

Assessing Climate Change Vulnerability: A Conceptual and Theoretical Review

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Abstract: The extensive scope of climate change research and the diversity of scientific traditions involved in vulnerability research have resulted in different conceptual definitions and theoretical conceptualizations of the climate vulnerability phenomenon. This diversity of interpretations has led to copious methods for operationalizing vulnerability as an analytical concept, i.e., frameworks and approaches for vulnerability assessments. This paper is intended to review literature on climate change vulnerability by exploring and synthesizing the various conceptual and analytical frameworks which is regarded to be important in the assessment of vulnerability to climate change. From the reviewed literature, several interpretation of the concept of climate change vulnerability as well as theoretical frameworks are brought to the fore. The paper further highlighted on the two well-known methodologies of estimating vulnerability in literature; the vulnerability variable assessment method and the indicator technique by espousing the merits and demerits of each approach. It is suggested that exploring integrated quantitative vulnerability assessment approach will enhance the understanding of climate change vulnerabilities.

Keywords: Assessment, Climate change, Indicator, Sustainable Livelihood, Vulnerability

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1. Introduction

The conceptual understanding of vulnerability emanated from discussions on development in the 1990's (Cambers, 1994) and widely used in engineering research and projects as it relates to hazard preparedness (Adger, 2006). The concept was eventually used in numerous field of research, such as food insecurity (Borre, Ertle, & Graff, 2010); assessment of disaster (Wisner, 2004; Cutter et al., 2003) and assessment of poverty and livelihood (Conway, 1992); vulnerability to climate change (Abson et al., 2012; Ericksen, et al., 2011). The wide scope of climate change research and the diversity of scientific traditions involved in vulnerability research have resulted in different definitions and theoretical conceptualizations of the climate vulnerability phenomenon. Furthermore, this diversity of interpretations has led to numerous methods for operationalizing vulnerability as an analytical concept,

i.e., frameworks and approaches for vulnerability assessments. There is a consensus in literature on the need for greater clarity concerning vulnerability and related concepts. Numerous studies have, due to the prevailing confusion, attempted to assess the various definitions and conceptualizations in order to identify and create overarching frameworks. For better understanding of the different usage of vulnerability in climate change literature, this work intends to provide the numerous interpretations of the concept and theoretical frameworks used in literature.

2. Methods

This paper is purely based on the secondary literatures. Keywords such as "Climate Change, Sustainable Livelihood and Vulnerability" to search for relevant articles in journal databases.

3. Results and discussion

3.1. Conceptual definitions of vulnerability

There are many definitions of vulnerability in literature depending on the disciplines and their origin (Adger, 2006; Fellmann, 2012). In the general sense the word vulnerability denotes the ability or the state of being wounded, in other words it is the extent to which the system will possibly suffer from harm as a result of its exposure to hazardous condition. The root of the word owes its' origin from geography and hazard literature but has now become an integral concept in many disciplines. The concept of vulnerability therefore, seems to have been defined differently by different scholars (Füssel 2007).

Vulnerability literally is considered to mean the tendency or susceptibility to be harmed, it has been considered as a composite of adaptive capacity, sensitivity and exposure to hazards (Füssel 2007; Paavola 2008; Ghimire, Shivakoti, & Perret, 2010; IPCC, 2012). While adaptive capacity is regarded as the capacity of the people to deal with or acclimatize with the changing situation and is normally defined by socio-economic indicators. Sensitivity is the responses of the system as it is been affected, and exposure is the occurrences of events or stimulus (Paavola 2008). Vulnerability therefore, comprises of risk situation or a series of risky situations that households are faced with in trying to meet up with their means of livelihood, the sensitivity of the livelihood to those risky situations, the responses or choices that households have to make to manage those hazards and eventually the circumstances that explain the loss in wellness (Turner et al., 2003). It is generally regarded as the predisposition or susceptibility to being affected, and has been considered as a function of adaptive capacity, sensitivity and exposure to hazards (Kelly & Adger, 2000; McCarthy, 2001; IPCC, 2012).

From the definition given by Chambers (1983), vulnerability have two sides. These sides are the external consisting of risk, or shock emanating from the changes in climate which individuals or households are subjected to, while the inner dimension is the defenselessness, translated into the lack of ability to manage this risk or shock without adverse effect. The person's or group's characteristics to in respect of their ability to predict, manage, and withstand, and resuscitate from the adverse effects of environmental threats. It can be seen as a spectrum from being resilient to susceptible (Blaikie, Cannon, David, & Wisner, 1994). It is the degree of susceptibility to sustained injury from climate change by natural or social system (Adger, 1999).

Generally speaking, vulnerability is understood to be a function of two aspects. The effects of an event on the human being, called the capacity or social vulnerability and the danger of the likely occurrence of the event signifying the system's exposure. According to Watson, Zinyowera, Marufu, and Moss (1996) vulnerability is the

degree of damages or harm caused by climate change, this depend on the systems sensitivity and also the extent to which the system adapt to new changes in the climate condition.

Kasperson, Kasperson, Turner, Hsieh, and Schiller (2003), defined vulnerability as the extent whereby an exposure unit has the propensity to be harmed as a result of disturbance or stress and the capacity or otherwise to manage and recover or adjusting to new condition or become extinct.

Vulnerability is related to issues like "marginality, resilience, adaptability, susceptibility, risk, fragility, coping, sensitivity, exposure, criticality, robustness and coping capacity" (Füssel & Klein, 2006). Owing to this fact, the concept has a multiple dimension in its policy context as a result of the wide ranging concepts and approaches in its assessment (Füssel 2007). Recently the term symbolizes a "conceptual- cluster," a conglomeration of coupled human- environmental research (Newell et al., 2005; Füssel 2007).

Moreover Füssel (2007), shows that the concept of vulnerability could be meaningfully understood when it is attributed to a particular system, to a particular hazard or variety of hazards and differentiated base on time horizon, as current and/or future vulnerability. To describe vulnerability appropriately, there should be four of the following dimensions; firstly, there should be a system of analysis, e.g. the coupled human- environment system, or a population group, an economic sector, geographical area or region, or a natural system; secondly, it should also indicate a particular attribute shown to be threatened through exposure to a given hazard.

For instance, public life and health, income, community cultural identity, biodiversity etc., thirdly, it should indicate the hazard i.e. the potentials of being destroyed or damaged by a particular physical event, or a phenomenon or human action that is capable of causing harm or loss of life, or properties, disruption of other social or economic activity, or a general environmental destruction; fourthly, it should have a temporal dimension or reference (Singh , Bantilan, & Byjesh, 2014), this is needed specifically when the amount of risk situation is expected to aggravate with time (Luers, Lobell, Sklar, Addams, & Matson, 2003; Luers, 2005; Füssel 2007).

Recently, Intergovernmental Panel on Climate Change (IPCC) defines vulnerability as "the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. But in the context of climate change as put forward by the IPCC, vulnerability therefore, is said to be a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity"(IPCC, 2007; Singh et al., 2014).

This definition, illustrate the fact that Vulnerability comprises of three components in the system. System's exposure as an external component in form of climatic variability, the internal component or dimension in form of system's sensitivity, as well as system's adaptive capacity to that particular exposure and sensitivity (O'Brien et al., 2004; Füssel & Klein, 2006; Bryan,

Deressa, Gbetibouo, & Ringler, 2009; Gbetibouo & Ringler, 2009; Gbetibouo, Ringler, & Hassan 2010;). Exposure portrays the magnitude within which a system is approaching harm, while system's sensitivity is the magnitude of been affected after exposure to the stress(Luers et al., 2003; Luers, 2005). The capacity or system's ability to get prepared and modify the stress, so as to minimize the deleterious impact and or taking the advantage from the opportunities offered. Adaptive capacity modifies vulnerability with its moderating effects on exposure and sensitivity (Adger et al., 2007; Engle, 2011). This can be graphically depicted, thus;

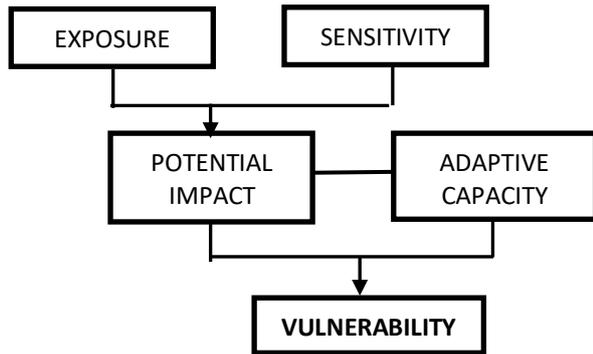


Fig 1: Vulnerability and its Component
Source: Fellmann (2012)

This means that a given system is said to be vulnerable when it is exposed and show sensitivity to climatic changes with low adaptive capacity. A system is less vulnerable when it's exposure and sensitivity to climate changes is low, and or its adaptive capacity is high (Smit & Wandel, 2006; Engle, 2011; Fellmann, 2012).

From climate change perspectives, exposure therefore, refers to the extent and intensity of system's exposure to great climatic changes (Griggs & Noguera, 2002). It denotes the contextual climate settings and stimulus determining system's responses against those settings. Exposure as an element of vulnerability encompasses not only the extent but also how enormous a system face serious changes in climatic conditions (Adger, 2006). In vulnerability assessment, the climatic changes could be summed up as climatic variability or distinct changes in the climatic system such as rising temperatures, variation and changes in rainfall, etc.

Collectively, exposure level and sensitivity of the system expresses the possible impact a system might experience but these alone did not in any way make system vulnerable no matter how exposed or how sensitive that system is. Both exposure and sensitivity do not explain the ability of the system to adjust to the climatic changes, rather vulnerability is the residual impact after adaptation has taken place as indicated in Figure 2.4. It is the adaptive capacity that influences vulnerability through modifying exposure and sensitivity (Yohe & Tol, 2002; Adger et al., 2007; Fellmann, 2012).

Engle (2011), describes adaptive capacity as an essential substance or positive trait of a system needed to ameliorates vulnerability. The higher the adaptive capacity

of a system, the more is the possibility of system to adjust and the less the vulnerability to climate change and variability. The role of adaptive capacity is shown pictorially in figure 2 below;

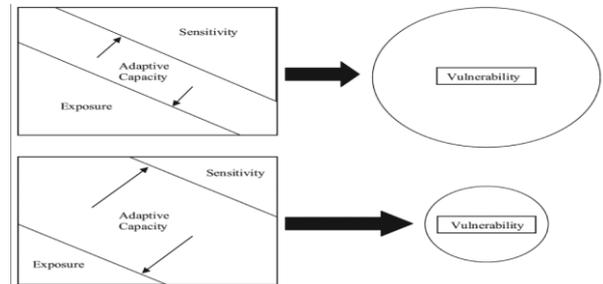


Fig 2: The Vital Function of Adaptive Capacity towards Vulnerability
Source: Engle (2011)

Generally speaking, vulnerability, together with its three surfaces i.e. exposure, sensitivity and adaptive capacity, and their determining factors have both temporal and spatial variation, they vary with type and climate stimulus as well (Smit & Wandel, 2006; Adger et al., 2007; Fellmann, 2012; Singh et al., 2014). Therefore, vulnerability is relative to the specific context, and the factors that influence system's vulnerability to climatic changes depend on the nature of the system and the impacts (Brooks, Adger, & Kelly, 2005).

3.2. Contending Interpretations of Vulnerability Assessment

There are a number of alternative concepts in literature as there are various definitions of vulnerability. Each of these concepts emanates from various academic areas and professional background and the unit of analysis (Füssel 2007; Hinkel, 2011). Yet, in the context of climate change two well-known concept of vulnerability abound in literature; these are outcome vulnerability and contextual vulnerability. The outcome vulnerability is the “end-point” while the contextual vulnerability is the “starting point” vulnerability.

The Outcome vulnerability is called the end-point vulnerability analysis considers vulnerability to be the possible final impact of climate changes on a particular unit of exposure such as biophysical or social when possible adaptation is being considered. Therefore, the outcome method takes into account information on possible biophysical impact of climate change along with information regarding socio- economic ability to withstand and adapt appropriately (Füssel 2007; O'Brien, Eriksen, Nygaard, & Schjolden, 2007; Fellmann, 2012).

On the basis of natural science orientation and climate change model scenario prediction, the outcome vulnerability methods typically centered on biophysical changes within a given system. With a clear demarcation between physical and social components and consider vulnerability as outcome that can be estimated and

measured. In this approach, vulnerability outcome is measured by the levels of system's adaptive capacity, with a greater emphasis on biophysical components while the function of socio-economic component on the effects of climate change is often neglected. It is therefore, assumed that highly vulnerable system is the one to have a serious physical change. Studies that follow this tradition consider technological solution in adaptation and mitigation strategy in minimizing a given climate change impact (Eriksen & Kelly, 2007; Fussler 2007; O'Brien et al., 2007). Studies that focus on the vulnerability of agricultural yields to climate change in the future usually follow the tradition of outcome vulnerability approach.

The concept of contextual vulnerability otherwise referred to as the starting-point interpretation viewed vulnerability as a current lack of capacity of a given system to deal with the changing climate conditions. Therefore, vulnerability is seen to be affected by both biophysical conditions and the changing social, economic political, institutional and technological structures and processes. This approach considers vulnerability to be a function of the character of ecological and social systems which are shaped by multiple factors and processes (Adger, 2006; O'Brien et al., 2007).

From the social science tradition, contextual vulnerability methods cheaply give emphasis on the current socio-economic determinants or drivers of vulnerability, i.e. social, economic and institutional conditions. Those determining factors that influences the vulnerability of a system comprises of "marginalization, inequity, food and resource entitlements, presence and strength of institutions, economics and politics" (Adger, 2006; Fellmann, 2012).

Hence, the contextual explanation of vulnerability clearly identifies that vulnerability to climate change is not only a function of biophysical components of the environment, but is essentially controlled by the extent of socio-economic circumstances in which climate changes occur. Both natural and social milieu are normally viewed "as the two sides of the same coin", i.e. a strong human-environment interrelationship is assumed and the boundaries between nature and society are not firmly drawn" (Fellmann, 2012). This approach holds that the present vulnerability to climatic perturbation defines the system's adaptive capacity, and the changing climate modulates both the biophysical settings and also the circumstances of climate change occurrence (Turner et al., 2003).

From the contextual perspectives, vulnerability can be reduced by changing the conditions where climate change take place so that the affected population both individuals and groups can be supported to appropriately manage and adjust to the changing climatic perturbations (Adger, 2006; Eriksen & Kelly, 2007). Therefore, studies along the perspectives of contextual methods normally consider sustainable development approaches to strengthen people responses and adaptive capacities to tackle the issue of vulnerability to climate changes. One vital element of contextual methods is the involvement of the people and other stakeholders in the identification of the stressors,

impacts and the adaptive options (Fellmann, 2012). The various concepts and explanations of vulnerability make its study to be context, purpose, place and time specific, as well as the perception of its assessors (Adger, 2006; Fellmann, 2012; IPCC, 2012a).

In practice, Fellmann (2012), opines that the question of "who is vulnerable to climate change?" can usually be explained in both the two perspectives of vulnerability. Fellmann, further explain that endpoint vulnerability usually addresses questions like "what are the expected net impacts of climate change in different regions?" or "which sector is more vulnerable to climate change?" He pointed out that same question can equally be addressed through contextual methods, much as the study is dealing with an economy that is characterized by sensitivity to climate changes. Hence, contextual vulnerability approach deals with the question of "why are some regions or social groups more vulnerable than others?" (Fellmann, 2012).

Nonetheless, vulnerability is seen as context- and purpose-specific; neither of the two approaches could be seen as superior to the other. Rather the two approaches should be seen as complementary to each other in climate change studies. As highlighted in O'Brien et al. (2007), the outcome and contextual interpretations of vulnerability should be recognized as being two complementary approaches to the climate change issue. The two approaches assess vulnerability from different perspectives and both are important to understand the relevance of climate change and corresponding responses (Kelly & Adger, 2000; Adger, 2006; O'Brien et al., 2007). Additionally, in recognizing that any complex system commonly involves multiple variables such as physical, environmental, social, cultural and economic, it is better to assess the vulnerability of that system through an integrated or multidimensional approach in order to capture and comprehend the whole picture of vulnerability within the perspective of climate change (Cardona et al., 2012).

In a nutshell, climate change vulnerability as shown above is considered as a construction of both biophysical and socio-economic vulnerabilities, and each of these is influenced by the exposure, sensitivity and adaptive capacity components. On the basis of timeframe vulnerability assessment could be current or future. For instance, outcome vulnerability is conceptualized as future vulnerability, while contextual vulnerability is cantered on assessing current vulnerability. This difference is attributable to the differences in the fields that are concern with the vulnerability and adaptation research.

Natural science field usually considers the biophysical factors of climate changes and therefore, examine potential vulnerability as an end-point analysis. While scientists working with socio-economic factors examine current or starting-point vulnerability analysis (Fellmann, 2012). Although, such division of vulnerability analysis on the basis of timeframe as it is important, and valid to maintain the different perspectives, yet, socio-economic factors play a significant role in modifying climate change impacts (Carter et al., 2007; Fellmann, 2012). This underscores how vulnerability depend on the on-going

autonomous and or planned adaptation practices (Carter et al., 2007).

Hence, to have thorough understanding of vulnerability requires the combination of the various perspectives, as an integrative approach (Fellmann, 2012). The integrated vulnerability analysis, combine both the socio-economic and biophysical component of the system under study. The approach considers all the internal dimension of vulnerability and the external stressors of concern. This integrated diagnostic technique was used in an agro-ecologically based household's vulnerability analysis in Ethiopia (Madu, 2012), similarly, (Deressa, Hassan, & Ringler, 2008) used the approach in vulnerability analysis of farmers at the regional level in Ethiopia. Moreover, the dynamics of vulnerability makes its assessment as a continuous process so as to portray the spatial and temporal dimensions of vulnerability of a particular system of concern (Luers, 2005; Ericksen and Kelly, 2007). This study adopts the integrated vulnerability assessment approach by assessing the of paddy farmers' households and communities vulnerability to climate change variability.

3.3. Theoretical Framework for Vulnerability Assessment

There are different type of methods and tools use in the assessment of vulnerability as a result of the multiplicity of interpretation and concepts. The various methodological approaches use in assessment of climate change vulnerability in agricultural sector ranges from experimental, modelling, meta-analysis, and survey-based.

There are two well-known methodologies of estimating vulnerability in literature; the vulnerability variable assessment method and the indicator technique. The vulnerability variable assessment procedure is based on econometric technique of determining welfare loss of particular variables of interest such as household food consumption, income, agricultural crop yields etc., as it relates to particular set of stressors for instance climate change (Schimmelpfennig & Yohe, 1999; Gbetibouo et al., 2010). Although this approach can provide vulnerability index of a particular area, yet, could not adequately reflects all the three levels of vulnerability (Luers et al., 2003; Gbetibouo et al., 2010). These approaches include entitlement-based and Sustainable Livelihood Approach (SLA)

Entitlement- Based Approach

This is one of the variable assessment approaches applied in the development economics to understand the occurrence of food insecurity. This framework was first formulated in the 1980's following the initial work of Sen (1981) entitled "poverty and famine". This pioneering work marked the turning point of the paradigm shift in the food insecurity research as an advancement of the Malthusian theory. The emphasis is tilted away from the issue of food availability to food accessibility concerning individuals or household (Devereux, 2001). This theory

therefore dispelled the assumptions of Malthusian theory that insufficient agricultural food production as the main determinant of food insecurity. It argued that entitlements bundles of individuals are the determinant of the access to food, thereby the theory used economic and institutional factors to unbundle the vulnerability to food insecurity (Sen, 1981).

According to this theory, entitlement entails collections of commodity bundles that a person can command in society using the totality of rights and opportunities that he or she faces alternatively" (Sen, 1984, p. 497). These are resources which could be actual or potential comprising of mutual arrangements (reciprocal), production as well as productive assets available to a given household or community at the time of difficulty (Sen, 1984). Availability of food in the market does not guarantee its access by individuals or households rather the amount of entitlement is what determinant the vulnerability of the household when food crises arise (Sen, 1981). Food insecurity arises where a given household or individual cannot access food by the use of entitlement at disposal even in the presence abundant food supply (Devereux, 2001).

Based on this theory four types of relationship concerning entitlements were identified to include production, trade, labour and heirloom or remittance. The theory posits that individuals or households will have food access directly or otherwise via these means. Three fundamental ways by which individual or household will have food entitlement are three; (i) Individuals or households produce their own food as a direct entitlement; (ii) indirectly where household members purchases food from the market; and/or (iii) households or individuals are provided with food through charity, non-governmental organization (NGO) or remittance from family and friends, this is a transfer entitlements (Fraser et al., 2005). When households experience disruption in their entitlement bundle they became susceptible to food insecurity as they do not have the capacity to change their strategies for food entitlement (Fraser et al., 2005).

This theory was criticized as it gave too much emphasis on economic market-based causality (Antwi-Agyei, 2012). The approach did not take into consideration the socio-political and bio-physical factors influencing food insecurity in a given area, also the manner through which individuals make their means of livelihood at times of difficulty (Burchi & De Muro, 2016). The entitlement approach has been practically criticized by Devereux (2001) when he argued that Sen's ideas of entitlement had four shortcomings. First, in connection with the idea of endowment, in reality, people choose hunger instead of selling their assets. Second, on the basis of De Wall's health crisis model, death is not caused by the right, but is more due to the pattern of migration and exposure to new diseases. Thirdly, criticism also focuses on entitlement rights, in many cases, in relation to individual as a unit of analysis, in developing countries, the right to poverty is owned by society not by individuals. Finally, the shortcoming of this theory is due to extra-entitlement transfer problems. Hunger problems are not

just problems with individuals but also problems with institutions, social contexts and political crises. In spite of its criticisms, this approach provides a useful premise upon which an assessment of how the several bundles of entitlement own by individuals could be used to provide explanation of buffer this may create at the time of extreme climate events. In this research this approach provides a wider conceptualization and explorations of numerous capital assets a given farming households and communities will have access to in order to ameliorate negative effects of climate change variability.

Sustainable Livelihood Approach

The Sustainable Livelihood Approach (SLA) was intended for the assessment of poverty and this theory builds on the entitlement approach (Sen, 1981). Essentially, the SL framework deals with the issue of assets that is readily available to the households and could either be tangible assets or intangible assets, it is akin to the concepts of endowments in the entitlement theory. These assets are categorized into five: human, financial, natural, social capital and physical capitals. Even though this approach is considered as a people-oriented, the somewhat "pentagon of asset" in actuality is the major thrust of the Sustainable Livelihood framework. This approach has been used for various developmental issues, such as food safety (Devereux et al., 2004; Hussein, 2002).

There are two distinguishing characteristics of the general framework of the Sustainable Livelihood approach that serves as merits in food security analysis against the past approaches. The first is that the theory has a long term views; the second is its focus on context (economic, social, physical, cultural and political etc.), even though this theory is limited to agricultural activities and rural areas, and rarely took into consideration macroeconomic or economy-wide issues. The amalgamation of both analytical features with household asset studies give rise to three interconnected concepts in the food security analysis specific to the SL frameworks which were not considered in the earlier approaches:

Firstly, the theory clearly considered risk and shock, and the internal sides of vulnerability translating into lack of ability to manage without being damaged which Chambers (1995) 'referred to as not lack or want but exposure and helplessness. It has two sides: the outer side of exposure to shock, stress and risk; and inner weakness, which means lack of means to overcome without facing damaging loss. Secondly, the idea of sustainability, which is closely related to vulnerability and resilience, is among the central principles of the framework of sustainable livelihood:

As according to Department For International Development (DFID, 1999) there is sustainability in livelihood when it can overcome and recover from stress and shock and maintain or improve its capacities and assets both now and in time ahead. Thirdly, is addressing coping strategies which 'represent a set of sequence of activities conducted, specifically by households in reaction to external shock resulting in the decline in the

food availability (Curtis, 1993, quoting Davies, 1993). Coping strategies are incorporated into a more generalize survival instinct that is a combined activities chosen by the public to achieve their livelihood objectives. The concept of sustainable livelihood has also been extensively been applied in the measurement of food security, mostly in humanitarian disasters.

The DFID SL framework (Figure 3) is intended to hypothesize the way through which individuals reacted when they are vulnerable which is influenced by several factors such as seasonal limitations as well as opportunities, economic misfortunes and long-term trend. How the individuals harness numerous livelihood alternative assets or capital singly or in combination as affected by vulnerability situation, access and influence of various institutions and procedures. How they can optimize their livelihoods strategy to attain their preferred livelihood outcomes (DFID, 2000). It is therefore, assumed that when individuals possess good access to capital assets, the better they are able to effect structures and processes for them to be highly reactive to their needs (Carney, 2000).

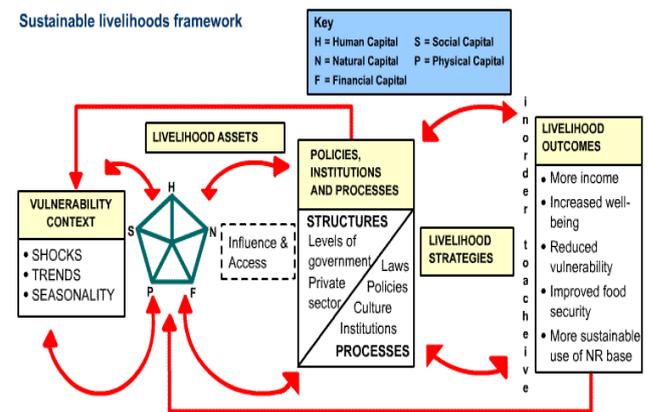


Fig 3: DFID Sustainable Livelihood Framework Source: DFID (2000)

Vulnerability to Climate Variability and Livelihood Capitals

It is important to highlight the fact that individuals become vulnerable to climate variability whenever their means of livelihood is at stake. The theory of SLA approach is anchored on the belief that local farming communities have numerous capabilities which needs to be considered. Basically, the Sustainable Livelihood Approach is useful in the understanding of the way individuals or communities use a combination of variety of capital endowments comprising of tangible capital asset, example land asset, and intangible capital asset such as the level of education or farmers experience, claim and access etc. individuals possess and have control over to use it in achieving livelihood goals within the existing social, economic and political milieu (Carney, 1998; Yaro, 2004). Usually, the sustainable Livelihood Approach is used by taking into consideration the five capital assets i.e. the human, physical, financial, social and natural assets

and also their connection to aggregate vulnerability situation (context), process, institution and policy as well as livelihood outcome (DFID, 2000).

Human capital asset denote the quality and quantity of labor, which at the individual household this is represented by the size and composition of household and its characteristics in terms of Age, gender, levels of education, levels of training and skills, experience, knowledge (perception) and the health status of the members of the household (Defiesta & Rapera, 2014). Natural assets comprises of the natural flow and stock and other environmental resources which is vital in the construction of livelihood outcomes (Scoones, 1998). Similarly, it involves land quality and quantity, meadow, water, agro-ecological characteristic including slope, terrain, and forest resources (Elasha, Elhassan, Ahmed & Zakieldin, 2005), and the quality of these natural endowments can be enhanced or devalued through human activities. Financial capital assets include, income, saving, credit and other form of liquid saving (Scoones, 1998; Ellis, 2000). This also involves donations and assets that can be disposed easily like livestock and poultry (Elesha et al., 2005; Hesselberg and Yaro, 2006).

The physical assets are assets that are not related to land; they include infrastructure such as markets, road networks, electricity and irrigation facilities (Elasha et al., 2005) machinery and equipment (Scoones, 1998; Ellis, 2000) and type of housing (Scoones, 1998). Although infrastructure are beyond the individual household's capability and direct control, as these are provided by the government typically as public goods, but the quality and quantity of these assets contributes immensely to the viability of rural livelihoods (Ellis, 2000). Social Capital entails the numerous rights and claims arising from membership of recognized group or association (Elasha et al., 2005); social relationships, collaboration, membership of voluntary organizations, community groups, professional union, social or political networks and also reliance on family and relatives as well as friends at the time of need (Ellis, 2000).

A number of studies have used this SLA framework (Reid and Vogel, 2006; Thomas et al., 2007 Sallu, et al., 2010). The various studies help to provide a clear understanding of the way communities or individuals responded to past environmental shocks by employing the various form of capital assets at their disposal to overcome climatic shocks.

This present study therefore, intends to adopt this framework as assessing livelihoods provides the advantages of understanding various adaptations that are readily available in dealing with declining crop productivity arising from the effects of climate variability and by extension how the consequences of this could affect livelihoods (Antwi-Agyei, 2012). The study uses the SLA to frame how rural livelihoods, including paddy rice production is vulnerable via the identification of the farmers various capital assets. The assets are utilized by the individual households differently to lessen the effects of climate variability (Eakin and Bojorquez- Tapia, 2008). Therefore, individual farmers access to wide ranging

capital assets fundamentally help to influence the capacity of households to deal with climate variability (Adger and Kelly, 1999).

In spite of the usefulness and wider applicability, the framework has been faulted as difficult to address temporal dimension as well as multiple scales and the dynamics of power as an analytical tool (Antwi-Agyei, 2012). It was observed to provide a constricted view of household vulnerability or the community at a particular point in time and does not provide wider temporal variation linked with the shocks (Scoone, 2009). Vulnerability situations and policies and collection of assets are changing constantly with uncertainties. Hence, it is essential to incorporate time frame with the study framework to give more strength to the value of the analysis (Scoone, 2009).

The framework also fails to clearly take into consideration political capital (Toner, 2003; Baumann, 2000). The framework therefore, underestimates the importance of politics and power in determining the vulnerability of farming communities to the effect of climate variability. The inclusion of these it was argued have the tendency to improve the analytical prowess of this framework (Baumann and Sinha, 2009). Equally the absence of inclusion of the political capital makes it difficult to assess the impact of structures transformation and processes on rural livelihood (Antwi-Agyei, 2012).

Also, another shortcoming of the framework is in its inability to recognize the variation of livelihood analysis using multiple scales. While its assumption to link micro and macro, it was observed that such assumption is unrealistic (Scoones, 2009). Scoones (2009) opined that the framework is limited in its incapacitation to capture the globalization phenomenon and how this process impacted on the activities and outcome of household livelihood. The author stressed the role of globalization processes in influencing decision-making and choice of local livelihood. The model was indicted for its inability to recognized distributional issues (Yaro, 2004) which is believed to be vital in terms of coping and adaptation to climate change variability.

Although the framework centered on the individuals in the assessment of their livelihood vulnerability and relative inequality facing the respective households which ultimately change the development objectives (Toit, 2005; Dijk, 2011), its methodology was considered to be individualistic. Furthermore, the livelihood assessment apparently assess, only the capital assets available to the farming household. For example, analyzing household the livelihood of a household may provide only evaluation of the availability of natural capital to deal with extreme events, but, the evaluation lack the ability to provide useful explanation as to whether a given agro-system is possibly sensitive to such changes in the environment (Fraser, 2007). The framework therefore, could not take into consideration the physical and ecological environments (Adger, 2006).

Quantitative Indicator Approach to Assessment of Vulnerability

Another classical approach for quantification of vulnerability is the indicator method of vulnerability assessment which employs the use of particular set or collection of some proxy indicators, and assess vulnerability by calculating indices, averages or weighted averages for the selected variables or indicators (Gbetibouo et al., 2010). Therefore, indicators referred to as quantitative measures normally in form of single values employed as a representation of phenomenon of interest concerning a given community, household or a particular system (Hinkell, 2011). A chosen indicator is meant to simplify useful information which can be measured and quantified, rather it makes the phenomenon perceptible (Moss, Brenkert, & Malone, 2001).

The process of aggregating diverse indicators as a representation of a single value to be used in characterizing particular households, community or a system of interest usually proves cumbersome. It appears more tasking where the assessment are carried out in a very large spatial area as the indicators used may appear different in different areas (Eakin and Luers, 2006; Hinkel, 2011). Therefore, it is desirable to clearly comprehend the methodology involve in the measurement of the indicators needed in vulnerability assessment (Gallopín, 1996; Abson et al., 2012).

The advantage of this method is that it can be applicable in any scale of analysis, such as household level, district or national level. The disadvantage of the indicator approach is that applying indices may be marred by subjectivity in variables selection, but could be very useful in observing trends and also discovering conceptual frameworks, multiple indices can accurately measure the multiple dimension of vulnerability (Leichenko & O'Brien, 2002; Gbetibouo et al., 2010). Therefore, other studies may consider integrated vulnerability assessment approach to construct vulnerability index for the identification of the most vulnerable to climate change variability among farmers' households, villages and communities.

4. Conclusion

Climate change is caused by disruption of the global energy balance referred to as climate forcing which may be internal or external. Global changes in the climate will greatly impacted on agricultural systems with negative consequences on food production by disrupting the global pattern, hence affecting all component of food security. Although the effects of climate change will vary from place to place, however, comprehending the complexity of the effect of climate change on agriculture needs to be continuously studied as well as more vulnerability assessment of many countries across the world.

Notwithstanding the difficulty in conceptualizing and describing vulnerability, the review made in this study provide an in-road into the various theoretical as well as conceptual framing of vulnerability and its assessment,

Especially as it relates to vulnerability to climate change and variability. Such vulnerability assessment can be employed in the identification of vulnerable groups in a given geographical expression and help in inform policy concerning allocation of resources in the affected areas.

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