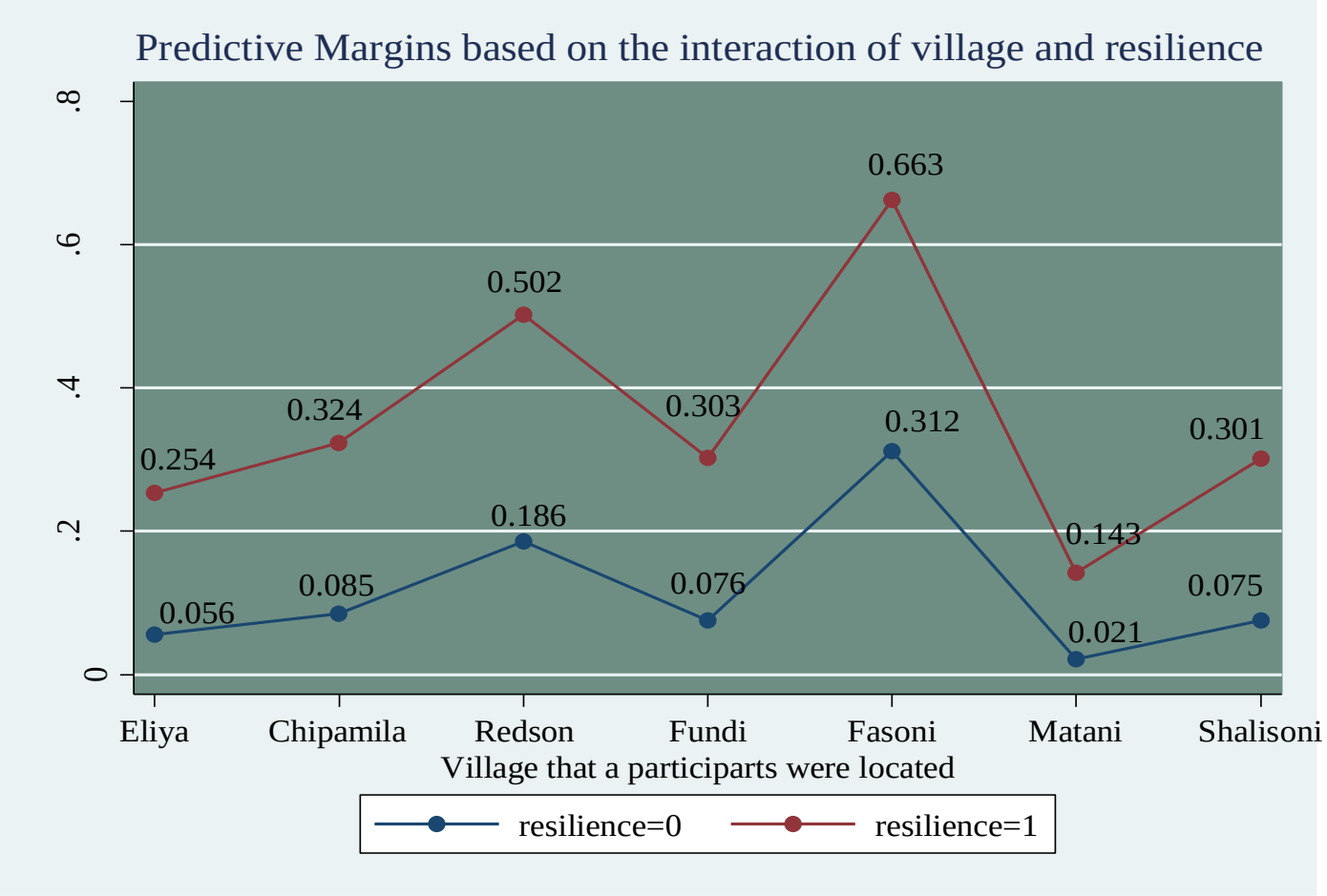


Key results

- Vulnerability based on susceptibility is high for most households (0.51-0.756).
- Measures of susceptibility such as: early warning systems (0.008); training and awareness (0.001) and prediction measures (0.005) were all significant at $p \leq 0.05$

RESULTS

Prediction Margins of villages based on Resilience.



Key results:

- Resilience of households very low.
  - Reasons: capacity gaps, dependent on one farming system (rice as main): limited land for diversification.
  - Rice is heavily impacted by climate change.

Results

Generated computations based on Multiple logistical Regression Model

The output of Equation 1 with its generated relationships (Equations 2-5) produced the computed scores to measure household flood vulnerability. The computed score gave rise to: physio-exposure factors (PEFs), socio-susceptibility factors (SSFs), eco-resilience factors (ERFs) and enviro-exposure factors (EEFs)

$$E_{hmt} = 3.09 - 0.76PC_{sint} - 0.07PC_{svint} - 0.01CM_{sint} - 0.51CM_{svint} - 0.04CR_{sint} + 1.39CR_{svint} \quad \textbf{(Eq.6)}$$

$$E_{ge} = 3.49 + 18\,CL_{sint} + 1.59CL_{svint} - 0.98EM_{sint} + 1.18EM_{svint} - 1.65PLM_{sint} + 0.55PLM_{svint} + 0.93AUR_{sint} - 1.3AUR_{Svint} \quad \textbf{(Eq.7)}$$

$$S_{ca} = 1.7 - 0.64HR_{int} + 0.37HR_{vint} - 0.3HS_{int} + 0.11HS_{vint} \quad \textit{(Eq.8}$$

$$R_{ihh} = 1.19 - 0.74PV_{svint} - 0.29PV_{svint} + 1.09AL_{svint} + 0.21AL_{svint} \quad \textbf{(Eq.9)}$$

- PEFs
- EEFs
- SSFs
- ERFs

Results

Final output of agglomerated UVFs and VCs

Agglomerated category	Flood vulnerability Index (FVI)	Description
Physio-exposure factors (PEFs)	0.64	High vulnerability
Enviro-Exposure factors (EEFs)	0.81	Very high vulnerability
Socio-susceptibility factors (SSFs	0.61	High vulnerability
Eco-resilience factors (REFs)	0.80	Very high vulnerability

The major implication of the overall study in theory (policy) and practice (for engineers/planners/decision makers etc) and in order to Build Back Better, a flood vulnerability assessment (FVA) framework has been proposed.

FVA FRAMEWORK FOR RURAL & URBAN INFORMAL SETTLEMENTS IN MALAWI

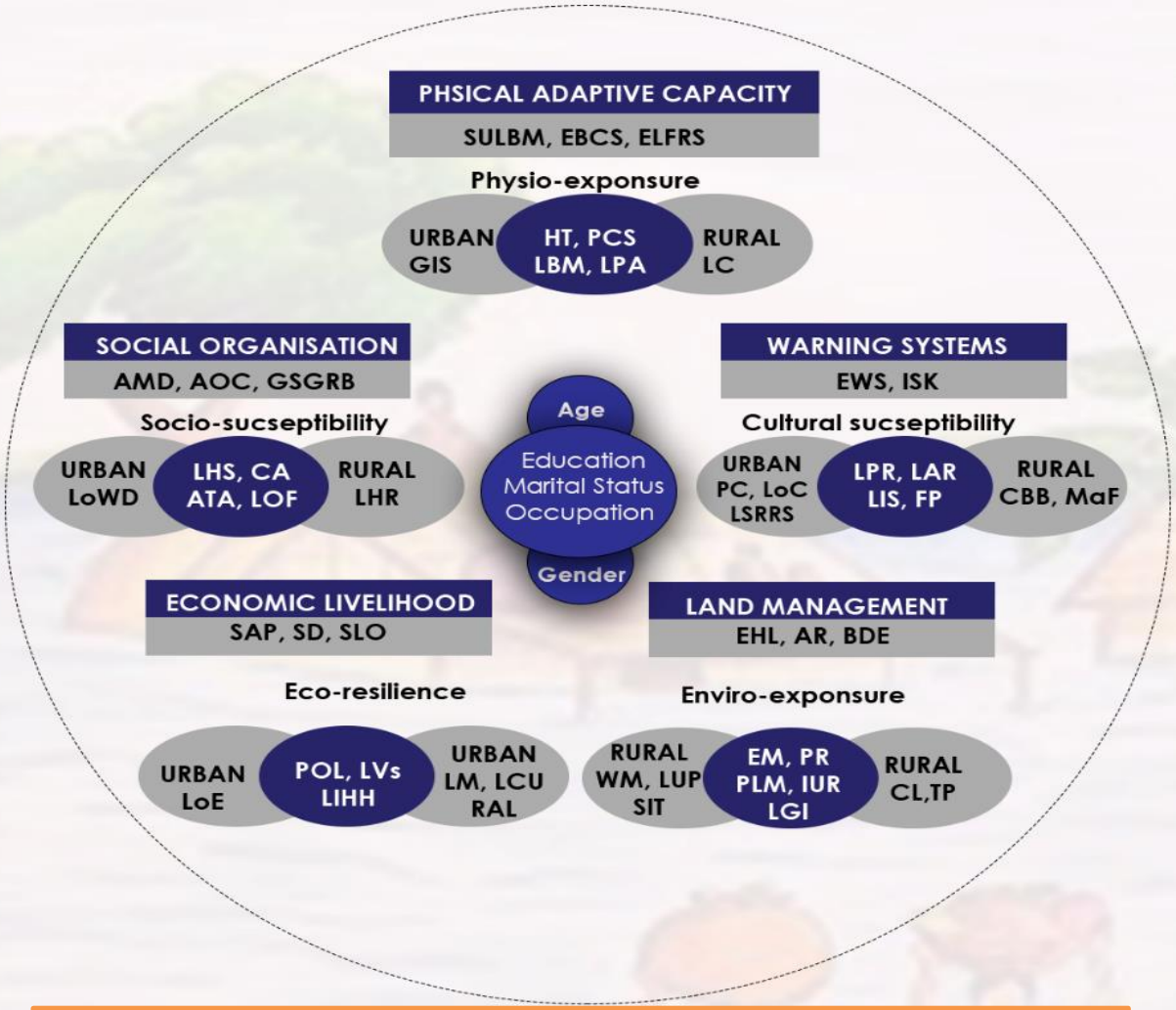


Figure 5: Vulnerability Framework for Rural and Urban Settlements: Source (Mwalwimba 2022)

Indicators to support engineering

KEY

- **HT:** Housing Typology
- **PCS:** Poor Construction of Standards
- **LBM:** Lack of Building Materials
- **LPA:** Loss of Physical Assets
- **LC:** Location
- **GIS:** Growth of Informal Settlements
- **SULBM:** Strengthening Availability of Building Materials
- **EBCS:** enforcement of building codes and standards
- **ELFRS:** Empower Locals on Flood Resilient Structures
- **LHS:** Lack of Access to Health Services
- **CA:** Communication Accessibility
- **ATA:** Access to Training and Advocacy
- **LoS:** Level of Sanitation
- **LHR:** Lack of Human Rights
- **LoWD:** Level of Waste Management & Drainage System
- **AMD:** Ability to Make Decision
- **AOC:** Ability to Organize and Coordination
- **CSGRB:** Communal Strategic Grains for Resilient Building
- **PO:** Poverty
- **LVs:** Limited Livelihoods
- **LIHH:** Lack of Income of Household Heads
- **LM:** Lack of Markets
- **LCU:** Limited Credit Unions
- **RAL:** Reduction in Agricultural Land
- **LoE:** Lack of Employment
- **SLO:** Strengthen Livelihoods Opportunities
- **EM:** Environmental Mismanagement
- **PR:** Proximity to Rivers
- **PLM:** Poor Land Management
- **IUR:** Inappropriate Use of Resources
- **LGI:** Land Governance Issues
- **CL:** Cultivated Land
- **TP:** Topography
- **WM:** Level of Waste Management & Drainage System
- **LUP:** Land Use Planning
- **SIT:** Short Lag Time
- **EHL:** Elevating House Location
- **AR:** Afforestation and Re-Afforestation
- **BDE:** Building Dykes and Embankments
- **LPR:** Lack of Adherence to Regulations
- **LIS:** Lack of Institutional Support
- **FP:** Flood Perception
- **CBB:** Cultural Beliefs and Behavior
- **MaF:** Myths about Floods
- **PC:** Power Conflicts
- **LDRRS:** Limited DRR Strategies
- **LoC:** Lack of Cooperation
- **EWS:** Early Warning Systems for Impending Flooding (WS)
- **ISK:** Use of Indigenous and Scientific Knowledge
- **SD:** Strengthen Diversification

4. Remaining Gaps for Engineers and Planners

1) *Limited integration of vulnerability data and DRR into construction of design infrastructures increase.* ***This must be improved to build back better and address current risks.***

2) ***Neglect of utilization of mitigation measures proposed in environmental and social impact assessment/ESMPs*** *to address environmental problems in all phases of construction processes.* ***This must be improved to avoid wastage of resources and time.***

3) *Limited development of early warning systems and prediction methods.* ***Development of early warning systems must improved taking a multi-hazard process.***

4) *Lack of harmonisation of government institutional systems towards implementation of common mitigation and prevention measures.*

4 Major Actions for Engineers/Planners/Contractors to build back better

- *Engineers and contractors **should prioritize to utilize vulnerability data to compliment environmental and social impact assessment (ESIA)** during designs and development of physical infrastructures such as roads, bridges storey buildings etc. (**Think of designs of culverts in some roads-e.g. Mangochi road).***

- *Engineers and planners **should ensure working with DRM experts to incorporate DRR strategies in their design structures & land allocation. Think of Judicial review process for Blantyre City Council.***

- *Engineers **should lobby government to enforce of laws and regulations** without basing on societal leniency and specific operation process of some groups of people with their own interests.*

- *Engineers **should join hands with other institutions to lobby government not treat DRM policy centric symbol of disaster enterprise**. Building back would be impossible with this arrangement! **(Think of DRM Act, 2023).***

Concluding Remarks

- The extent of vulnerability in the study areas is very high while actions for resilience building are very limited.
- A number of vulnerability indicators have been revealed, complimented by what needs to be done to building back better.
- It is expected that at this 2023 Engineering conference will ably adopt some actions suggested in this presentation.

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The End