



Original paper

Developing a Community-Based Resilience Assessment Model with reference to Northern Ghana

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Abstract

Faced with adversarial climatic and physical conditions and an inept socioeconomic development priorities, Northern Ghana remains one of the regions that are most vulnerable to climate-related shocks and disturbances in semi-arid Africa. Because of the effect of frequent floods, droughts, and bushfires, entire livelihoods in Ghana's predominantly smallholder agricultural population are under threat. In this paper, we present a model for community-based resilience assessment. This model was developed through an experiment conducted in selected rural communities in the Tolon and Wa West Districts in the Northern and Upper West Regions of Ghana. This experiment underpinned an ongoing five-year collaborative research project, *Climate and Ecosystem Change Adaptation and Resilience Research in Semi-Arid Africa: An Integrated Approach (CECAR-Africa)*, and involved researchers and scientists from institutions in Ghana and Japan. Drawing on the findings from extensive literature review, field surveys, focus group discussions, unstructured interviews with various stakeholders, and participatory observations, we developed a matrix for assessing the different categories of community

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resilience (ecological, engineering, and socioeconomic). The outcome of this resilience matrix, herein called an “integrated” assessment model, offers a mix of factors that could improve societal reorganization when faced with shocks or disturbances. The integrated model provides a workable assessment criteria and key indicators for community level resilience assessments. This experiment proved valuable and highly effective in selecting case study communities for CECAR-Africa. The next step will involve the testing and development of similar criteria and indicators to measure household level resilience.

Key words Climate and ecosystem change; Ghana; Community resilience; Integrated assessment model; Floods; Droughts

1. INTRODUCTION

“Anthropogenic climate change is now a well-established reality” (IPCC 2007). Thus, the human dimensions of climate change urge us to develop a conceptual framework that is useful for clarifying the relationships between current and expected physical, social, and environmental changes. The clarification of such relationships would enable experts and policy makers to facilitate and enhance the preparedness, mitigation, and adaptation of the affected socioecological systems to the expected changes to guarantee their survival. The concepts of resilience and vulnerability have become central to environmental change frameworks (Janssen and Ostrom 2006; Cutter *et al.* 2010).

Resilience, as originally developed in ecology, is the capacity to maintain a sustainable relationship with the habitat (Holling 1973). With increasing influences from outside the ecological field, such as human geography, cultural theory, and other social sciences in the 1990s (Thompson *et al.* 1990; Zimmerer 1994; Scoones 1999; Abel and Stepp 2003; Davidson-Hunt and Berkes 2003), the concept of resilience began to embrace different dimensions of social change. Neil Adger (2006) described social resilience as the ability of social systems to deal with and withstand the external shocks to their organization and infrastructure caused by environmental, economic, or political crises. Currently, a popularized socioecological definition of resilience includes the notions of learning, reorganization, innovation, and transformability (Folke 2006). Much of the current understanding regarding resilience has been primarily build on Crawford Stanley Hollings’ (1973, 1986) original work that focused on maintaining the structure and function of complex systems that had undergone significant disturbance. One of the concepts that evolved from Hollings’ seminal work was “community resilience,” which is the ability of communities to deal with disasters (Paton and Johnson 2001; Klein *et al.* 2003; Bruneau *et al.* 2003; Twig 2007; Wamsler 2007).

On the other hand, vulnerability measures the degree to which a system is susceptible to and unable to cope with the adverse effects of climate change, including climate variability and weather extremes. Vulnerability is a function of the character, magnitude, and rate of climate change as well as the variation to which a system is exposed and the system’s sensitivity and adaptive capacity (IPCC 2007:883). Three types of vulnerability have been identified in research: exposure, sensitivity, and the capacity to respond. Exposure is the “degree, duration, and/or extent in which the system is in contact with, or subject to, the perturbation” (Gallopín 2006: 296), whereas sensitivity is the “degree to which the system is modified or affected by a

disturbance or set of disturbances” (Gallopín 2006: 295). Further, capacity to respond is the ability of the system to adjust to or resist the perturbation, deal with moderate potential damage, take advantage of opportunities, and cope with the consequences of the transformations that do occur (Gallopín 2006).

Resilience and vulnerability have ambivalent attributes; particularly, a resilient system is often considered less vulnerable than a non-resilient system (Walker *et al.* 2004; Gallopín 2006). However, resilience relates more to a system’s persistence in the considered domain, whereas vulnerability refers to a transformation that primarily changes the system (Gallopín 2006). Thus, there are differences between resilience and vulnerability. Resilience builds on the concept of vulnerability, which has been primarily used in poverty analyses to indicate a lack of ability in a particular population to respond to external shocks (Adger 2006). As adaptation to climate change has become one of the main international policy concerns in the 21st century, the concept of vulnerability has been considered useful for the evaluation of existing policies to assess whether they sufficiently address a target population’s capacity to deal with climate change. For example, by mapping vulnerability, pathways to the assessment and enhancement of resilience can be identified (Bankoff *et al.* 2004). In comparing vulnerability and resilience, Ellina Levina and Dennis Tirpack (2006:16) concluded that “vulnerability” seems largely to imply an individual’s or society’s inability to cope, and “resilience” seems to broadly imply an ability to cope in the face of stressors or shocks.

Among the target populations prioritized in the international policy framework to alleviate vulnerability and enhance resilience, rural populations in low income countries, especially in Africa, have been identified as being highly vulnerable to climate change (Lynn *et al.* 2011). African rural populations depend on climate-sensitive agro-ecosystems, rain-fed agriculture, and stock management but suffer from poor governance, insufficient safety nets, and poor educational progress (Boko *et al.* 2007; Vogel *et al.* 2007); therefore, they are influenced not only by climate change itself but also by persistent poverty and the lack of public services and technologies to mitigate the impacts (Downing *et al.* 2001; Adger 2006; Boyd *et al.* 2009; Antwi-Agyei *et al.* 2011). Enhancing rural population resilience (i.e., the capacity to adapt to change) requires strategies that engage with “a broader agenda concerning how to enable poor and vulnerable people to move out of poverty and vulnerability” (Sabates-Wheeler *et al.* 2008). Such strategies include the implementation of new technology and policy planning to promote climate-smart agriculture, such as effective environmental services and adaptive forms of governance to enact planning (Folke 2006; Boyd 2008; FAO *et al.* 2012). Further, to enhance climate change adaptation and mitigation, local scientific knowledge requires enhancement to allow for its integration into modern agricultural concepts, practices, and policies that promote organic soil carbon storage (Boakye-Danquah *et al.* 2014).

The emphasis on Africa stems from most part of the regions ’extreme vulnerability to climate change impacts, which is primarily due to the dependence on climate-sensitive agro-ecosystems, as discussed in the previous paragraph (Boko *et al.* 2007; Vogel *et al.* 2007). Poor rural societies are the most likely to be affected, which could result in internal migration, loss of income, and political unrest. The northern part of Ghana (hereafter, referred to as Northern Ghana) in West Africa is one of the areas that has a highly vulnerable population as the residents are increasingly exposed to extreme weather-related hazards such as erratic rainfall and episodic floods and droughts.

The Climate and Ecosystem Change Adaptation and Resilience Research in Semi-Arid Africa:

An Integrated Approach (CECAR-Africa) project, which was conceived in 2010 to explore the nature and extent of the vulnerability and assess the potential to enhance the resilience in this region in the midst of climate variability and ecosystem changes, is an international collaborative research project involving Japanese and Ghanaian researchers. This paper is the outcome of the project's preliminary research activities and reports on the outline and focus of the international project as well as presents the results of the initial experiments at the project site selection using a community-based participatory approach. This paper explains the rationale for the development and application of different categories of resilience at the community level and examines the usefulness of this method for future research. Findings from this preliminary study provides an essential baseline data for the conduct of further research within the CECAR Africa project.

2. METHODS AND MATERIAL

2.1 Study Area

The project is being conducted in Northern Ghana, which is in the semi-arid region of West Africa. Administratively, northern Ghana consists of the Northern, Upper West, and Upper East regions (Figure 1) and is characterized by

- sub-humid (Northern and Upper West) and semi-arid (Upper East) climate zones with high susceptibility to ecosystem changes and
- high poverty rates in the regional population, making them chronically vulnerable (World Bank 2011; UN 2011; Songsore, 2011).

In the national development context of Ghana, the three regions in Northern Ghana together account for about 17.3% of the national population and about 40% of total land area of the country. Yet, these regions have received only 1% of investment since the structural adjustment period, resulting in internal conflicts and the social exclusion of ethnic nationalities (Songsore 2011: 176). Poverty in Northern Ghana has increased from 33% in 1991–92 to 37% in 1998–99 and to 50% in 2005–2006 (Ghana Statistical Service 2007:8). Nearly 90% of the population comprises smallholder farmers whose livelihoods depend on existing agro-ecosystems (GSS 2013).

project proposes to 1) generate a scientific understanding of extreme weather events with a special emphasis on floods and droughts and their impact on the savannah agro-ecosystems by focusing on ten, purposely-selected, rural communities within the Northern and Upper West regions of Northern Ghana; 2) identify technological and institutional factors that could be strengthened or modified in order to develop adaptive management capacities in the local populations and institutions, thus enabling rural communities to become less vulnerable and more resilient; and 3) develop an integrated model for enhancing resilience, which could be applied to other areas with similar conditions in semi-arid Africa.

To assess the different capacities, we consider the “community” (or a set of communities in the same area) as the core of the socioecological system, the self-organization and adaptive capacities of which need to be scientifically examined (Smit and Wandel 2006). In the context of this project, a community refers to a group of individuals or families living in a similar geographical area and sharing certain common characteristics. Specifically, we define a community as people with common access to infrastructure and nature-based resources and who share a common boundary. This focus on community, however roughly defined, is methodologically useful in determining the causes and outcomes of extreme weather events and the capacity of certain groups of people to deal with these events. This is imperative considering that communities are similar to institutions and countries in that they inherently possess varying degrees of ecological resilience and assets (Fraser 2006).

In 2010, the CECAR-Africa project initiated a community-based resilience assessment in Northern Ghana. This approach involved consensus building between the multiple stakeholders and groups at local and district levels through joint observations and fact-finding exercises in the focal study areas. In addressing the project’s three themes—assessment of climate change impact on agro-ecosystems, risk assessment to deal with the physics of the weather events, and institutional capacity development to address governance and empowerment—this paper uses the concept of community resilience as analytically embracing ecological, engineering, and socioeconomic capacities (Folke 2006; see also Peterson *et al.* 1998). Obviously, these elements are interdependent; thus, we emphasize the need to elaborate integrated strategies.

In the following sections, we outline the parameters selected to identify communities with different levels of resilience and the development of the integrated resilience assessment that was used to highlight the technological and institutional factors that could affect a community’s capacity to respond to externally driven changes. We begin by identifying and exploring the concept of community resilience in northern Ghana under ecological, engineering, and socioeconomic headings. Then, we examine and report the outcomes of the resilience assessment experiment employed in this study. The paper concludes by discussing the practical applicability of and challenges faced by the proposed community-based resilience assessment model household-level analyses.

2.2 Community Resilience in Northern Ghana

Community resilience assesses the ability of a group of people to cope with change and uncertainty by studying their ability to learn from shocks and crises, to develop ongoing social and ecological monitoring for rapid response capacity, and to diversify their livelihoods through flexible decision making. Community resilience is measured across ecological, engineering, and socioeconomic dimensions (Berkes *et al.* 2003).

2.3.1 Ecological and Engineering Resilience in Northern Ghana

Ecologically, Northern Ghana generally falls within the Guinea Savannah zone, which has seven different land cover types but predominantly features agricultural land (Antwi *et al.* 2014) (Table 1). However, small portions of the Upper East region (particularly around the Bawku area) belong to the Sudan Savannah ecological zone. The Guinea Savannah comprises fire tolerant, deciduous, broadleaved trees interspersed with a ground flora of mainly grass, which is sometimes more than 1.5 m high (Yaro 2007).

Table 1. Description of Dominant Land Cover Types Found in Northern Ghana

Land Cover Types	Description
Agricultural land	Areas where over 50% land is under agriculture excluding tree crops. It also includes areas used for livestock grazing. Some of the agricultural land is used for cultivating maize, cassava, yams, rice, vegetables, cowpeas, sorghum, millet, and tobacco and also for mixed arable farming and pasture.
Forest garden	An area noted for plant-based food production and agroforestry systems. In most cases, crop patches are planted within the savannah woodland. Ghanaian forest gardens often feature a mix of farm land (short/long fallow) in naturally or semi natural grown forests.
Grassland with/without trees	Savannah land is mostly grasslands with a sparse distribution of trees per hectare. It covers both coastal and inland savannah in Ghana.
Water body	The free water surfaces of rivers, dugouts, small-scale dams, ponds, and lakes wide enough to be delineated as map units.
Open land	Surfaces that lack any form of vegetation, either naturally (rock and sand) or through the results of human activities (erosion, mining, road construction).
Built-up areas	Surfaces modified by construction activities (e.g., villages, towns, roads, airfields)
Savannah woodland	Areas with a high tree density (>150 trees/hectare). It also includes protected areas, the most significant of which is the Mole National Park, the largest park in the country and home to many wildlife species.

Source: Antwi *et al.* 2014

Following Crawford Stanley Holling (1996), the ecosystem stability in the dominant land cover types in Northern Ghana can be measured through “engineering resilience,” which assumes that a system can remain within a stable domain while, in reality, the ecosystem changes as the system reorganizes to further transform itself or shift to another stable domain. In line with

the engineering resilience, ecological resilience refers to the process of ecological reorganization after a disturbance, which is a discrete event affected by both internal and external forces that can alter the structure of populations, communities, and ecosystems (Pickett and Rogers 1995). This means that for communities in Northern Ghana, we first needed to define “disturbance,” which is concerned with the environmental fluctuations that could cause destructive events whether or not these are seen as normal in a community. From the developmental viewpoint, changes in the environmental structure cause changes in living conditions and economic opportunities for the inhabitants of the disturbed areas (Walker and Willig 1999). In addition, the severity and duration of a disturbance affect communities differently even though they may have similar adaptive features. For example, an intermediate disturbance hypothesis points out that severe disturbance or even a prolonged absence of disturbances often has a depressing effect on biodiversity, but an intermediate disturbance enhances system diversity (Pickett and Rogers 1995). Thus, the “intermediate disturbance hypothesis” postulates the following:

- Communities experiencing intermediate levels of disturbance have high biodiversity or species richness.
- Disturbances alter the availability of resources (physical, chemical, and biological) and are the source of multiple levels of environmental heterogeneity.
- At low or high levels of disturbance, environments tend toward homogenization and competitive relationships thus leading to the selection of a few best adapted species.

Based on this general understanding of disturbance and recovery, ecological and engineering resilience in Northern Ghana can be measured by (1) the magnitude, severity, and frequency of biodiversity disturbances, including the agricultural diversity in farming communities; (2) the recovery potential from the disturbance based on the short- and long-term land use changes and changes in the distribution and number of species or soil composition for agro-biodiversity. Further, from the magnitude and rate of reorganization, ideal infrastructure capacity may be examined by clarifying the types of “hardware” (e.g., roads, irrigation, afforestation, early warning systems) available to enable the community to realize more rapid returns from possible disturbances (Sovacool *et al.* 2012). In addition, as a regional ecosystem comprising a variety of farming systems (i.e., plots within and across communities), attention is paid to the farming practices that can facilitate reorganization after a disturbance. As an indicator of the effect of farming practices on farming system resilience, soil compositions are studied with particular reference to the potential for organic soil carbon sequestration and its implications for the sustainable management of the existing agro-ecosystems (Boakye-Danquah *et al.* 2014).

2.3.2 Socioeconomic Resilience in Northern Ghana

Socioeconomic resilience has been widely discussed in previous climate adaptation literature and focuses on the planning and enactment of climate-smart development policies (Andah *et al.* 2003; Environmental Protection Agency Ghana 2007) for agriculture. The sustainable livelihoods framework has often been used to evaluate adaptive capacity in the socioeconomic context in terms of its relationship with policy. Household assets are evaluated to assess “how relationships within a household might protect its members against a shock” (Dasgupta and Baschieri 2010: 809; see also Vogel *et al.* 2007). Thus, socioeconomic resilience is primarily

measured by household livelihoods and assets, such as the various forms of land tenure, labor availability, employment opportunities (including income and remittances), access to social services (health care, clean water, transport, electricity, education, etc.), non-labor productive assets (land and any machination ownership), and social capital (groups and mutual aid/self-help collective mechanisms).

In Ghana, the absence of a coherent land use policy has been identified as a barrier to resilience, as this absence has stifled investment in the agricultural and industrial sectors (Wily and Hammond 2001; Benneh et al. 1995). Ghana has a complex land administration system that “recognizes the primary ownership and authority of the chiefs and heads of clans and families by the various tribal communities” (Ghana LAP-2 2012); therefore, different tribal customs and practices govern the land use and land acquisition policies. However, this customary land administration is especially localized in Northern Ghana where land is traditionally claimed not by chiefs but by earth priests (referred to locally as *tendamba* or *tindana*) who are considered descendants of the original settlers. Recently, the position of the *tendamba* has been largely assumed by the chieftaincy institutions (Kasanga 2002), thus aligning the historical customary institutional developments with national land policy planning.

In Ghana, the institutional development for the “enactment of legislation that requires all landowners to demarcate and register their lands and the development of district, regional, and national land use plans to guide land development” (Ghana LAP-2 2012) need to be understood in the context of decentralization, which was fully implemented under the Provisional National Defence Council (PNDC) government in 1988. Today, communities belong to metropolitan, municipal, and district assemblies (MMDAs), which have been designated as the primary political, legislative, budgeting, and planning authorities (Institute of Local Government Studies and Friedrich-Ebert-Stiftung Ghana 2010). The number of MMDAs has been increasing through a series of reforms in Ghana, and currently, there are 216 MMDAs after 46 newly created districts were inaugurated in June 2012 (Ghana Districts 2013).

In Northern Ghana, district assemblies are responsible for the planning and zoning of their respective jurisdictions with support from national institutions such as the Land Commission and the Administrator of Stool Lands. Usually, more than 85% of the assemblies’ budget comes from donors, central government transfers, and the District Assembly Common Fund (Ahwoi 2010). Internally generated funds (IGF) derived from taxes and tolls are used to supplement these major income sources of assemblies. Recently, the district assemblies’ budgetary allocations have included provisions for social infrastructure, such as school classroom blocks, clinics, and potable water and sanitation as well as for administrative overheads. However, these district assemblies have been found to lack the technical and financial capacities to effectively and successfully perform these responsibilities (Ahwoi 2010; Songsore 2011).

Simultaneously, this local government incapacity has made Northern Ghana a site for some of the most innovative development interventions in the country (Jackson and Gariba 2002; Lentz 2006). For instance, through the demand-driven community management of common resources, important lessons and models have been generated to improve national policies and the use of donor and government investments (Ahwoi 2010). However, decentralization in Ghana has been considered to be largely supply-driven, as the demand for effective decentralization originated primarily from international donors. More serious commitment by the national government and regional elites to enhance the technical and financial capacity of local governments is expected to redress the north–south inequality within Ghana and highlight the

importance of preventing extreme natural events from becoming disasters.

To enhance community resilience, if technical and financial capacities are enhanced, local governments would be in the position to provide short-term responses, whereas regional and national governance could provide long-term political commitment to spatial planning and its enactment (Wilson 2006). A longer commitment requires a deeper analysis of institutional history and the modes of public participation and citizenship (Berry 2009), which have been affected not only by decentralization but also by neoliberal economic policies and the overall marginalization of the state in spearheading local development (Wiggins 2000; Afolayan 2010). From the 1980s onward, there has been active involvement of international donors and NGOs in Northern Ghana in the state's absence, leading to a proliferation of local associations and the flourishing of a civil society, which has highlighted what can and cannot be accomplished by the international community (Jackson and Gariba 2002: 1).

To summarize, socioeconomic resilience needs to be accompanied by an analysis of institutional resilience, which involves collaborative partnerships between the state, market, and civil society and an understanding of household livelihoods and assets.

3. IMPLEMENTATION OF COMMUNITY RESILIENCE ASSESSMENT MODEL

3.1 Project Site Selection: Processes and Outcomes

Most Northern Ghanaian communities are rural, poor, highly dependent on the savannah ecosystem, and engaged in subsistence agriculture (Wiggins and Leturque 2011; GSS 2013; Bofo *et al.* 2014). Because of these characteristics, the communities' vulnerability to periodic climate-related hazards such as floods and droughts has received considerable research attention (see Songsore 2011; Armah 2011; Antwi-Agyei *et al.* 2011). Floods and droughts as either natural or human-induced disasters have significantly contributed to the poor and degrading socioecological conditions in this semi-arid region. Even when communities have a homogenous climatic and vegetative landscape, their level of resilience to periodic droughts and floods varies depending on their existing coping strategies, which is a result of the variations and dynamics in the local level's physical (ecological), socioeconomic, political, and infrastructure systems. Therefore, it is practical to identify and categorize resilience at the community level.

To determine the optimum combination of factors for community's ecological, engineering, and socioeconomic resilience when faced with periodic disaster events, we considered the broader districts when selecting the experimental study sites. An assessment of all districts in the Northern and Upper West regions was conducted which examined (1) the magnitude and intensity of recent flood and drought events and utilized coping strategies, (2) the accessibility, and (3) the availability of previous studies and reliable data (e.g., peer review articles, research reports, government and development reports). Using set criteria, the assessment was conducted by the CECAR-Africa project researchers in consultation with relevant regional stakeholders such as the Environmental Protection Agency (EPA), the National Disaster Management Organization (NADMO), the Ghana Meteorological Agency, the Ministry of Food and Agriculture, and the District Assembly Planning Departments. From this assessment, two districts were selected as project study districts—*Tolon* (formerly Tolon-Kumbungu) and *Wa West*—which lay in the Northern and Upper West regions respectively (Figure 2). Compared with the other districts in the regions, these two districts frequently experienced flood and/or

drought events. Despite the frequent occurrence of these extreme events, Tolon district was seen to be more drought prone than Wa West district. On the other hand, Wa West district was more flood prone than Tolon district. The selection of these two districts in terms of flood/drought vulnerability relied more on expert observation and knowledge, which may limit the replicability of this study and the explanatory power of the results. However, the selection was deemed sufficient for district level selection and as an exploratory study. Further studies could convert these variables into measureable indicators to enable a more robust outcome.



Figure 2. Map of Northern Ghana Indicating the Study Districts

Having selected the flood/drought localities at the district level, the next stage involved the identification and selection of particular communities/villages, hereto referred to as study sites, within each of the districts. To do this effectively, we developed a conceptual typology for classifying community resilience based on floods and droughts as periodic, extreme events. The physical setting of the community, the degree of damage experienced, and the existing response mechanisms were considered and assessed using a rapid assessment survey, and the sites were visited by the study team in consultation with relevant local community stakeholders. Specifically, the study team evaluated the duration and effect of floods and droughts at the community level and investigated the availability and effectiveness of response mechanisms. Through this process, we identified communities that were more prone to floods in Wa West district or to droughts in Tolon District. Based on this typology, we categorized communities to be either *less resilient* or *more resilient* (Table 2).

Table 2. Conceptual Typology of Project Sites

		Degree of Damage to Village/Community	
		Less Resilient	More Resilient
Extreme events	Flood	F-L (The site is frequently and severely affected by floods and/or recovers very slowly from the flood event)	F-M (Under the same flood event, the site sustains less damage due to existing preparedness and/or exhibits a quick recovery to normal conditions after the event)
	Drought	D-L (The site is frequently and severely affected by drought and/or recovers very slowly from the event)	D-M (Under the same dry weather conditions, the site sustains less damage because of irrigation and water-related infrastructure and management and/or exhibits a quick recovery to normal conditions after the event)

Note: F - Floods, D - Drought, L - Less resilient, and M - More resilient

This conceptual typology (Table 2) was developed so that further resilience criteria and indicators for project site selection finalization could be applied. A community’s resilience is a function of criteria and indicators which dependently and/or independently interact to produce varying outcomes of different rates and magnitudes. Therefore, a community might be considered more resilient for one indicator but less resilient for another indicator. Using this typology, we worked with the communities to understand their resilience levels (*low* or *high*) through the development and application of a resilience matrix. This resilience matrix was particularly relevant at the community level, as it included socioeconomic, ecological, and engineering indicators at both the household and community levels (Table 3). The resilience matrix was developed to enable accurate tracking of the process of transforming from a less

resilient to more resilient community and to identify the indicators that contributed to this process. Once the community resilience is identified, the indicators needed to upscale to a more resilient community become easier to determine. Thus, the use of these indicators offers stakeholders the possibility to assess a community's resilience and adopt a place and evidence-based community intervention strategy.

Table 3. Resilience Matrix: Criteria and Indicators for the Community-Based Resilience Assessment

Resilience Category	Resilience Criterion	Indicator of Community Resilience	
		High Resilience	Low Resilience
Ecological Resilience	Landscape with high biodiversity (habitat diversity/ species diversity), sacred groves, or biodiversity hotspots	Diverse landscape with protected areas	Less diverse landscape without protected areas
	Landscape with agroforestry or crop diversification	Most community members practice agroforestry or crop diversification on farms.	Fewer community members practice agroforestry or crop diversification on farms.
	Vegetation health or state	Healthy vegetation with high regeneration potential after disturbances	Unhealthy vegetation without regeneration potential after disturbances
	Recovery potential of communities after a disturbance (from previous events)	Exhibits steady recovery potential from past disaster events	Comparatively low recovery potential from past disaster events
	Heterogeneous landscape (open land, agricultural areas, built-up areas, watercourses)	Heterogeneous landscape with different land use types	Less heterogeneous landscape with few land use types
	Topography (landscape elevation)	Upland areas at a considerable distance from the water course or valley	Low-lying landscape along or close to water courses or in a valley
	Soil improvement technology in farms	Most community members use soil improvement technology on their farms.	Selected few or no soil improvement technology used on farms.
	Access to irrigation system	With access to irrigation facilities (or means of watering crops, e.g., water bonding especially in dry season	No access to irrigation systems (or means of watering crops) in dry season
	Facilities for dry season farming (active/inactive)	Most community members are actively involved in dry season	None or few community members engage in dry season farming using

Engineering Resilience		farming using informal irrigation systems such as pumps.	informal irrigation systems.
	Reliable early warning systems	Access to reliable early warning systems	With unreliable or no early warning system(s) in place
	Flood/drought protection measures other than early warning systems	Community has flood/drought protection measures in place. Very few or no farms (or livestock) and houses are affected by floods/droughts.	Community has unreliable or no flood/drought protection measures. Most farms and houses are affected by floods/droughts.
	Improved crop variety	Mostly use improved crop variety noted on most farms.	Few farmers use improved crop variety on farms.
	Agricultural output and storage facility	High or stable agricultural output/yield	Low or unstable agricultural yields
Socioeconomic Resilience	Alternate source of livelihood income	Community engages in diversified sources of livelihood/income, e.g., non-farming jobs like trading or food processing or as blacksmiths.	Community engages in less diversified sources of livelihood/income, is highly dependent on agriculture, and accrues less non-farming income
	Diversity of resources e.g., livestock, poultry, and through fishing	Community maintains diverse resources including livestock, poultry, or through fishing.	Community has less or no diversified resources and mainly depends on food crops.
	Knowledge of climate and ecological risks	Shared knowledge of climate and ecological risks (floods and droughts)	Less knowledge sharing of climate and ecological risks (floods and droughts)
	Rural-urban migration	Low migration rate among young people	Higher migration rate among young people
	Access to support services such as agricultural extension officers, microfinance, relief agencies such as NADMO or Red Cross	Community often has access to services from agricultural extension officers; microfinance and relief agencies and community members optimize such services/support.	Community has little or no access to services from agricultural extension officers; microfinance and relief agencies and/or community members are not able to fully optimize such services/support
	Community stakeholder organizations	Presence of diverse and actively-engaged community associations or interest groups	Little or no access to diverse and actively-engaged community associations or interest groups

Source: CECAR-Africa Preliminary Field Survey, 2012

To develop the resilience matrix, the different criteria and indicators were organized into three categories: ecological, engineering, and socioeconomic (Table 3). Indicator selection for each resilience category was achieved through collaboration between community stakeholders and the study team, who possessed expert local knowledge of the socioecological landscape and had conducted an extensive literature survey. Although the indicator choice was debatable and therefore needed careful consideration (since this could differ from community to community), a consensus was deemed adequate for determining what was essential to accurately understand the extent of a community's resilience.

When selecting the indicators for the resilience matrix, the first process involved a comprehensive literature review to identify the issues to be considered under each of the resilience levels. Based on this review, the first between the Ghanaian and Japanese researchers occurred, during which the selected indicators in the draft of the resilience matrix were refined for further analysis. Subsequently, preliminary field visits and observations were conducted to completely finalize the criteria for the draft of the resilience matrix. The preliminary field observations, which involved walking through the communities and consultation with experts in the local community, were conducted between 2011 and 2012 in each of the study communities. During the walk through the communities, each study team member was given the draft of the resilience matrix and asked to locate evidence of availability or non-availability. For those variables that could not be observed, an in-depth interview was conducted with key community members. The results of the preliminary field observation were then discussed with the community through a stakeholder validation durbar. The validation durbar involved a meeting of community leaders and households at a central place, where the researchers shared the findings from the field surveys. Subsequently, a final telephonic meeting was conducted, through which feedback from the community validation durbar was discussed and the concerns of the community were incorporated in the final determination of the variables to be included in the resilience matrix (Table 3).

Finally, the project site selection based on the three forms of community resilience was finalized at a project meeting with more than 20 project researchers by cross examining the assessment of the resilience matrix in each community with the type of extreme events. Accessibility to the community and data availability from previous projects were also considered during finalization.

4. DISCUSSION AND CONCLUSION

In this paper, within the framework of the CECAR-Africa project, which comprises a joint team of scientists from Ghanaian and Japanese universities, a community-based resilience assessment model was developed with reference to a literature review on ecological, engineering, and socioeconomic resilience in the context of Northern Ghana. Based on the review, the paper discussed the methods for and process of study site selection in two regions and districts within Northern Ghana, with consideration to the communities' characteristics based on their vulnerability to floods/droughts and the coping strategies that could be further strengthened to enhance resilience. The site selection laid the foundation for further research aimed at determining the combination of factors that could enhance or reduce resilience in different communities through the development and application of a site selection matrix.

The development of a community resilience matrix follows a logical sequence. First, there is a need to measure the ecological and engineering resilience that is related to disturbances caused by climate change. This involves investigating previous studies on the existing infrastructure, land use, and soil composition to understand the agro-biodiversity and the reorganization rate and degree needed in the community, which requires a land use-based survey to understand the management practices and the sustainability potential of the agro-ecosystem. Second, socioeconomic resilience is examined through a socioeconomic household survey and governance research. The household survey involves an examination of the assets and livelihood strategies that influence societal reorganization. In parallel, through governance research, the informal and formal institutional forms of governance that affect the reorganization are explored through key informant and individual interviews, focus group discussions, and observations with key actors with relation to the ongoing (or lack of) development interventions.

To facilitate the combination of ecological, engineering, and socioeconomic resilience, we proposed a matrix table that could be applied to project site selection activities based on a community-based resilience assessment. The table showed the potential indicators for each type of resilience and how they could be applied to the selection of potential research sites. Such a table is useful when researchers need to identify research sites at the preliminary stage of a project. As it is often unclear how study sites are selected in case studies on resilience assessment, this paper has demonstrated a viable model, which could function as a resilience assessment checklist for other researchers. The current assessment criteria and indicators were particularly focused on community-level resilience measurements. In future studies, additional criteria and indicators for household-level resilience could be developed through detailed household socioeconomic surveys and accordingly integrated into this list.

Based on the selection of the variables in this paper to measure community-level resilience, there is a need to deepen our understanding of how to enhance resilience, as it is now clear that such resilience enhancement requires an integrated approach. Nevertheless, it is important to state that in this paper, we do not claim that the variables used under each resilience category are exhaustive. However, the selection was grounded in the specific local peculiarities that evolved out of our engagement with community stakeholders and our expert local knowledge of the socioecological landscape. Even with this information, more field-based research is needed in the selected communities to interpret or customize our proposed assessment methodology so as to adequately meet the specific local sociocultural and traditional contexts. This could involve strengthening or improving the resilience matrix and not necessarily incorporating all three levels of resilience. Therefore, though an extensive list of indicators did emerge from this process, we do not recommend the use of all indicators because using more than five indicators makes it difficult to identify which indicators are more crucial. Even if all indicators are used, the application of the model would involve more detailed field studies of both community and household assessments by converting the variables into measureable indicators through which each community can be scored. Ultimately, community-based resilience assessment needs to be usable not only by researchers and experts but also by local stakeholders and practitioners, including local government officials working in disaster and natural resources management. The effective use of this resilience matrix could help reveal where intervention options could be most effectively channeled to enhance the capacity of flood- or drought-vulnerable communities within or across communities for optimum benefit.

Based on our assessment, we recommend that in the flood-prone communities in Tolon

district, early planting and harvesting as well as flood recession agriculture could be used to minimize losses due to flooding. Agricultural extension agents could play a critical role by sensitizing farmers to these possibilities. An active adoption of simple irrigation techniques through the use of pumps in the dry season, as is being promoted by the Ministry for Food and Agriculture through the district assemblies, is highly recommended if communities are to evolve from being less to more resilient. For the communities in Wa West district, the availability of the Black Volta river, which provides water throughout the year, presents a welcome incentive for such enhancement strategies. In drought-prone communities such as Tolon district, the use of groundwater for irrigation should be supported. However, this would require research on the sustainability of groundwater for irrigation in these areas.

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