



Quantifying vulnerability of rural communities to flooding in SSA: A contemporary disaster management perspective applied to the Lower Shire Valley, Malawi

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ABSTRACT

In response to the increasing frequency and economic damages of natural disasters globally, disaster management has evolved significantly to incorporate vulnerability assessments that are multi-dimensional, integrated and metric-based. This is to support knowledge-based decision making and hence sustainable disaster risk reduction. In Malawi and most of Sub-Saharan Africa (SSA), however, flood vulnerability assessments mainly focusing on social vulnerability, have been largely qualitative. The subjective nature of such qualitative assessments makes their use for identifying relative vulnerabilities of specific people and places, targeting of interventions, allocation of scarce resources and monitoring of benefits that may arise from interventions extremely problematic. Viewing vulnerability through exposure, susceptibility and capacity dimensions, all linked to social, economic, physical and environmental factors, this study has used an index-based approach to quantify and profile vulnerability to flooding of rural, subsistent communities in the Lower Shire Valley, Malawi. Results show that vulnerability to flooding is susceptibility-driven with susceptibility magnitudes manifesting as high to very high. In particular, socio-economic and to a large extent environmental susceptibilities are predominantly high to very high. Economic and physical capacities tend to be low but societal capacity tends to be high thereby attenuating overall capacity-induced vulnerability to medium levels. Physical exposure is medium. Except for environmental vulnerability, spatial differentiation in all forms of vulnerability across communities is in general marginal.

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1. Introduction

Vulnerability has generally been defined as the degree of susceptibility or fragility of communities, systems or elements at risk and their capacity to cope under hazardous conditions [1] although the term carries numerous and often contested definitions across disciplines. Over the years, there has been a shift in the analytical frameworks used in measuring vulnerability, from those that conceive vulnerability as solely a biophysical or social phenomenon, to those which emphasise its integrative nature. The frameworks further emphasise multi-dimensioning and the use of quantitative metrics [2–4]. Consequently, such frameworks are now seen as the pathway to sustainable disaster management [5].

In the literature of human vulnerability to natural hazards, the term ‘social vulnerability’ has been used to describe vulnerability arising from historical, cultural, socio, economic and political

processes that make people vulnerable [4,6]. Biophysical vulnerability on the other hand has related to characteristics of the stressor (e.g. frequency, duration) (external biophysical vulnerability) and the physical environment in which the human system resides (internal biophysical vulnerability) [7].

However, such a definition of biophysical vulnerability is associated with the climate change discipline [7]. In the natural hazard discipline [2,5,8], external biophysical vulnerability is a hazard; vulnerability is independent of the hazard and is confined to the social system and its physical environment. Further, while both aspects constitute ‘vulnerability’ in the climate change discipline, their integration defines risk in the natural hazard discipline. This paper adopts a natural hazard discipline conceptualization of vulnerability. Either way, the aspect of integration of social and biophysical aspects is important for holistic interventions. Fussel [7], for example, observed that social vulnerability studies that define vulnerability as socially constructed are important only for the design of adaptation policies but limited in informing mitigation policy.

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Dimensioning vulnerability or grouping vulnerability factors to some common bracket has followed several thematic areas. However, both the climate change and natural disaster risk communities have broadly viewed vulnerability through the *exposure, susceptibility, capacity/resilience* lens [1,3]. *Exposure* has been defined as “the presence of people; livelihoods; environmental services and resources; infrastructure; or economic, social and cultural assets in places that could be adversely affected”; *susceptibility* as “the predisposition of elements at risk to suffer harm” and *resilience*, also treated synonymously with *capacity* across vulnerability literature [1], as “the ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event” [1,9]. The natural hazard discipline has also emphasised thematic areas of sustainable development i.e. social, economic, environmental and physical [1,2]. In this regard, *physical vulnerability* relates to factors of exposure and susceptibility of the built environment in terms of material and design, remoteness of the place etc. *Social vulnerability* refers to the level of individual, community and societal well-being in terms of such indicators as literacy levels, health, governance, institutions etc. *Economic vulnerability* also looks at the level of individual, community and society well-being but in terms of economic resource base including the diversity of such resources, and the availability of basic socio-economic infrastructure. *Environmental vulnerability* describes the state of the environment. An emphasis on dimensioning stems from the understanding that while a single aggregate metric for vulnerability may provide a useful tool for differential ranking of vulnerability of places, it does not reveal the relative importance of its constituent dimension and hence their trade-off possibilities. Thus, as observed by Cinner et al. [10], an aggregate vulnerability metric is limited in informing interventions that will be most effective for reducing vulnerability at a particular location.

Metric-based assessments of vulnerability have become important to decision-making and policy in that they allow comparison of vulnerabilities of specific people and specific places. This facilitates the targeting of interventions and allocation of scarce resources, an important aspect for resource strapped developing countries. Metrics further enable the monitoring of progress accruing from policy interventions made [11,12].

The above attributes of multidimensional, integrated and metric-based vulnerability assessments are even more relevant in Sub-Saharan Africa (SSA) where droughts and floods alone account for 80% of disaster related mortality and 70% of the economic losses [13]. However, this approach has been confined to vulnerability to climate change studies [11,14–16] but more recurrent and immediate hazards such as flooding that constantly erode the asset base of poor rural communities reducing their quality of life have not been so analysed. Rather, the assessment of vulnerability to flooding has been largely qualitative; describing, notably, causative factors, impacts, coping and adaptation capacities at hand [17–21]. While providing a rich insight into the vulnerability problem and therefore useful in the design of interventions, such studies offer very little in terms of decision making on aspects of comparisons across places, targeting of scarce resources and monitoring over time. Their social emphasis also provides a limited view of vulnerability thus undermining the effectiveness of vulnerability reduction measures.

Using this contemporary discourse on disaster management, this paper quantifies and profiles vulnerability to flooding of rural communities in the Lower Shire Valley, Malawi. In particular, vulnerability is examined within a coupled IPCC and Sustainable Development framework i.e. as exposure, susceptibility and capacity and as manifested through the social, economic, physical and environmental dimensions.

2. Case study area

The Lower Shire Valley lies at the southern tip of Malawi at an elevation of between 30 and 150 m above sea level [22] (Fig. 1). It is drained by the Shire River, the only outlet of Lake Malawi. Administratively, the Valley falls in two districts: Chikwawa and Nsanje.

Rainfall in the Lower Shire Valley is low (600–750 mm annually). Nonetheless, its upper and middle catchments, dominated by the orographic influences of mountains, have annual rainfall around 900 mm and in excess of 2000 mm in the Ruo sub-catchment to the east on its main tributary. Although the Shire at Chiromo averages 450 m³/s annually, and the Ruo at Sinoya averages 54 m³/s, flows as high as 1430 m³/s and 5400 m³/s respectively have been recorded at these two stations [23]. Landuse and landcover studies in the Shire River basin [24] and in Lake Malawi basin upstream of the Shire River Basin [25], point to an increasing trend in cultivated/grazing area at the expense of woodlands. Poverty rates in the two districts (calculated with respect to 37,002 Malawi Kwacha poverty line which is equivalent to US\$0.40 per person per day as of 2012) are over 80%, the highest in the country [26], significantly exceeding the national average of 50.7%. As the rest of the country, the population is predominantly rural and subsistence farming, more practised in the low lying wetlands in this region, is the main source of livelihood. Other forms of livelihoods are artisanal fishing, livestock rearing and casual labour popularly known as *ganyu*. These livelihoods, however, are fragile and productivity is very low given the multiplicity of stressors (floods, droughts, stock mortality and morbidity and stock theft) in the region [27].

3. Methods

3.1. Scale of analysis

Vulnerability is a scale-dependant variable determined by spatial scale (global to individual) and specificity of a place; as well as time scale (over a period of time or for a specific moment in time) [28]. As such vulnerability outcome at different scales serves different purpose. For example, while global, regional and national scales assessments allow comparisons across nations, which is useful for flagging to aid and development agencies, prioritisation of resources at global scale and also for bench marking purposes the local scale is more important for the design of disaster risk reduction [29,30]. Besides consideration of purpose, it is important that vulnerability assessments are linked to scale of decision-making as vulnerability reduction measures are developed, promulgated and implemented through institutions [6].

While vulnerability may operate at an individual or household scale, the policy scale i.e. the scale for which policies are valid and implemented [28] is the most pertinent in this study. Therefore, the study follows the institutional framework for disaster management in Malawi. Disaster management activities in Malawi are coordinated at national level in the Department of Disaster Management Affairs (DoDMA). The department is supported at the lower level through local government decentralised structures: the District Level, Area Development Level and Group Village Development Levels. The Lower Shire Valley falls into two district level units: Chikwawa with an area of 4755 km² and Nsanje with an area of 1942 km². Chikwawa District has 11 Area Development Committee levels (ADCs) and Nsanje 9, with each ADC level corresponding to the area under the jurisdiction of a chief (Traditional Authority, TA). Further Chikwawa comprises 79 Village Development Committees (VDC) and 593 villages. Nsanje on the other hand has 82 VDCs and 790 villages. The number of VDCs and

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