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# Conceptualization of Vulnerability, its Linkages to Climate Change and Policy Implications

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**A B S T R A C T**

The last two decades have witnessed extensive research on potential and observed vulnerability to climate change on all kinds of natural and social systems**.** Vulnerability depends critically on context, and the factors that make a system vulnerable to a hazard will depend on the nature of the system and the type of hazard in question. Thus, a clear description of the vulnerable situation is an important first step for avoiding misunderstandings around vulnerability. The assessment of vulnerability in the context of extreme climate events and historical climate variability is an important avenue for engaging the policy community. A focus on climate variability automatically brings to the fore the way in which socio-economic systems becomes vulnerable to climate hazards. At the same time, this analysis provides insights that are relevant immediately to deal with extreme climate events well before the full range of consequences of mean changes in the climate state become apparent. Therefore, improved understanding of vulnerability and adaptive capacity is essential for identifying and realizing the full benefits of developmental projects, and in ensuring that such projects, particularly infrastructure projects, do not lead to mal adaptation with regard to future climate change. With this background, the present study extensively reviewed the different concepts, definitions and terminologies used to describe vulnerability, its linkages to climate change and emphasized on existing and required policy formulation to cope with the adverse impacts of climate change and variability on environmental and human systems.

**Keywords**

Climate change,
concept,
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## Introduction

The term 'vulnerability' has its roots in geography and natural hazards research but now days it becomes the central concept in climate change research as well as in a number of other research contexts. The concept is equally emphasized by various research communities such as those dealing with disaster management, public health, development, secure livelihoods, and climate impact and adaptation and conceptualized in many different ways. For instance, natural scientists tend to apply the term in a descriptive manner whereas social scientists tend to use it in the context of a specific explanatory model (Füssel, 2005). Therefore, widespread disagreement about the appropriate definition of vulnerability is a frequent cause for misunderstanding in interdisciplinary research on vulnerability and adaptation to climate change. To ameliorate this confusion, a comprehensive and consistent conceptual framework of vulnerability that combines a terminology of vulnerable situations, a classification scheme for vulnerability factors, and a terminology of vulnerability concepts are required (Füssel, 2006). This paper combines a generally applicable nomenclature of vulnerable situations and a terminology of vulnerability concepts to review earlier the attempts at classifying vulnerability concepts**.**

## Concept, meaning and definitions of vulnerability

The existence of competing conceptualizations and terminologies of vulnerability has become particularly problematic in climate change research, which is characterized by intense collaboration between scholars from many different research traditions, including climate science, risk assessment, development, economics, and policy analysis. This collaboration must be based on a consistent terminology that facilitates researchers from different traditions to communicate clearly and transparently despite differences in the conceptual models applied (Laroui and van der Zwaan, 2001). The ordinary use of the word `vulnerability' refers to the capacity to be wounded, i.e., the degree to which a system is likely to experience harm due to exposure to a hazard (Turner II *et al.,* 2003). One can only talk meaningfully about the vulnerability of a specified system to a specified hazard or range of hazards (Brooks 2003). Timmermann (1981) posited that "vulnerability is a term of such broad use as to be almost useless for careful description at the present, except as a rhetorical indicator of areas of greatest concern". Morgan (1981) regarded vulnerability as some measure of the impact of a hazard on human socio-economic systems, which suggests that we ought to explore vulnerability in the context of a framework where the hazard process can be represented, and its impacts and relationship to the characteristics of the system can be modelled. Vulnerability has been related or equated to concepts such as resilience, marginality, susceptibility, adaptability, fragility, and risk". Exposure, sensitivity, coping capacity, criticality and robustness could easily be added to this list (Liverman 1990).

The argument put forth by Luers *et al.,* (2003) suggested that vulnerability assessments should shift away from attempting to quantify the vulnerability of a place and focus instead on assessing the vulnerability of selected variables of concern and to specific sets of stressors". Vulnerability represents a conceptual cluster" for integrative human-environment research in the sense of Newell *et al*., 2005. Downing and Patwardhan (2004) presented a formal nomenclature for the vulnerability of social systems that includes the threat, the region, the sector, the population group, the consequence, and the time period. It may be described as a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity (Patwardhan, 2006). Whereas Fussel (2004) described climate-related vulnerability assessments based on the characteristics of the vulnerable system, the type and number of stressors and their root causes, their effects on the system, and the time horizon of the assessment. The vulnerability of ecosystems to global change with respect to a particular ecosystem service, a location, a scenario of stressors, and a time slice (Metzger *et al.,* 2005).

The above nomenclature and frameworks largely agree that the following four dimensions are fundamental to describe a vulnerable situation.

**System**

The system of analysis, such as a coupled human-environment system, a population group, an economic sector, a geographical region, or a natural system, note that some research traditions do restrict the concept of vulnerability to social systems or coupled human-environment systems whereas others apply it to any system that is potentially threatened by a hazard (McCarthy *et al.*, 2001).

**Attribute of concern**

The valued attribute(s) of the vulnerable system that is/are threatened by its exposure to a hazard. Examples of attributes of concern include human lives and health, the existence, income and cultural identity of a community, and the biodiversity, carbon sequestration potential and timber productivity of a forest ecosystem.

**Hazard: United Nations (2004)** define `hazard' broadly as "a potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation". Hence, a hazard is understood as some influence that may adversely affect a valued attribute of a system. A hazard is generally but not always external to the system under consideration. For instance, a community may also be threatened by hazardous business activities or by unsustainable land management practices within this community. Hazards are often distinguished into discrete hazards, denoted as perturbations, and continuous hazards, denoted as stress or stressor**.**

**Temporal reference**

The point in time or time period of interest, specifying a temporal reference is particularly important when the risk to a system is expected to change significantly during the time horizon of a vulnerability assessment, such as for long-term assessments of anthropogenic climate change.

These four attributes allow characterizing a vulnerable situation independent of a particular research tradition. The following nomenclature may be used to describe a vulnerable situation: vulnerability of a system's attribute(s) of concern to a hazard (in temporal reference). The temporal reference can alternatively be stated as the first qualifier. Examples for fully qualified descriptions of vulnerability are "current vulnerability of smallholder agriculturalists in a specific region at risk of starvation to drought" (Downing and Patwardhan, 2004). Note that this nomenclature of vulnerability is also applicable to related concepts such as `adaptive capacity' and `risk'. The concept of "vulnerability" bears important communicative value: it describes in a powerful way that change is not always for the good. Vulnerability captures notions of possible loss, damage, and impact; of threat, risk, and stress; of uncertainty and insecurity; of a lack of power and control; and of a number of other factors that contribute to a feeling or state of being vulnerable (Fussel, 2006).

**Identifying key factors affecting vulnerability**

Vulnerability depends critically on context, and the factors that make a system vulnerable to a hazard will depend on the nature of the system and the type of hazard in question. The factors that make a rural community in semi-arid Africa vulnerable to drought will not be identical to those that make areas of a wealthy industrialised nation such as Norway vulnerable to flooding, wind storms and other extreme weather events. Isolation and income diversity might be important determinants of vulnerability to drought for rural communities in Africa, whereas the dominant factors mediating vulnerability to storms and floods in Norway might be the quality of physical infrastructure and the efficacy of land use planning. Nonetheless, there are certain factors that are likely to influence vulnerability to a wide variety of hazards in different geographical and socio-political contexts. These are developmental factors including poverty, health status, economic inequality and elements of governance, to name but a few. These may be referred to as generic determinants of vulnerability, as opposed to specific determinants relevant to a particular context and hazard type, such as the price of a particular food crop, the number of storm shelters available for the use of a coastal community, or the existence of regulations concerning the robustness of buildings.

Several researchers distinguish biophysical (or natural) vulnerability from social (socio-economic) vulnerability. However, there is no agreement on the meaning of these terms. The conceptual framework for coastal vulnerability assessment developed by Klein and Nicholls (1999) sees `natural vulnerability' as one of the determinants of `socioeconomic vulnerability'. Cutter (1996), in contrast, regards the `biophysical' and the `social' dimension of vulnerability as independent. Brooks (2003) viewed social vulnerability as one of the determinants of biophysical vulnerability. Intergovernmental Panel on Climate Change (IPCC), links vulnerability with climatic change, and point out that the vulnerability of a region depends to a great extent on its wealth and that poverty limits adaptive capabilities (IPCC, 2000). Further, they argued that socio-economic systems "typically are more vulnerable in developing countries where economic and institutional circumstances are less favourable". Also a common theme in the climate change impacts and vulnerability literature is the idea that countries, regions, economic sectors and social groups differ in their degree of vulnerability to climate change (Bohle *et al.*, 1994). This is due partly to the fact that changes in climatic patterns are uneven and are also not evenly distributed around the globe. Though vulnerability differs substantially across regions, it is recognized that "even within regions… impacts, adaptive capacity and vulnerability will vary" (IPCC, 2001). The glossary of the TAR (IPCC, 2001) 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. Thus, vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity'' (McCarthy *et al.*, 2001). However, Smit *et al.*, (2001) in the IPCC TAR, citing Smit *et al.*, (1999), described vulnerability as the ''degree to which a system is susceptible to injury, damage, or harm (one part—the problematic or detrimental part—of sensitivity)''. Sensitivity in turn is described as the ''degree to which a system is affected by or responsive to climate stimuli''.

United Nations (2004) distinguish four groups of vulnerability factors that are relevant in the context of disaster reduction: physical factors, which describe the exposure of vulnerable elements within a region; economic factors, which describe the economic resources of individuals, populations groups, and communities; social factors, which describe non-economic factors that determine the well-being of individuals, populations groups, and communities, such as the level of education, security, access to basic human rights, and good governance; and environmental factors, which describe the state of the environment within a region. All of these factors describe properties of the vulnerable system or community rather than of the external stressors. Moss *et al.,* (2001) identified three dimensions of vulnerability to climate change. The physical-environmental dimension accounts for the harm caused by climate". It refers to the climatic conditions in a region and to the biophysical impacts of climate change, such as changes in agricultural productivity or the distribution of disease vectors. The socioeconomic dimension refers to "a region's capacity to recover from extreme events and adapt to change over the longer term". The third dimension, external assistance, is defined as "the degree to which a region may be assisted in its attempts to adapt to change through its allies and trading partners, diasporic communities in other regions, and international arrangements to provide aid". In contrast to United Nations (2004), this conceptualization of vulnerability includes factors outside the vulnerable system, such as characteristics of the stressor and the expected level of external assistance. Brooks *et al.,* (2005) presented a set of indicators of vulnerability and capacity to adapt to climate variability, and by extension climate change, derived using a novel empirical analysis of data aggregated at the national level on a decadal timescale. The analysis is based on a conceptual framework in which risk is viewed in terms of outcome, and is a function of physically defined climate hazards and socially constructed vulnerability. Climate outcomes are represented by mortality from climate-related disasters, using the emergency events data base data set, statistical relationships between mortality and a shortlist of potential proxies for vulnerability are used to identify key vulnerability indicators. They identified 11 key indicators exhibit a strong relationship with decadal aggregated mortality associated with climate-related disasters. Validation of indicators, relationships between vulnerability and adaptive capacity, and the sensitivity of subsequent vulnerability assessments to different sets of weightings are explored using expert judgement data, collected through a focus group exercise. The data are used to provide a robust assessment of vulnerability to climate-related mortality at the national level, and represent an entry point to more detailed explorations of vulnerability and adaptive capacity. They indicate that the most vulnerable nations are those situated in sub-Saharan Africa and those that have recently experienced conflict. Adaptive capacity—one element of vulnerability—is associated predominantly with governance, civil and political rights, and literacy.

Fundamental research on extreme events, nonlinear impacts and tipping points needs to be extended beyond physical climate systems to biological, social and economic systems (Berkes, 2007), such as the effects of world food crises and financial crises on adaptive capacity. More diagnostic studies (Peterson and Manton, 2008) of exposure and vulnerability to climate extremes and their related socio-economic, demographic and cultural factors are also important (Russill and Nyssa, 2009). These studies can contribute to understanding societal vulnerability to climate variability and extreme events today as well as how this may change under changing climate conditions. Finally, more research should focus on how to effectively mobilize and conduct rapid scientific assessment both for short-term policy decisions and long-term understanding when extreme events occur (UNEP, 2013).

Kriegler *et al.,* (2012) explored that a more consistent use of socio-economic scenarios would allow an integrated perspective on mitigation, adaptation and residual climate impacts remains a major challenge. They asserted that the identification of a set of global narratives and socio-economic pathways offering scalability to different regional contexts, a reasonable coverage of key socio-economic dimensions and relevant futures, and a sophisticated approach to separating climate policy from counter-factual ‘‘no policy’’ scenarios would be an important step toward meeting this challenge. To this end, we introduce the concept of ‘‘shared socio-economic (reference) pathways’’. Sufficient coverage of the relevant socio-economic dimensions may be achieved by locating the pathways along the dimensions of challenges to mitigation and to adaptation. The pathways should be specified in an iterative manner and with close collaboration between integrated assessment modelers and impact, adaptation and vulnerability researchers to assure coverage of key dimensions, sufficient scalability and widespread adoption. They can be used not only as inputs to analyses, but also to collect the results of different climate change analyses in a matrix defined by two dimensions: climate exposure as characterized by a radiative forcing or temperature level and socio-economic development as classified by the pathways. For some applications, socio-economic pathways may have to be augmented by ‘‘shared climate policy assumptions’’ capturing global components of climate policies that some studies may require as inputs. They concluded that the development of shared socio-economic (reference) pathways, and integrated socio-economic scenarios more broadly, is a useful focal point for collaborative efforts between integrated assessment and impact, adaptation and vulnerability researchers. Chaturvedi *et al.*, (2014) emphasized on temperature variability, precipitation variability, rising sea-levels, extreme events (drought and flooding), and risk to environmental health to demonstrate the impact of climate change in India. Gizachew and Shimelis (2014) developed a biophysical and socio-economic indicator based integrated vulnerability assessment technique to map climate change vulnerability. Indicators were generated and analysed under three components of vulnerability, namely exposure, sensitivity and adaptive capacity; and finally aggregated into a single vulnerability index. The values of all indicators were normalised by considering their functional relationship with vulnerability, and expert judgment was then used to assign weights to all indicators. Aggregate vulnerability index (VI) was finally determined from the weighted sum of all indicators and mapped over the 16 districts in Central Rift Valley (CRV) of Ethiopia. This study shows that vulnerability mapping is crucial in determining the varying degrees of vulnerability of different localities, and generating information that can help researchers, policy makers, private and public institutions in formulating site-specific adaptation strategies and prioritising adaptation investments to the most vulnerable hotspots.

## Linking climate change and vulnerability

The last two decades have witnessed extensive research on potential and observed impacts of climate change on all kinds of natural and social systems (McCarthy *et al.*, 2001). A number of research has been conducted to advance scientific knowledge and to support the formulation and implementation of policies that limit adverse impacts of climate change and variability on environmental and human systems. Kohnle and Gauckler (2003) evaluated the impact of the storm called Lothar in December 1999 on a forest district in the periphery of the area of major damage in south-western Germany. The evaluation was based on timber salvage data of four publicly owned forests, on inventory data gathered for all stands during a survey in the summer of 1999, and for selected stands in spring 2000. Based on the growing stock prior to the storm and the volume of salvage (post the storm), the vulnerability of spruce was ranked highest followed by beech, oak and ash/sycamore. Apparently, species composition of stands did not mediate vulnerability of spruce: the proportion of standing volume of spruce removed by the storm did not differ significantly between stands of almost pure spruce and mixed stands of spruce and deciduous trees. Rahmstorf *et al.,* (2007) in their study of recent climate change observations, compared the Intergovernmental Panel on Climate Change's (IPCC) projections, found that: 'the data now available raise concerns that the climate system, in particular sea level, may be responding more quickly than climate models indicate'. The threat of dangerous 'tipping points' in the global climate system being breached is also increasingly being discussed (Lenton *et al*., 2008). Numerous examples can now be cited of shifts in climate and ecological systems that reflect these recent changes. They include the more rapid melting of Antarctic ice and increased hurricane activity (Rignot *et al.*, 2008). *The Stern Review* highlights the potential economic implications, noting that abrupt and large scale climate change could lead to a 5 to 10% loss of global GDP (Stern, 2007).

## Impact on agricultural systems

The agriculture sector in India is already threatened by existing factors such as land use changes, scarcity of water resources, increasing air pollution and loss of biodiversity. In a tropical country such as India, even minimal warming will lead to loss in crop yields (Parry *et al*., 2007). Further studies conducted by the Indian Agricultural Research Institute (IARI) indicate the possibility of loss of 4-5 million tons in wheat production with every rise of 1 degree C temperature throughout the growing period even after considering carbon fertilization. Losses for other crops are still uncertain but are expected to be smaller, especially for kharif crops (Aggarwal, 2008). Research also suggests that erratic monsoons will have serious effects on rain-fed agriculture with projected decreases in the productivity of crops including rice, maize and sorghum (especially in the Western Ghats, Coastal region and North eastern regions), apples (in the Himalayan region) (Kumar *et al.*, 2011). Studies indicate that increased droughts and floods are likely to increase production variability and lead to considerable effects on microbes, pathogens, and insects needed for the upkeep of healthy agricultural systems. The UNFCCC (2007) have indicated that increasing sea and river water temperatures are likely to affect fish breeding, migration, and harvests. Increasing glacier melt in Himalayas could affect availability of irrigation especially in the Indo-Gangetic plains, which, in turn, would have consequences on food production. Aggarwal *et al.,* (2009) estimated the impact of climate change on livestock and conclude that animal distress could lead to effects on reproduction and subsequently loss of 1.5 million tons of milk by 2020.

Tripathi (2013) assessed the vulnerability to climate change of farmers in Uttar Pradesh (UP). He used 17 environmental and socioeconomic factors to see which districts of UP are the most vulnerable to climate change, and attempts to identify the factors on a set of explanatory variables. The study finds that infrastructurally and economically developed districts are less vulnerable to climate change; in other words, vulnerability to climate change and variability is linked with social and economic development. This observation is corroborated by the findings of relational analysis. In relational analysis, livestock, forestry, consumption of fertiliser, per capita income, and infant mortality rate are observed to be important correlates of farmers' vulnerability to climate change; these should be focussed on. Also, farmers' awareness and adaptive capacity to climate change needs to be strengthened, for which policy options such as crop insurance and early warning systems would help.

## Impact on forests and biodiversity

Chaturvedi *et al.,* (2011) developed a vulnerability map and projected the impact of climate change on Indian forests and conclude that 39% and 35% of the forests grids in India will likely undergo change under the A2 and B2 scenarios respectively. The vulnerability map suggests that the concentration of vulnerable forest grid is higher in the upper Himalayan stretches, parts of central India, northern Western Ghats and Eastern Ghats. The upper Himalayan stretches and parts of central India currently have low development indicators, so that they will struggle to cope with any impacts they might be faced with. The forests of northeast, southern Western Ghats and eastern parts of India are projected to be least vulnerable. This is on account of their high biodiversity, low fragmentation, high tree density as well as low rates of vegetation change (as these regions experience lower levels of temperature increase and gain substantially in terms of precipitation). They also suggested that low vegetation vulnerability in North-eastern India means these regions are suitable especially for forest conservation projects.

## Impact on infrastructure systems

In India, investments worth US$ 120 billion have been planned for infrastructure asset creation during 2011-2012 (Naswa and Garg, 2011) Climate change induced natural disasters could put serious pressure on these investments. The critical climate parameters of temperature, precipitation, sea-level rise and extreme events pose direct and indirect threats to India's infrastructure assets. Enhanced landslides, vegetation cover, excessive siltation in rivers, and soil erosion could be direct impacts. Groundwater table depletion, energy demand changes, and migratory traffic could be the possible indirect impacts. The risks could be physical, technological, supply-chain or regulatory in nature (Naswa and Garg, 2011). A study on the adverse impact of climate change on the Konkan Railways (a 760 kilometre line connecting Maharashtra, Goa and Karnataka – a region of criss-crossing rivers, deep valleys and mountains) leading to both direct and indirect risks in the railway sector has indicated key impacts such as infrastructure damages, disruption to services, repair and reconstruction costs, changes in both agricultural freight traffic and passenger traffic as a result of climate change. For instance, the study identified that 20% of repair and maintenance expenses on tracks, tunnels and bridges were due to climatic reasons (Gachui *et al.,* 2007).

## Some real time examples of climatic vulnerable situations

Pandey *et al.,* (2007) analysed the data from Kalahandi and Nuapada districts of Orissa (India) revealed that (a) droughts in this region occurred with a frequency of once in every 3 to 4 years, (b) droughts occurred in the year when the ratio of annual rainfall to potential evapo-transpiration (Pae/PET) was less than 0Ð6, (c) EDI better represented the droughts in the area than any other index; (d) all SPI, EDI and annual deviation from the mean showed a similar trend of drought severity. The comparison of all indices and results of analysis led to several useful and pragmatic inferences in understanding the drought attributes of the study area. Guiteras (2007) estimated the economic impact of climate change on Indian agriculture using a 40-year district-level panel data set covering over 200 Indian districts. These panel estimates incorporate farmers' within-year adaptations to annual weather shocks. He argued that these estimates, derived from short-run weather effects, are also relevant for predicting the medium-run economic impact of climate change if farmers are constrained in their ability to recognize and adapt quickly to changing mean climate. The predicted medium-run impact is negative and statistically significant: I find that projected climate change over the period 2010-2039 reduces major crop yields by 4.5 to nine percent. The long-run (2070-2099) impact is dramatic, reducing yields by 25 percent or more in the absence of long-run adaptation. These results suggest that climate change is likely to impose significant costs on the Indian economy unless farmers can quickly recognize and adapt to increasing temperatures. Such rapid adaptation may be less plausible in a developing country, where access to information and capital is limited.

Gosain *et al.,* (2011) projected the impact of climate change on the 17 most important river basins in India up to mid-century and towards the end of the century. They estimated a decline in rainfall in 14 out of the 17 river basins towards the 2030s (mid century) and the 2080s (end century). In almost all river basins rainfall declines from 4% to 23%, following changes in precipitation, as a result of the decline in basin level rainfall, water yield in most of the river basins will decline by the 2030s and almost all (except the Krishna and Cauvery basins) by the 2080s. The massive Kosi River floods of August 2008 caused unprecedented loss to lives, livelihoods, infrastructure and property in north-eastern Bihar. Although floods have been a recurring feature in parts of the state, the 2008 floods were not usual. The Kosi burst its embankments and changed course, inundating areas of Bihar that had not experienced such flooding for half a century. About 1,000 villages in five districts (*Araria*, *Madhepura*, *Purnia*, *Saharsa* and *Supaul*) were affected, involving three million people, of whom about one million were evacuated. The estimated loss was amounting around Rs. 1960 crore (UNDP, 2009).

## Conclusions and policy implications

Many of the strategies and activities designed to achieve adaptation to climate change overlap with and will be integrated into those taken to achieve national development goals, poverty alleviation, disaster risk reduction and other dimensions of sustainable development and resilience (e.g., the green economy, green jobs and green growth). Simultaneously, efforts to mitigate climate change are gathering momentum and are generating changes within human society as well (Klein *et al.,* 2007). Vulnerability of a particular district may be measured by the frequency of occurrence of extreme events, in this case the occurrence of cyclones, storms and depressions (Patnaik and Narayanan, 2005). Mitigation efforts may profoundly transform societal systems with respect to energy, land use, infrastructure and manufacturing, with the potential for far-reaching consequences at local, national and global scales. Understanding the complex nature of VIA-mitigation interactions is a high priority in order to make possible more effective elaboration of development pathways that achieve desired combinations of adaptation and mitigation and that maximize co-benefits and minimize undesired side-effects (Wilbanks, 2010; Wilbanks and Sathaye, 2007).

In most discussions of climate change, climate policy has commonly been used to refer to mitigation policy. While mitigation is certainly important, developing countries have no obligations for mitigation under the UN Framework Convention on Climate Change. For these countries, issues of vulnerability and adaptive capacity are perhaps more germane, and it is therefore important to examine adaptation policy as a key element of overall climate policy. In many countries, and India is no exception, climate policy often lies within the jurisdiction of the Environment Ministry, as the issue is framed in terms of response to an environmental problem. On the other hand, adaptation is linked to core developmental issues, whether with regard to infrastructure or institutions or sectors such as water resources, agriculture or health. These sectors are generally the responsibility of different agencies and ministries within the government. Therefore, perhaps one of the first steps to increase the visibility of climate policy would be to frame the issue of climate policy in terms of developmental priorities and policies Patwardhan (2006).

The applicability of existing policy tools for addressing this interface should be explored and guidance developed for how decision makers can choose appropriate tools that integrate adaptation, mitigation and sustainable development and for the particular conditions they are addressing (Yohe and Leichenko, 2010). In this regard understanding the complexities and challenges to determine potential organizational and governance structures can be effective in different contexts are needed to be addressed on immediate basis (Klein *et al.*, 2007; Wilbanks and Sathaye, 2007). Planning and design are critical to regional vulnerability reduction and effective adaptation because they can have long-term effects and can change the way people behave (Saavedra and Budd, 2009; Smit and Pilifosova, 2003; Tanner *et al.* 2009).

Richardson *et al.*, (2009) emphasized on equity issues and societal transformation to mitigate and adapt to climate change and bring long-term benefits. This is the climate change science and policy arena that faces the adaptation community: while scientific research findings are painting an increasingly challenging picture, the policy community and industry have yet to develop an effective response. Taken together, these warning signs add urgency to calls to reduce greenhouse gas emissions, while at the same time planning for the challenges and potential opportunities linked to the changing climate. Extreme weather events exert a huge cost on economies and societies. Innovative design can invoke and illuminate new visions of possible futures and inspire further creativity and optimism. The role of innovative design in adaptation, mitigation and sustainability paradigms should be investigated as well.

There is a major role for both the arts and the humanities in such planning and design. Changes in engineering standards, coastal and flood zone planning and management, requirements for private and public sector climate hazard disclosure and in public and private insurance and reinsurance markets could also lead to a ‘new normal’ that catalyzes large-scale changes in mitigation, sustainable development and adaptation potential (Dawson, 2007).

The key questions include how to minimize impacts of transition on the most vulnerable communities, the extent to which transitional costs (e.g., shoreline retreat) should be borne by those exposed to the hazard or society as a whole and how to ensure that all stakeholders are included in long-term decision-making (Smit and Pilifosova, 2003). Integrated research is needed across private and public entities on how to minimize the risk of perverse incentives, including those that can be associated with price distortions in insurance markets, the resilience of our society, financial and the natural economy, data and projections in support of adaptation, mitigation and sustainable development, the effectiveness of planning and design for climate change responses in urban areas, their surrounding infrastructure and resource-sheds and rural areas are extremely required (Betts *et al.*, 2011).

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