Vulnerability of Communities to Environmental Change

Barry Smit, Johanna Wandel and Gwen Young
University of Guelph
April 10, 2005

IACC Project Working Paper No. 21

Please contact Barry Smit at bsmit@uoguelph.ca.

Vulnerability of Communities to Environmental Change
as part of the project
Institutional Adaptation to Climate Change (IACC)
Draft, April 10, 2005

By Barry Smit, Johanna Wandel and Gwen Young

1. Introduction

The concepts of Vulnerability, Exposure, Sensitivity, Adaptation and Adaptive Capacity have wide application. One way or another, they are all relative concepts – vulnerability *of* something *to* something, exposure *of* something *to* something, et cetera. The applications range in scale from the vulnerability of an individual or household to a particular climate stress such as drought, through the vulnerability of a community to various environmental stresses, to the vulnerability of humankind (or the global ecosystem) to all stresses and forces. These applications vary by spatial scale (individual to global), by phenomena (biological, economic, social, etc.), and by time scale (instantaneous, months, years, decades, centuries). In this paper, we do not develop applications relating to the vulnerability of physical or biological phenomena or systems, even though some of the concepts, e.g. adaptation, have long – if contested – use in those fields (Smit and Pilifosova, 2001; Smit and Pilifosova, 2003). This paper addresses applications to human systems and human-environment systems, meaning communities, households, groups, sectors, regions and countries.

To some degree, the most fundamental elements of the central concepts should be and are applicable at any spatial and temporal scale. However, depending on the scale of application, there are differences in how the concepts apply, how the nested hierarchies structure, and certainly how empirical or field applications can be undertaken. There have been some attempts to define universal characteristics of human vulnerability, that is, conditions and factors that underlie inherent vulnerability of a system to any and all conditions and changes. In this paper, these broad conceptualizations of vulnerability are reflected in the broad conditions or higher-scale forces that appear to influence or shape the more stress-specific vulnerabilities. At finer spatial scales and for particular types of communities these vary broad-scale forces are reflected in more specific local conditions that contribute to vulnerability.

The aim of this paper is to develop and refine robust, generic model of vulnerability (and its associated concepts of exposure and adaptive capacity, etc.) with practical utility at a range of spatial and temporal scales. However, to simplify the presentation (e.g. to avoid giving applications at every stage to a wide range of scales), we focus on the **vulnerability of communities to climate-related conditions and changes in the context of broader environmental and societal changes**. Hence the "system" or "observation unit" of interest is the community (here used to mean some definable aggregation of households, interconnected in some way, and with a limited spatial extent, including all the stakeholders and institutions that directly or indirectly influence the exposures, sensitivities, adaptabilities and hence vulnerabilities of communities). The conditions, stimuli or stresses (to which the communities may be vulnerable) are those related to climate and climate change (hence immediate or year to year weather and climate conditions and longer term shifts in such conditions), and these are

considered in the context of other conditions and changes that are relevant to the community (*ie.* climatic stimuli are not considered in isolation, but as part of a suite of stimuli that influence vulnerability).

The main reason for focusing this climate change issue at the community scale and for considering both current and future conditions is because it appears that practical initiatives that actually do something about improving adaptive capacity (and hence vulnerability) in the climate change area have been widely demonstrated at the community scale and are rarely evident at national or international scales. Notwithstanding the importance of broader national and international conditions and programs, development enhancement, resource management and disaster preparedness initiatives that relate to adaptation seem to be most effective at subnational scales.

This paper provides an overview of the concepts of vulnerability, adaptation and adaptive capacity (with reference to related concepts like resilience, risk, sensitivity, hazard, exposure, stability, coping and adaptability, especially as they have been used in the context of climate change. The paper reviews common interpretations and applications of the terms, and develops a general conceptual model of vulnerability as it relates to human societies or communities. The paper also provides a critique of analytical approaches and methods to assess vulnerability and to identify opportunities to enhance adaptive capacity and to provide information directly applicable to the development of adaptation strategies. These methods are described to show how enthnographic principles and procedures provide insights that can be systematically integrated with institutional analyses and modeling of climatic, hydrologic and ecologic systems.

The review is broad in that it relates to general concepts and applications, but given the focus of the IACC project, the paper pays particular attention to current and future vulnerabilities related to **water** in environments such as Prairie Canada and Chile, and to the roles of formal and informal **institutions** in enhancing or constraining the capacity to deal with water-related vulnerabilities.

2. Climate Change, Water Resources and Institutions

It is widely accepted that climate change is occurring and it is recognized internationally as a cause for concern. In addition to an increase in average global temperature, changes in climate variations and in the magnitude and frequency of extreme events are expected (Houghton et al., 2001). However, the effects of changing climatic conditions will not be felt equally around the globe (Rosenzweig and Parry, 1994; O'Brien and Leichenko, 2000; Mirza, 2003; Tol et al., 2004).

Climate change and variability challenge countries, regions, sectors and communities that are most exposed and least able to respond or adapt to changing conditions, that is, those who are most vulnerable (Handmer et al., 1999; Smit and Pilifosova, 2003). Vulnerability, or susceptibility to harm, can be moderated by adaptive capacity – the ability to cope with change (Smit and Pilifosova, 2003; Füssel and Klein, 2002; Yohe and Tol, 2002).

Climate change is expected to stress both natural and human systems such as water resources, agriculture, forestry, and human health, and is expected that many regions will experience a greater scarcity of natural resources (McCarthy et al., 2001; Tompkins and Adger, 2004). Water resources are particularly sensitive to climatic variability and change.

The Intergovernmental Panel on Climate Change (IPCC) predicts that there will be a decrease in water availability for populations in arid and semi-arid areas which are particularly sensitive to climate variations. This could potentially be devastating for the approximately 30% of the world's population who currently live in regions that are water stressed (McCarthy et al., 2001). An increase in water scarcity for these areas could have serious implications for livelihoods, industry such as mining, power generation and agriculture, and cause or enhance soil degradation. In areas sensitive to water stress there is an interest in seeing how water resource management can be adapted to better deal with changing environmental conditions and to reduce vulnerability to climate change. Such improvement in adaptive capacity of water resource management would include considerations of the institutional arrangements and how these contribute to or reduce regional vulnerability to changing conditions.

The management of water resources necessarily involves both formal and informal institutions, such as household rights, community access, ownership structures, public management authorities, the market, and so on. The adaptive capacity of a community to deal with changes in water resources will be greatly influenced by the structure and effectiveness of institutions.

3. Bodies of Scholarship

Several bodies of scholarship provide insights into ways of conceptualizing this issue and ways of analyzing it, including the fields of climate change, natural hazards, water management and political ecology. These bodies of scholarship are not independent of each other, but they provide particular insights into concepts and methods.

The **climate change** literature gives insights on current and potential future climate, mainly through climate change scenarios and their modeled impacts. It primarily focuses on the biophysical impacts of climate change, and to a lesser degree estimates implications on socio-economic and resource systems (e.g. West et al., 2001). It provides an indicator of potential consequences of climate change (e.g. Yohe and Schlesinger, 2002; Ziervogel and Calder, 2003). Increasingly, studies of the implications of climate change have considered not only changes in average temperature, but also the increased risk of climate extremes (e.g Mirza, 2003; Bruce, 1999). In this field, vulnerability is most commonly seen as a residual impact (or "end point") of a specified climate change scenario, estimated for the purposes of gauging the seriousness (or "dangerousness") of climate change (O'Brien et al., 2003; Kelly and Adger, 2000). Where the purpose is to identify adaptation needs and implement or promote adaptation measures, there is increasing consideration of vulnerability in light of system exposure and adaptive capacity.

Natural hazards literature examines how people and societies respond to natural events with potentially adverse consequences for humans (or hazards), what factors influence response choices, and how risks are managed (Cutter, 1996; Hewitt, 1997). A natural event only becomes a hazard if it has the potential to adversely affect people; and thus hazards (and their worst-case

scenarios, disasters) are socially constructed (Cannon, 2002). Risk of hazards such as flood or drought is of particular significance for water resource management, as management implies human dependence on the resource and its potential scarcity has the potential to negatively affect those who use it. Commonly, natural hazards scholars deal with one type of hazard, primarily from a physical science perspective. Vulnerability, in this scholarship, is considered a characteristic of people living in hazardous areas, *ie*. Disaster = Hazard + Vulnerability, with little attention to the interaction between hazard and vulnerability (Cannon, 2000).

Water resource management literature is concerned with the planned development, distribution and allocation of water resources for current and future human and natural uses (Stakhiv, 1996). A high relative water demand (water withdrawal/water use : discharge) in a given catchment or region determines vulnerability, and thus areas with high dependency on irrigation or industrial water and limited water supply (e.g. parts of South America, the American and Canadian Great Plains, sub-Saharan Africa) are considered vulnerable as their water supplies are not secure under potential climate change (Vörösmarty et al., 2000).

Political ecology provides a particular contribution by considering the broader social, economic and political conditions which influence the differential exposures of peoples and their adaptive capacities. It outlines the role of social structural constraints and political economic factors that cause differential access to resources and influence the vulnerability of marginalized groups (Bryant and Bailey, 1997; Mustafa, 2002). Vulnerability, therefore, is seen as a function of a person or community's dependence on and access to resources, and access relates to political power, institutional arrangements, poverty/wealth, livelihood strategies, and so forth. Blaikie et al. (1994) define vulnerability as the capacity to anticipate, cope with, respond to or recover from external stimulus.

The concept of vulnerability clearly has various meanings in the fields reviewed above. The definition and approach advocated for the IACC Project is based on synthesis and evolution in the fields above and other contexts.

4. Vulnerability Concepts and Definitions

The concept of vulnerability has been developed and employed with reference to various contexts, including food security (Sen, 1981; Watts and Bohle, 1993), environmental change (Liverman, 1994), and natural hazards (Cutter, 1996; Blaikie et al., 1994; Wisner et al., 2004). More recently, the concept has been employed in the climate change literature as a way to characterize and understand the implications of climate change for human communities (Handmer et al., 1999; Leichenko and O'Brien, 2002; Adger, 2003). The variations in the meaning and use of the term reflect various epistemological orientations including politically ecology, human ecology, physical science and spatial analysis (Cutter, 1996).

Broadly, the term vulnerability refers to susceptibility to harm (Smit and Pilifosova, 2003). Particular interpretations of vulnerability vary among bodies of literature and contexts used. In natural hazards scholarship, vulnerability has been referred to simply as the "degree or loss resulting from the occurrence of natural phenomena to a given element or set of elements" (UN Disaster Relief Organization, 1982). Similarly, vulnerability has been defined in the water

management context as "how severe the consequences of failure may be" (Stakhiv, 1996). More recently, natural hazards work has moved beyond vulnerability as the potential magnitude resulting from a hazard to include determinants of vulnerability, or "the characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard, an extreme natural event, or process" (Wisner et al., 2004). This is congruent with a political economy conceptualization of vulnerability as a function of exposure, capacity and potentiality (Watts and Bohle, 1993) and Sen's (1981) argument that vulnerability is largely a societal construct which results from a lack of entitlements, democracy and power in the food security context. Vulnerability becomes "an aggregate of human welfare that integrates environmental, social, economic and political exposure to a range of harmful perturbations" (Bohle et al., 1994).

In recent years, the climate change community, as captured in the IPCC's Third Assessment Report, has commonly defined 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" (McCarthy et al., 2001). The "most vulnerable" thus are those who are most likely to be exposed to perturbation, possess limited capacity for adaptation, and are least resilient to recovery (Bohle et al., 1994).

Notwithstanding definitions in early natural hazards and water management scholarship that focused on magnitude of event and effect, recent work on the incorporates the notion that vulnerability of a system or community is a function or reflection of both the exposure (or sensitivity) of the system to hazardous conditions or risks and also the capacity of that system to absorb, cope, manage, deal with, adapt or recover from that exposure.

There is a general agreement that developing countries are deemed to be more vulnerable to climate change compared to developed countries, partly because of their exposure but mainly because of their limited adaptive capacity (Downing et al., 1997; McCarthy et al., 2001; Beg et al., 2002; Mizra, 2003; Handmer, 2003). Downing et al (1997) note that vulnerability of developing countries is higher in part due to their higher dependence on resources which are affected by climate (e.g. fishing, forestry, agriculture) relative to industrialized countries; *i.e.* they are more exposed. They also tend to have less economic, technological and other resources to deal with, adapt to and recover from hazardous exposures.

Within countries it is generally accepted that the poorer groups or communities are more vulnerable, both because they are often in more exposed livelihoods and locations, and because they have very limited capacity to adapt.

Vulnerability can be assessed at many scales: individual, household, community and nation. While some scholars apply the term at very aggregate scales (Barnett and Adger, 2003; Tol et al., 2003), vulnerability if often understood to pertain explicitly to individuals or social groups/communities (Adger and Kelly, 1999).

4.1 Dynamic Vulnerability

To most authors, vulnerability is a dynamic concept (Hewitt, 1997; Adger, 1999; Adger and Kelly, 1999; Handmer et al., 1999; Leichenko and O'Brien, 2002; Downing, 2003). Vulnerability is seen as a process in constant flux in an individual, group, location or activity through time. Handmer et al. (1999) characterize vulnerability as a process of continual evolution as its determinants (e.g. technological and institutional factors) change and evolve. Leichenko and O'Brien (2002) define dynamic vulnerability as "the extent to which environmental and economic changes influence the capacity of regions, sectors, ecosystems and social groups to respond to various types of natural and socio-economic shocks". Of course, this relates primarily to the adaptive capacity element of vulnerability. The exposure element is also dynamic as extreme conditions such as climate change, and as occupancy characteristics of groups evolve.

Adger (1999), Adger and Kelly (1999) and Handmer et al. (1999) emphasize the need to identify trends in vulnerability. Although this is often not specified explicitly, there is a distinction between, on the one hand, the vulnerability of a system (including dynamic vulnerability and including the dynamics of its exposures and its adaptive capacities) and, on the other hand, the broader conditions or forces (environmental, economic, social, cultural, institutional, etc.) that shape, constrain or influence the exposures and adaptive capacities. Smit and Pilifosova (2003) call these the "determinants" of vulnerability or adaptive capacity, and these forces and processes are also dynamic.

4.2 Physical and Social Vulnerability

Distinctions are sometimes made between physical and social vulnerability. Physical vulnerability is described as the sensitivity of the physical system, or the likelihood of exposure (Liverman, 1994; Cutter, 1996). Research in natural hazards and climate change often uses biophysical conditions to define vulnerability (Liverman, 1994; Smith and Lazo, 2001). Populations are considered vulnerable if they live in hazardous locations, and their ability to reduce the effect of hazard via adaptation is greatly downplayed. Thus, vulnerable populations are understood to be those who live in areas with a high probability of occurrence of potentially problematic physical phenomena (e.g. earthquakes, tsunamis, hurricanes…). Physical vulnerability is seen to be related to the degree of inundation with sea level rise, or the increased frequency of drought – and it is indicated that such vulnerability can be characterized independently of the resource use or livelihood features of the population, and independently of the population's abilities do deal with their physical hazards. This physical or biophysical vulnerability essentially is about the *exposure* of a system to physical stimuli with little reference to adaptation or livelihood strategies, and does not develop the social forces that may have influenced the location of certain groups in hazardous areas.

The term "social vulnerability" emerged from the recognition that exposure to environmental stress alone was not the only component influencing vulnerability (Liverman, 1994). Physical hazards, disasters, climate change and variability cause tremendous harm, but that harm (and hence vulnerability) is also influenced by existing social conditions. Social conditions enhance or reduce the susceptibility to harm from hazardous events (famine, drought, disease, flooding).

Social vulnerability has been related to many factors including marginalization, equity, the role of institutions, food and resource entitlements, economics and politics (Adger and Kelly, 1999; Adger, 2000; O'Brien and Leichenko, 2000; Pelling 2002). These are considered attributes of a social system that increase exposure and/or limit adaptive capacity. An examination of social vulnerability includes an understanding of the human use of and access to resource which in turn determines the ability of an individual or society to cope with and adapt to change (Wisner et al., 2004).

Sen (1981) recognizes the role of social vulnerability in exacerbating or reducing impacts of a hazardous physical event. The occurrence of famine is not simply because of natural events but also the social, economic and political conditions that make people susceptible to the event and limit the capacity to cope or deal with it. Thus, the capacity to adapt to hazard stress is rooted in the ability of an individual or community to compete for access to rights, resources and assets (Sen, 1981; Blaikie et al., 1994). Mustafa (2002) showed the importance of the unequal distribution of power and wealth as fundamental elements of vulnerability to floods. Other fields, such as natural hazards, resource management and sustainable development, have increasingly employed concepts of vulnerability that recognize both physical stimuli and human conditions contribute to exposure and are essential to adaptive capacity.

In the climate change scholarship, social vulnerability has been described as an issue of entitlements, where access, availability, and distribution of resources determine or influence or define the level of vulnerability of a social group (Liverman 1994; Adger and Kelly, 1999). The extent to which individuals, groups or communities are entitled to use resources determines the ability of that population to cope and adapt to stress (Adger an Kelly, 1999). Inequality affects vulnerability by constraining the options of systems when faced with changing conditions, i.e. by constraining their adaptive capacity. Inequity within a population can increase social vulnerability to climate change as climate change can alter communal allocation of resources.

5. Conceptual Vulnerability Model

Consistent throughout the literature is the notion that the vulnerability of any system (at any scale) is reflective of a function of both the exposure of that system to hazardous conditions and the ability or capacity of the system to cope, adapt or recover. These concepts are labeled in different ways and given different emphases in various fields.

A conceptual model of vulnerability has emerged from the climate change community scholarship (Kelly and Adger, 2000; Downing, 2001; Smit and Pilifosova, 2003; Yohe et al., 2003). Vulnerability here is characterized as a function of the exposure of a system to climate change and its adaptive capacity. A system may be a household, community, sector, ecosystem, activity, nation and so on. Generally, a system that is more exposed to a climate stimulus will be more vulnerable, and a system that has more adaptive capacity will tend to be less vulnerable due to its ability to cope with the exposure. Vulnerability, and the elements of exposure and adaptive capacity, are dynamic (they vary over time), they may vary from stimulus to stimulus, and they are place and system-specific (*i.e.* their features and determinants tend to differe drom to community to community and from place to place). This idea can be expressed formally as:

$$V_{ist} = f(E_{ist}, A_{ist}) \qquad (1)$$

Where
V_{ist} = vulnerability of system *i* to climatic stimulus *s* in time *t*
E = exposure of *i* to *s* in *t*
A = Adaptive Capacity of *i* to deal with *s* in *t*

The functional relationship between the two components is not defined as vulnerability is context specific and dynamic. However, it is understood that vulnerability is a positive function of exposure and a negative function of adaptive capacity (Smit and Pilifosova, 2003). The subscript *i* denotes that the nature of the elements making up vulnerability, and the broad forces influencing them, are specific to particular systems (households, communities, regions, sectors, locations), even though they might relate to common processes and conditions (resources, access, wealth, equity, etc.). The subscript *s* recognizes that, even for a particular system, vulnerability is unlikely to be the same for all stimuli (e.g. increasing temperature, floods, sea level rise, low-frequency droughts, high-frequency droughts, high-frequency extended droughts, etc.). Not only is the physical stimulus distinct, but it is also unlikely that the exposure of people differs with the type of stimulus, and the adaptive capacity may vary with the type of stimulus. The subscript *t* is a crude acknowledgement that vulnerability (and its elements and determinants) are dynamic, that is, they vary over time. Here this is suggested with a simple subscript, though this should be interpreted as more of a continuous property than discrete time points. Algebraically, the dynamic nature of vulnerability as expressed in (1) can be re-stated as a differential equation:

$$\frac{dV}{dt} = f\left(\frac{dE}{dt}, \frac{dA}{dt}\right) \qquad (2)$$

5.1 Exposure

Exposure is a property of the system relative to climatic conditions. Exposure is dependent on both the characteristics of the system and on the attributes of the climate (Downing, 2003; Smit and Pilifosova, 2003). Smit and Pilifosova (2003) illustrate this concept at a coarse level: Switzerland and Bangladesh have different exposures to sea level rise (vastly different elevation of land, proximity to sea), whereas Florida and Bangladesh have more similar exposures to sea level rise (both low-lying locations adjacent to open water). However, the exposures of Florida and Bangladesh also differ considerably. Even if the sea level rise itself is similar in the two places, the nature of human settlement, the density of population in exposed areas, the structure of buildings and infrastructure, the dependence of people's livelihoods on conditions related to sea level, and so on all influence exposure, and these differ between Florida and Bangladesh.

Exposure is not simply the presence of some external stress, nor can it be seen as some summation of external forces and local conditions. Rather, exposure represents the juxtaposition and interaction of local conditions (reflecting broader forces) and external physical stimuli (also reflecting broader physical systems). Exposure is a property of a system that reflects jointly the physical stimulus and the occupance characteristics of the system relative to that stimulus. The occupance characteristics are similar to the term sensitivity used in some treatments. Here sensitivity is a part of exposure, in that exposure to a physical stimulus only has meaning relative to the occupance characteristics (sensitivity) of a system.

The term exposure is sometimes used to describe climatic conditions or events occurring or expected in a particular place. We use the term climate stimulus or condition to refer to these. The term exposure is not a property of climate, but a property of the affected system (e.g. community). It refers to the manner and degree to which a system is unprotected from or at risk to some stimulus. Clearly exposure reflects the characteristics of the system relative to the stimulus. A community located on a low-lying coast with unprotected houses is more exposed to a given sea level rise stimulus than a community located further from the sea confronted with the same stimulus, or a similarly located community with protection confronted with the same stimulus. Similarly, a community whose livelihood is highly dependent on water is more exposed to droughts than a community facing equivalent drought yet having livelihoods that do not depend on the availability of water.

Figure 1 shows diagrammatically how the exposure of a system (e.g. a community) to a climate change risk (e.g. drought) reflects a combination of the probability of the particular climatic conditions (which reflects the broader climate regime and the non-climate conditions which influence the stimulus) and of the occupance characteristics (or sensitivity) of the system to the stimulus. The occupance characteristics (e.g. settlement location and types, livelihoods, land uses, etc.) reflect broader social, economic, cultural, political and environmental conditions. Many of these "determinants" of occupance or sensitivity are similar to those that influence or constrain a system's adaptive capacity.

The stimulus part of exposure may be broken down into particular characteristics (e.g. drought frequency, magnitude, duration, speed of onset), just as the occupance or sensitivity part can be characterized according to various elements. For those who prefer such associations expressed algebraically:

$$E = f(P,O) \quad (3)$$

Where

E = *Exposure*
P = *Physical Stimulus*
O = *Occupancy Characteristics (Sensitivity)*

Physical Stimulus in turn is:

$$P = f(C, N) \quad (4)$$

Where

C = *Climate System*
N = *Non-climate Conditions*

Occupance is expressed as:

$$O = f(S, E, P, R, L\ldots) \quad (5)$$

Where

S = *Social Conditions*
E = *Economic System*
P = *Political System*
R = *Resources*
L = *Location*

Replacing P and O in (3) with (4) and (5):

$$E = f((C,N),(S,E,P,R,L\ldots) \quad (6)$$

So the exposure of a system in a particular location over time reflects the occupancy characteristics of the system relative to the climatic stimuli that influence those characteristics. The climatic particular stimuli, in turn, reflect the broad climatic regime and various non-climatic conditions that influence or constrain the attributes of the stimuli (e.g. onset, frequency, magnitude and effect). The occupancy characteristics of the system that contribute to its exposure reflect the broad social, economic, political, resources and location conditions within which the system functions.

While this conceptualization of Exposure indicates the general characteristics that make it up, it does not imply that there are universally applicable indicators of physical stimulus, occupancy characteristics, or the broader physical and socio-economic-political conditions within which they evolve. The relevant "variables" for the elements may be quite system specific.

For example, an agricultural community which is dependant on fresh-water supplies may be exposed to longer dry spells, which are a reflection of changes in the climate regime and perhaps regional deforestation, because the community's agricultural livelihoods are susceptible to moisture deficits. If the community livelihoods were not water dependent, they would not be exposed to longer dry spells even if the physical stimulus were present.

The research challenge to characterize or assess the Exposure element of vulnerability is to identify those combinations of climate conditions and system occupancy characterisctics that are considered to be problematic, risky or hazardous in some way. These are rarely known *a priori*. The empirical research task is to identify, document and describe the combinations of occupancy characteristics and physical stimuli that matter in the system of interest.

Two systems with identical exposures need not have the same vulnerabilities because one may have considerable capacity to deal with, manage, or adapt to the exposures (hence reducing vulnerability), with the other may have limited ability to cope, manage, adapt or recover (and hence have greater vulnerability).

5.2 Adaptive Capacity

Adaptive Capacity is widely used to describe a system's ability do deal with exposure or risk (Wheaton and McIver, 1999; Bryant et al., 2000; Smit and Pilifosova, 2003; Yohe and Tol, 2002; Füssel and Klein, 2002). The IPCC defines adaptive capacity as "the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences". Adaptive capacity is context-specific and varies from country to country, from community to community, among social groups and individuals over time. However, the scales of adaptive capacity are not independent: the capacity of a household to cope with climate risks depends on some degree on the enabling environment of the community, and the adaptive capacity of the community is reflective of the adaptive capacity of the region (Smit and Pilifosova, 2003).

Adaptive capacity is analgous to a host of other commonly-used terms, including adaptability, coping ability, management capacity, stability, robustness, flexibility, and resilience (Stakhiv, 1996; Smithers and Smit, 1997; Adger and Kelly, 1999; Smit et al., 1999; Jones, 2001; Fraser et

al., 2003; Tompkins and Adger, 2004). Fraser et al. (2003) identify adaptive capacity as social resilience and describe it as the ability of a society to respond to environmental changes. Inherent in this is a recognition that an assessment of the effects of climate change requires an understanding of how communities adapt or cope with change. Similarly, a system's "coping range" is defined by the range of conditions that a system can deal with, accommodate, adapt to, and recover from (de Loe and Kreuzwiser, 2000; Jones, 2001; Smit et al., 2000; Smit and Pilifosova, 2001 and 2003). Most communities and sectors can cope with normal climatic conditions and deviation from the mean to some degree. However, exposures involving extreme events that may lie outside the coping range may exceed the adaptive capacity of the community, which increases vulnerability (Figure 2).

A system's coping range is not static as it appears in Figure 2. Coping ranges are flexible and respond to changes in economic, social, political and institutional conditions over time. For instance, population pressure or resource depletion may gradually reduce a system's coping ability and narrow its coping range, while economic growth or improvements in technology could lead to an increase in adaptive capacity (deVries, 1985; Smit and Pilifosova, 2003).

Figure 2 illustrates a system's coping range with respect to both exposure and adaptive capacity, and hence vulnerability. Moisture deficit and the occurrence and severity of drought conditions vary from year to year, yet the system is able to cope with a degree of variation around the mean or average conditions. The amount of variation the system can deal with is indicated in the shaded area, here called the coping range (which could also be called the adaptive capacity of the system). However, as mean moisture deficit increases (as is expected with climate change), the entire distribution shifts and the system will experience (and be more vulnerable to) an increase in the frequency and magnitude of events beyond the coping range. To the extent that the system may be able to expand the coping range or enhance its adaptive capacity to deal with these exposures, it will reduce its vulnerability to drought risk. The forces that influence the ability of the system to increase adaptive capacity are the driving forces, external factors, influencing processes and determinants of adaptive capacity.

The graphical representation of coping range presented in Figure 2 shows increases in coping range over time. It should, however, be noted that the coping range can also decrease for a variety of reasons. External socio-economic and political factors (e.g. war, the collapse of an institution such as a crop insurance program, loss of a key decision-maker) may lead to a narrower coping range with respect to a stress such as drought. Furthermore, increased frequency of events near the limit of the coping range may decrease the threshold beyond which the system cannot cope/adapt/recover (e.g. two consecutive years of high moisture deficit which are not beyond the limits of the normal coping range present little problem in the present but require drawing on stored resources – and the consumption of these resources subsequently narrows the coping range until they can be built up again, so a third and fourth year of the same magnitude may well exceed the now smaller coping range). Similarly, conditions which are within the coping range may introduce unforeseen side effects which will narrow the coping range. For example, a warm, wet year may be an ideal year for crop production and lead to high yields. Subsequent years of warm, wet conditions can, however, encourage the development of pest and fungal outbreaks and actually decrease yields and thus the coping range is reduced. Finally, a catastrophic event beyond the limit of the coping range may permanently alter the system's

normal coping range if it is not able to recover from it (e.g. a system that relies on irrigation water, captured in a dam. A very wet year, far beyond the normal conditions expected, may lead to the dam's failure, and thus the previous coping range cannot be returned to in a subsequent "average" year.

Just as exposure can be seen as a system property reflective of broader conditions and processes within which the system evolves, so too can adaptive capacity be seen as reflective of broader conditions. For example, a frequently cited manifestation of adaptive capacity is the initiation or adoption of adaptive measures. Adaptations, or change in the system to better deal with exposures, reflect adaptive capacity. Clearly there are many forms and "levels" of adaptations, and these can be classified by timing relative to stimulus (anticipatory, concurrent, reactive), intent (autonomous, planned), spatial scope (local, widespread) and form (technological, behavioural, financial, institutional, informational) (Smit et al., 2000).

It is also possible to distinguish adaptations according to the degree of adjustment or change required from (or to) the original system. For an agricultural system facing water shortage exposures, a simple adaptation might be to use more drought resistant cultivars. A more substantial adaptation might be to shift away from crop farming to pastoralism. An even more substantial adaptation might be to abandon farming altogether.

In the hierarchy of adaptations and adaptive capacity (Figure 3), these are shown as different levels or regimes of adaptation. The ability to undertake adaptations (the adaptive capacity) is widely understood to be dependent on or influenced by any of a variety of conditions, including managerial ability, access to financial, technological and information resources, infrastructure, the institutional environment within which adaptations occur, political influence, kinship networks, etc. (Watts and Bohle, 1993; Hamdy et al., 1998; Adger, 1999; Handmer et al., 1999; Kelly and Adger, 2000; Toth, 1999; Smit and Pilifosova, 2001; Wisner et al., 2004). These conditions can be distinguished according to local determinants (e.g. the presence of a strong kinship network which will absorb stress) and broader socio-economic and political systems (e.g. the availability of state-subsidized crop insurance).

The determinants of adaptive capacity are not independent of each other. For example, the presence of a strong kinship network may increase adaptive capacity by allowing greater access to economic resources, increasing managerial ability, supplying supplementary labour and buffering psychological stress. Similarly, economic resources will facilitate the implementation of a new technology and ensure access to training opportunities and may even lead to greater political influence. Individual determinants, thus, cannot be isolated: adaptive capacity is generated by a combination of determinants which interact and vary in space and time. Consequently, the determinants of adaptive capacity will behave differently in different contexts (e.g. a strong kinship network can be expected to play a much larger role in a subsistence-based agricultural society than in a developed world agribusiness context).

The role of institutions in facilitating or constraining adaptive capacity with respect to water in agriculture is of particular importance for the IACC project. Appendix 1 presents definitions of institutions and discusses their relationship to adaptive capacity and vulnerability. Appendix 2

outlines water resource management in light of climatic variability and change, with particular attention to institutions.

To date, there is very little consensus (or documented support) for a robust, generic model of the local elements of adaptive capacity or the broader factors, determinants or "drivers" that influence or constrain the abilities of communities to deal with hazards or stressful conditions. Here we give only an illustration of the types of conditions and factors that might apply at two scales.

At the community (local) scale, Adaptive Capacity can be expressed algebraically as:

$$A_{local} = f(D, F, I, S, T...) \qquad (7)$$

where

A_{local} = *Adaptive Capacity*
D = *Distribution of Resources and Access*
F = *Financial Resources*
I = *Institutional Effectiveness*
S = *Social Cohesion*
T = *Available Technology*

The determinants of Adaptive Capacity vary from community to community, due in part to local conditions and exposures and in part to broader conditions and determinants. At the regional/national scale, Adaptive Capacity can be expressed as:

$$A_{local} = f(D, F, I, S, T...) = f(G, E, P, R) \qquad (8)$$

where

G = *Globalization*
E = *Economic System*
P = *Political System*
R = *Resources*

Hence the Adaptive Capacity of a community is a function of local processes and conditions which in turn are influenced by broader socio-economic and political processes and widespread resource availability. Consequently, even if our scale of analysis is the household or community, an estimation of the determinants of adaptive capacity requires an awareness of the larger context within which the community operates.

Note that the factors that broadly constrain Adaptive Capacity (equation 8) are very similar to those that constrain occupance (equation 5) and consequently exposure (equation 6). The relationship among Exposure (physical stimulus, occupance) and Adaptive Capacity is illustrated in Figure 4. For example, a kinship system (social cohesion) may influence livelihood strategies (deriving all household income from agriculture) as well as adaptive capacity (being able to call on the resources of family members to mitigate/recover from an extended drought). Thus, while many factors which determine vulnerability are relevant for the assessment of both Exposure and Adaptive Capacity, their manifestations and influence on vulnerability are different.

6. Assessing Vulnerability and the IACC Project

The objectives of the IACC project are:

1. ***To identify the current physical and social vulnerabilities related to water resource scarcity in the two dryland regions;***
2. ***To examine the effects of climate change risks on the identified vulnerabilities;***
3. ***To assess the technical and social adaptive capacities of the regional institutions to address the vulnerabilities to current water scarcity and climate change risks.***

The general vulnerability model provides a framework to structure empirical work in dryland communities, with the primary purposes being to identify their vulnerabilities (particularly related to water scarcity) and to assist in enhancing their adaptive capacity (particularly related to regional institutions). The preceding sections outlined the conceptual model and rationale of the vulnerability approach (ie. the why of vulnerability assessment). This section outlines issues specific to this context (institutions, communities) and some general principles and methodologies for applying the approach.

6.1 Institutions and Water Scarcity

Both of the study regions (El Norte Chico in Chile and the southern Prairies in Canada) have economic systems which rely heavily on the availability of water. While the introduction of irrigation technologies has facilitated the development of intensive, production-oriented dryland agricultural systems, water scarcity (and its potential exacerbation through climate change) is a limiting factor in further development and potentially the sustainability of existing economic activity.

The water sector has a history of adaptation to climatic variation through the institutions which serve to balance the competing needs of resource users (Ivey et al., 2004). Frequently, water management systems in arid and semi-arid areas are challenged by the demands of existing climate variability, and it can be expected that climate change will have further impacts on resource availability (Miller et al., 1997; Ivey et al., 2004; Frederick and Major, 1997). Furthermore, demographic change, increased environmental constraints related to water quality as well as quantity, and potentially changing seasonal patterns of water demand can challenges posed by climate change (Miller et al., 1997). Water management thus needs to broaden its focus to include not only institutional and legal aspects but environmental and social considerations in a holistic manner (Hamdy et al., 1995). Key to understanding water management is the role of institutions and how these relate to broader contexts. Research has often focused more on predicting the physical impacts of climate variability and change on water, and less on the role of institutions in determining response to past and current scarcity and managing future change (Miller et al., 1997). An assessment of exposure and adaptive capacity focused on water scarcity in light of environmental change of necessity must include an understanding of the roles of various institutional actors and their ability to respond (or facilitate or impede individuals' responses) to change.

The range of definitions of institutions is so great that O'Riordan and Jordan (1999) note that "the study of institutions will always be frustrated by the absence of agreement on the core topic being studied". Institutions have been broadly defined as "the humanly devised constraints that structure human interaction" (North, 1994). The broad definition can be interpreted in a

multiplicity of ways, from a consideration of structured organizations to socialized ways of looking at the world and culturally ascribed values (O'Riordan and Jordan, 1999).

Generally, institutions can be characterized as informal and formal: informal institutions include public perceptions (e.g. conceptualizations of water as a limitless, free public good), interaction among individual actors (e.g. labour and mobility) and social norms and community values (e.g. placing an emphasis on literacy) (Alaerts, 1997). Formal institutions include both organizations (e.g. local government) and legal and regulatory systems (e.g. water management policy such as riparian rights). For the purposes of this paper, the use of the term institutions will be synonymous with formal institutions.

Water management in an environment of scarcity and competing/conflicting demands cannot be examined independently of institutions, since these define how water is allocated and influence the nature of conflict if resource availability or demand change. Miller et al. (1997), in a comparative study of riparian rights and prior appropriation water allocation systems in the United States, noted that the two allocations systems had differential impacts on communities. Prior appropriation systems share the burden of decreased supplies inequitably since more junior users suffer comparatively more in times of scarcity. Furthermore, individual water rights such as those enshrined by prior appropriation may discourage institutional adaptation through planning mechanisms since more established users have a strong incentive for preventing change and may lobby authorities to maintain existing systems (Miller et al., 1997). Furthermore, more established users are likely to be proportionately more powerful given current security of access to the resource and thus have greater influence on institutional stability and change. Conversely, junior users who operate within an individual water rights system may actually have extremely high adaptive capacity since they are highly affected by current climatic variability and have much incentive to develop adaptation strategies for current periods of water scarcity and are thus comparatively better equipped to deal with future scarcity (Miller et al., 1997).

Climate change poses a particular problem for water management in arid and semi-arid areas: the impacts of water scarcity will be felt at the local and regional level, and mitigation and control of climate change is beyond the scope of local, regional and even national-level institutions. The Bruntland report notes that ecological and economic systems are not easily changed, so consequently policies and institutions must. The focus of adaptation to climate change in this context thus primarily becomes focused on institutions.

Institutions by definition are durable sources of authority (Willems and Baumert, 2003) that take time to develop and are frequently renegotiated (O'Riordan and Jordan, 1999). The development of an effective policy response to the challenges of climate change requires an understanding of the relationship between individuals and institutions (O'Riordan and Jordan, 1999). Objective 3 of the IACC Project explicitly identifies a focus on institutions; however, to understand the current physical and social vulnerabilities related to water resource scarcity in the southern Prairies and El Norte Chico (Objective 1 of the IACC Project) and to examine the effects of climate change risks on the identified vulnerabilities (Objective 2 of the IACC Project), an in-depth understanding of relevant institutions, their inter-relationships, and the relationship between institutions and individuals is vital. Key to this understanding is the involvement of a communities and institutions through stakeholders.

6.2 Communities and Stakeholders

The term community, like the term institutions, has a range of contested meanings – and like institutions, a discussion of the role of communities can easily be sidetracked into on-going discussion of the term (Wallerstein, 1999). Discussions of community invariably involved Tonnies' Gemeinschaft and Gesellschaft concepts – in essence, considerations of social cohesion, kinship and common goals or "community of interest" on the one extreme and physical proximity in geographical space on the other *[I realize that this is an over-simplification – I'm trying to avoid sidetracking myself in discussion of the term while recognizing its contested meanings. Alternate suggestions of wording welcome – JW]*. Furthermore, the term "rural community", interpreted as a discrete entity in space, introduces further contested meanings of "rural" in addition to disagreement on who comprises the rural community (Halfacree, 1993; Hoggart, 1990; Bollman, 2001). For the purposes of this paper, "a community" is treated as a collection of individuals and families sharing a geographic space in the form of a town or village with its associated institutions (local government, service clubs, etc.). The focus on geographic space thus includes all those who physically share the space for all or part of the year, regardless of diverse "communities of interest", occupations and location of occupation and existence or lack of kinship ties.

It follows that the definition of community as shared geographic with diverse membership and interests means that there is no single voice for a community (Wallerstein, 1999). Communities are not monolithic entities, and thus the selection of people to represent a community must be undertaken carefully to avoid tokenism and exclusion (Wallerstein, 1999). Community members from a multiplicity of backgrounds need to have a voice in the decisions that affect them, and thus should be involved in the assessment and design of effective policy instruments (Nieto et al., 1997). Community participation through meaningful, representative inclusion and engagement of stakeholders is one of the cornerstones of the approach and methodology outlined in this paper, and the tools and methods outlined here rely heavily on participatory approaches and methodologies commonly employed in ethnography.

6.3 Participation, Participatory Methods and Empowerment

Participatory research methods can be traced to Lewin's school of "action research" (Flax et al., 2002; Checkland and Holwell, 1998). In action research, the researcher is required to enter into a real-world situation with dual goals of understanding and improving the situation (Checkland and Holwell, 1998). This school of thought spawned requirements of collaboration among researchers, organizations and stakeholders to promote new knowledge production and problem-solving (Flax et al., 2002). Over the past 50 years, over 30 terms have emerged for participatory or action-oriented research methods and approaches including the frequently used Participatory Appraisal (PA), Participatory Rural Appraisal (PRA), Rapid Rural Appraisal (RRA), and Participatory Action Research (PAR) (Pretty, 1995; Pain and Francis, 2003).

While there are distinctions among the various approaches, they share a number of commonalities. Participatory approaches rely on methodologies which are focused on learning by all participants, they seek multiple perspectives, they rely on group learning processes

through research team members from a variety of backgrounds, they include both experts and stakeholders, they are context-specific and flexible enough to be adapted to include stakeholders which were not identified at the outset, and they are designed to facilitate and motivate change (Pretty, 1995; Pretty and Vodouhe, 1997).

"Participation" has become a requirement for much development work, particularly in the areas of agricultural extension, health promotion and sustainable development (Pain and Francis, 2003; Pretty, 1995; Laverack and Labonte, 2000). Participation has become a buzzword, so much so that nearly every project includes "stakeholders", "people's participation" and "popular participation" (Pretty, 1995). Given the popularity of the term, funding agencies frequently require community and stakeholder participation. However, incorporating stakeholder and community participation into research introduces challenges for "real" participation beyond discourse and paternalism (Pretty, 1995) to avoid Rahnema's (1992) caution that "more often than not, people are asked or dragged into partaking in operations of no interest to them, in the very name of participation".

Pretty (1995) and Pretty and Vodouhe (1997) have summarized different levels of stakeholder involvement in a Typology of Participation (Table 1). Participation ranges from "manipulative participation" with token stakeholder representatives on management boards through to "interactive participation" and ultimately "self mobilization", where stakeholders become full partners in the research and institutional change process. Ideally, participation in vulnerability assessment will involve real and relevant involvement of stakeholders and lead to outcomes such as education, awareness, networking and empowerment (Neito et al., 1997).

Community empowerment can be defined as the means by which people experience more control over decisions that influence their lives (Laverack and Labonte, 2000). Participation through participatory methodologies is basic to community empowerment (Laverack and Labonte, 2000; Pretty, 1995).

6.4 Participatory Methodologies for Assessing Vulnerability

In order to document a community's current exposures and adaptive capacity, it is necessary to see potential stresses from the perspective of individual community members. This requires real participation similar to Pretty's "interactive participation" (Table 1). In order to do this, it is necessary to establish some degree of validity, rapport and trust with the community. In many cases, a natural mistrust of researchers exists, and this can be compounded if researchers are working with communities who have been extensively studied with little perception of change resulting from their participation in researchers (Wallerstein, 1999) *[a situation which potentially exists in Canadian agricultural communities – JW]*. Mistrust of researchers is increased if there is any potential that the researcher is seen as a government informant or representative of an organization that has a controversial history in the community or as a total stranger whose language is difficult to understand or overly technical. This can be exacerbated in situations of (perceived or real) unequal power relationships, particularly in group situations where some members may feel diminished or silenced by other participants or even the researchers themselves.

Marginalized groups, who may be among the most vulnerable due to high exposure and low adaptive capacity, are frequently left out of community assessments (Pretty, 1995). Laverack and Labonte (2000) define marginalized individuals as those who are already unable to sufficiently meet their own needs, with limited access to resources and power. Consequently, marginalized people are less likely to participate in research and influence change – in part due to the more pressing concerns and competing time demand of meeting basic needs of food and shelter, and also because it may be difficult for these groups to articulate their needs and interests in the language understood by other groups Pretty, 1995; Laverack and Labonte, 2000; Pain and Francis, 2003).

6.4.1 Project Design

Potential research communities must be carefully researched through secondary sources and key informants before formal contact is established to understand the basic context of the community (demographic information, livelihoods, relevant institutions, history and nature of contact with researchers) and preliminary determination of stakeholder groups. An initial community visit can be greatly enhanced by **transect walks** and **community consultations**.

Transect walks are systematic travels through the community of interest with a key informant. The focus in a transect walk is on observing, asking, listening and looking. Pretty (1995) credits transect walks with being instructive even for experienced professionals in the field to "realize how much they do not see or do not think to ask about". Transect walks can serve to refine the preliminary determination of stakeholder groups based on visual observation and informal conversation with community members.

Community consultations serve to introduce researchers and the community to each other. In many cases, including the case of the IACC Project, researchers come from cultural and socio-economic circumstances which are very different from those of community members and may not be fluent in the local (research) language. Similarly, the community needs to know the objectives of the research and have input into refining objectives. In many instances, it is helpful to be introduced to the community through a meeting organized by a regional association or local government representatives. Community members often lack incentive to attend a generic public meeting on potential research, and thus combining the meeting with an existing event such as a town hall meeting (or sponsoring an event such as a community picnic or "feast" *[in the Arctic context, sponsoring a "feast" – a free buffet for community members with drum dancing, throat singing and visiting – guarantees a full house. Similar events for Prairies, Chile? – JW]*) can increase attendance.

Carefully facilitated community meetings allow locals to express concerns about the research (or decline to participate) and can serve to identify **local facilitators and collaborators** who are particularly interested. The intimate involvement of a local increased the validity of researchers in the community's eyes, enables that researchers are aware of sensitive wording and issues and helps to overcome language and cultural barriers.

At this stage, the establishment of a **steering committee** which advises the project throughout the research project can serve as a valuable tool in vulnerability assessment (Flax et al., 2002).

Steering committees ideally are comprised of locals which represent all community stakeholder groups and institutions as well as representatives from the research and broader-scale policy community (Flax et al., 2002; Nieto et al., 1997; Pain and Francis, 2003). The steering committee takes an active role in research design, including refinement of research questions to be locally relevant and phrased in appropriate terms (the latter is particularly important if working through an interpreter), selection of research tools, determination of timing of the research, and clarification of how locals can contribute to the research (Flax et al., 2002).

The engagement of the steering committee from the earliest stages of the assessment makes full community participation in later stages more likely. In addition, it contributes to underlying goals of empowerment since it can establish a network of interested stakeholders and facilitate sharing information and collaboration among them (Alaerts, 1997; Nieto et al., 1997). Furthermore, if groups with relatively high power in the community are involved, this can facilitate achieving change since their cooperation is frequently necessary for action (Pain and Francis, 2003).

6.4.2 Vulnerability Assessment and Methodologies

6.4.2.1 Questions to Guide Vulnerability Assessment

Vulnerability assessment involves the assessment of current and future exposures and adaptive capacities. The identification of **current exposures** involves documenting the conditions or risk that people have had to deal with or are dealing with in their lives, livelihoods, businesses, sectors etc. This requires collection of existing secondary source data such as climate records as well as identification of which conditions are relevant/problematic for various stakeholders. This entails documenting both the physical and other stresses that are identified by the people and the occupance characteristics (livelihoods, settlement, etc.) that make the condition problematic or risky or a stress. In essence, researchers are guided by the questions: *what sort of conditions have posed problems for this person/household/group/community/institution in the past? What problems are currently being dealt with?*

Assessing **current adaptive capacity** involves identifying the ways in which the community deals with exposures. The goal here is to answer the questions, *how have individuals/households/groups/institutions dealt with/coped with/managed/adapted to the problematic conditions of the past? What adaptations or adaptive strategies were employed, how, why, by whom, under what circumstances? How are problematic conditions currently being dealt with? How effective or otherwise are current strategies? What are current barriers and enabling factors for management of problematic conditions?* It must be remembered that assessing current adaptive capacity means assessing capacities, since different community members have differential access to resources and powers and thus capacity is not uniform.

Furthermore, assessing current adaptive management requires an identification of the broader conditions that constrain or facilitate adaptive initiatives. This introduces the questions: *If there have been measures or policies or other forms of institutional support that helped deal with exposures, what were the conditions that made them feasible and effective? Are there needs and opportunities not realized?* Not all adaptive strategies will be at the scale of the community (ie. internal to the community). While some adaptive strategies/capacities exist only at the level of

the community, others are institutionalized at a larger level and beyond the (perceived or real) control of community members, and this influences how responses to the questions are followed up upon. For example, a need or opportunity not realized could be the resolution of a transboundary water rights issue which would result in more equitable distribution of available water, but inter-regional or inter-national water negotiations are beyond the scope of community actors.

Together, the above questions represent the characterization of current exposures and adaptive capacities and provide the community's collective ability to address changing conditions and risks in the future.

The assessment of future vulnerability (and thus future exposures and adaptive capacities) combines local knowledge/community data sources with secondary sources and scientific modeling. **Future exposures** relate to conditions which are expected to represent risks or opportunities to the community at a later date. The identification of current exposures provides a description of those conditions that are particularly pertinent to the community. These relevant conditions can be considered by climate modeling, hydrologic modeling, policy analysis, demographic analysis, key informant interviews and others to assess the likelihood of changes in these (community-relevant or community-identified) conditions in the future. For example, an assessment of current exposures may reveal that the community has, in the past, been challenged to meet community demand for freshwater supplies for agriculture. Currently, the majority of community members engage in agriculture, and this is encouraged by state-level food security policies. Climate and hydrologic modeling may reveal that there is a likelihood of diminishing water supplies while demographic analysis reveals a classic "pyramid" age-sex distribution indicating rapid future population growth. Policy analysis shows little indication of a change in the institutional encouragement of agriculture and a strong lobby to maintain existing water market control structures relying on prior rights. Thus, researchers, can conclude that future exposure will be greater than current exposure due to the combination of these factors.

This type of analysis introduces a somewhat different (but not independent of) approach from the conventional scenario modeling of climate change. In this approach, the choice of variables to be modeled is influenced by an identification of relevant parameters. In addition, the climate, water, and ecosystem analysts may identify some expected changes in conditions beyond the experience of the community residents, and once these are related to occupancy characteristics of the community, these too would be included in "future exposures".

Analyzing **future adaptive capacity** has two related parts. The first assess the manner and degree to which the current management practices could deal with or accommodate the estimated future exposures. More broadly, the assessment could consider the degree to which the community's adaptive capacity has the scope, resilience, resources and potential to deal with expected future exposures. Furthermore, analyzing future adaptive capacity needs to include a consideration of future inequalities in the community (e.g. differential adaptive capacities of junior and senior water users under a prior rights water appropriation system, as outlined earlier).

Data sources at this stage are a combination of information collected through in-depth field work at the local level and insights from key informants at local, regional and national scales as well as

the results from scientific analyses such as modeling and policy and demographic analyses. Combining future exposures and future adaptive capacity to identify future vulnerability becomes necessarily and integrative exercise which, ideally, involves local partners, stakeholders, researchers, and institutional representatives.

While the exercise outlined above should identify and document all relevant stressors to community members' lives/livelihoods, IACC work should give particular attention to those stresses which are directly or indirectly related to water supply, resources, management and use as well as climate variability (drought, flooding, changes in seasonal distribution).

6.4.2.2 Methodologies for Vulnerability Assessment

Research methods which involve communities and recognize the role of both the researcher and empowerment have been variously referred to as participatory, ethnographic and qualitative. While this section outlines a number of these methods and their applications, it should be noted that the selection of particular methods – and the order in which they are employed – will vary by community, be influenced by a steering committee, and change throughout the research process depending on new research needs and preliminary results. Thus, it is crucial that researchers be reflexive, flexibility and adaptive in their research process (Pain and Francis, 2003).

Tools which enhance researcher reflexivity, flexibility and adaptability include team contracts and rapid report writing. **Team contracts** are agreements among research team members to hold regular discussions on the progress of the research. Since research teams will include locals (at the very minimum, the steering committee and local facilitators and translators), it is important that a team member be assigned to record interactions at team meetings (either through minutes or by "diagramming" conversations) to identify who is quiet and who dominates (Pretty, 1995). Through team contracts, issues are discussed as they arise, and careful attention to the pattern of conversation can serve to ensure that team meetings are a reflection of all team members' thoughts.

Rapid report writing, with self-correcting notes subsequent to initial notes not only creates an essential record of the research before some details are forgotten but serves to focus researchers on processing the current information and facilitates the formulation of appropriate follow-up/clarification questions (ideally, discussed at team meetings) while still in the field (Pretty, 1995). For many researchers, writing a private diary or frequent updates to colleagues in the form of letters or emails makes rapid report writing a natural element of research.

In all cases, the "night halt", or practice of **staying in the community** during the research period, is an essential part of participatory research (Pretty, 1995). Staying in the village, with locals if possible, not only helps to build familiarity and rapport but can change outsider attitudes and perceptions, improve linguistic ability, facilitate informal discussion, and demonstrate a commitment to village life (Pretty, 1995).

Data collection can be achieved through semi-structured interviews, participatory diagramming/mapping, work sharing and focus groups. The **semi-structured interview** (SSI) is

guided by a series of issues/questions (as outlined above), but does not appear as a formal interview (Pretty, 1995). The interview takes the form of a free-flowing conversation which, on the surface, does not appear controlled or structured and relies on open-ended questions. The SSI, considered a central part of participatory methods (Pretty, 1995), can be one of the most challenging research techniques since it requires the flexibility to address topics as they arise, requires researchers to be well-versed in local customs/etiquette, and relies on receptive body language on the part of the researcher. The interview is enhanced by an interested facilitator/translator who helps establish rapport and validity and, during pauses for translation, allows the researcher time to process information.

Despite the best intentions, some community members may, for various reasons, not be able to communicate effectively with the researcher. They may feel that their comments are not important or relevant, or they may lack the ability to express their ideas and their interconnections coherently. In these situations, **participatory diagramming/mapping** is particularly helpful. These techniques involve the construction of **mental maps**, historical **time lines**, seasonal calendars or **activity profiles** and **Venn/network diagrams** to illustrate the individual's thoughts on the relevant questions. For example, the construction of a timeline noting historical water shortages can prompt recall of particular stresses, which can naturally facilitate discussions on their management. Similarly, the construction of a map frequently proves useful to highlight areas of concern/relevance. An activity profile may introduce the notion of migrant or seasonal workers who might be overlooked by the researchers if they are not present in the community at the time of the research. Network diagrams can serve to illustrate linkages and overlap among individuals and institutions and identify distances which can reflect lack of contact or empowerment (Pretty, 1995).

Various **card sorting techniques** are a participatory mapping exercises which allow individuals or groups to lay out an activity or illustrate relationships though a series of cards which are labeled with relevant actions, institutions, and locations to establish a picture of community relationships (Muller, 2001). Blank cards are provided for individuals to add missing concepts. Like other participatory mapping exercises, card sorting techniques allow potentially uncomfortable participants to focus on a physical task (arranging cards, drawing a map, etc.) and thus help overcome communication barriers and allow locals to take the lead in the research exercise.

Work sharing allows researchers to gain better understanding of some of the realities of community life (Pretty, 1995). For example, participating in an agricultural project which relies on human power to irrigate can give insights into the level of effort required to implement some adaptations. In addition, work sharing allows participants to see researcher commitment to the exercise, can help build rapport, and allow participants a sense of empowerment since they are the "experts" and the researcher the recipient of instruction/information relevant to the task.

Focus groups involve pre-selected participants to interact as a group, guided by questions from a facilitator. Kruger (1994) suggests seven to ten participants for a focus group, as it becomes difficult for some participants to make their voices heard in larger gatherings. The selection of a facilitator (preferably a local, fluent in the language) is critical, since the researchers should take on an observing role here. Focus groups allow for the interaction of community members from

various backgrounds, which can lead to the establishment of networks, interactive problem solving and empowerment. Focus groups can also be used with representatives of only one group, and have particular relevance in situations where marginalized individuals may not otherwise feel that their voice matters but can potentially overcome this in a critical mass of people facing the same challenges.

Focus groups need to come with a cautionary note – while they can be powerful tools for empowerment, they can also serve as catalysts for conflict if competing resource users are unable to reach consensus and the facilitator is not in a position to carefully manage this. With the exception of the steering committee, which can be viewed as a focus group, this technique is best employed once other techniques have already been applied.

7. Conclusions

Vulnerability assessment in the context of the IACC project involves both an approach and particular methodologies as outlined in this paper. The vulnerability approach is of necessity general, since it needs to be flexible enough to be applied to many diverse contexts. Even within a particular project such as the IACC, which is tightly focused on institutions and water management in dryland regions, a tremendous range of economic, cultural, value and management systems can be expected to be encountered. Thus, it becomes crucial that researchers have a high degree of familiarity and experience with a range of methods and, perhaps most difficult to learn, good judgment as to when to apply particular techniques and how to conduct oneself in various settings. Judgment can be gained through experience, self-reflexivity and team contracts.

Since participatory methods such as the ones outlined in this paper place the emphasis on stakeholder involvement and, in the ideal situation, lead to community empowerment and ultimately institutional change, the vulnerability approach extends to include the formulation of adaptation strategies (or "mainstreaming" of the research) and thus contributes to capacity building [*and that is a whole other literature and paper – JW*]. Although many commonalities exist, there is no universal prescription for increasing adaptive capacity and hence decreasing vulnerability, just like there is no one methodology or combination/sequence of methodologies for community assessments.

Participatory methods also introduce obligations for community feedback. From an ethical standpoint, researchers have a duty to make assessments relevant to the community and be accountable for their conclusions (Wallerstein, 1999). Researchers cannot simply place the responsibility for using research results on communities, since frequently the incentive structure of academia results in dissemination which is not appropriate for stakeholders. Two (or more) communities with different norms, values and rewards need to come together (Wallerstein, 1999), which invariably requires a return visit to the community for locally-appropriate dissemination.

List of References

Adger, W.N. 1998. Observing institutional adaptation to global environmental change: theory and case study from Vietnam. Centre for Social and Economic Research on the Global Environment Working Paper GEC 98-21. University of East Anglia, Norwich, UK.

Adger, W. N. 1999. Social vulnerability to climate change and extremes in coastal Vietnam. *World Development*, **27**: 249-269.

Adger, W. N. and Kelly, P. M. 1999. Social vulnerability to climate change and the architecture of entitlements. *Mitigation and Adaptation Strategies for Global Change*, 4: 253-266.

Adger, W. N. 2000. Institutional adaptation to environmental risk under the transition in Vietnam. *Annals of the Association of American Geographers*, 90(4): 738-758.

Adger, W.N. 2003. Social aspects of adaptive capacity. In J.B. Smith, R.J.T. Klein and S. Huq, eds. *Climate Change, Adaptive Capacity and Development*. London: Imperial College Press.

Alaerts, G.J. 1997. Institutional Arrangements. In Water Pollution Control – A Guide to the Use of Water Quality Management. Geneva: WHO/UNEP.

Appelgren, B. and W. Klohn. 1999. Management of water scarcity: a focus on social capacities and options. *Physics and Chemistry of the Earth (B)*, 24: 361-373.

Beg, N., J. Corfee Morlot, O. Davidson, Y. Afrane-Okesse, L. Tyani, F. Denton, Y. Sokona, J. Thomas, E. Lebre La Rovere, J. Parikh, K. Parikh and A. Rahman. 2002. Linkages between climate change and sustainable development. *Climate Policy*, 2:129-144.

Barnett, J. and W.N. Adger. 2003. Climate dangers and atoll countries. *Climatic Change*, 61: 321-337.

Blaike P., Cannon, T., Davis, I., and Wisner, B. 1994. *At Risk: Natural Hazards, People's Vulnerability, and Disaster*. London: Routledge.

Bohle, H. C., Downing, T. E. and Watts, M. J. 1994. Climate change and social Vulnerability. *Global Environmental Change*, 4**:** 37-48.

Bruce, J.P. 1999. Diaster loss mitigation as an adaptation to climate variability and change. *Mitigation and Adaptation Strategies for Global Change*, 4 (3-4): 295-306.

Bryant, R. and S. Bailey. 1997. *Third World Political Ecology*. Routledge, New York.

Bryant C.R., B. Smit, M. Brklacich, T.R. Johnston, J. Smithers, Q. Chiotti, and B. Singh. 2000. Adaptation in Canadian agriculture to climatic variability and change. *Climatic Change*, 45: 181-201.

Cannon, T. 2000. Vulnerability analysis and disasters. In D.J. Parker (ed.), *Floods*. London: Routledge, 43-55.

Cannon, T. 2002. Gender and climate hazards in Bangladesh. *Gender and Development*, 10(2): 45-50.

Checkland, P. and S. Holwell. 1998. Systemic Practice and Action Research, 11(1): 9-21.

Cutter, S. 1996. Vulnerability to environmental hazards. *Progress in Human Geography*, 20: 529-539.

De Loe, R.C. and R. Kreutzwiser. 2000. Climate variability, climate change and water resource management in the Great Lakes. *Climatic Change*, 45: 163-179.

De Vries, J. 1985. Historical analysis of climate-society interaction. In R.W. Kates, J.H. Ausubel and M. Berberian (eds.), *Climate Impact Assessment*. New York: Wiley, 273-291.

Dinesh, K.M. 2003. Enhancing sustainable management of water resource in agriculture sector: the role of institutions. *Indian Journal of Agricultural Economics*, 58**:** 406-437.

Downing, T.E., L. Ringus, M. Hulme, D. Waughray. 1997. Adapting to climate change in Africa. *Mitigation and Adaptation Strategies for Global Change*, 2: 19-44.

Downing, T.E. 2001. Climate Change Vulnerability: Linking Impacts and Adaptation. Report to the Governing Council of the United Nations Environment Programme. Environmental Change Institute, Oxford, UK.

Downing, T.E. 2003. Lessons from famine early warning and food Security for understanding adaptation to climate change: toward a vulnerability/adaptation science? In J.B. Smith, R.J.T. Klein and S. Huq, eds. *Climate Change, Adaptive Capacity and Development*. London: Imperial College Press.

Flax, L.K., R.W. Jackson and D.N. Stein. 2002. Community vulnerability assessment tool methodology. Natural Hazrds Review, 3(4): 163-176.

Fraser, E., Mabee, W., and Slaymaker, O. 2003. Mutual vulnerability, mutual dependence: the reflective notion between human society and the environment. *Global Environmental Change*, 13:137-144.

Frederick, K. D. 1997. Adapting to climate impacts on the supply and demand for water. *Climatic Change*, 37**:** 141-56.

Frederick, K. D., and D. C. Major. 1997. Climate change and water resources. *Climatic Change*, 37: 7-23.

Füssel, H.-M. and R.J.T. Klein. 2002. Assessing vulnerability and adaptation to climate change:

an evolution of conceptual thinking. Paper presented at the UNDP Expert Group Meeting in "Integrating Disaster Reduction and Adaptation to Climate Change", Havana, Cuba, 17-19 June 2002.

Grindle, M. S., and M. E. Hilderbrand. 1995. Building sustainable capacity in the public sector: what can be done? *Public Administration and Development*, 15**:** 441-63.

Hamdy, A., M. Abu-Zeid and C. Lacirignola. 1998. Institutional capacity building for water sector development. *Water International*, 23: 126-133.

Handmer, J.W., S. Dovers and T. E. Downing. 1999. Societal vulnerability to climate change and variability. *Mitigation and Adaptation Strategies for Global Change*, 4: 267–281.

Handmer, J.W. 2003. Adaptive Capacity: What does it mean in the context of natural jazards. In J.B. Smith, R.J.T. Klein and S. Huq (eds.), *Climate Change, Adaptive Capacity and Development*. London: Imperial College Press.

Hartvelt, F., and D. A. Okun. 1991. Capacity building for water resources management. *Water International*, 16**:** 176-83.

Hewitt, K. 1997. *Regions of Risk: A Geographical Introduction to Disasters*. Essex: Addison Wesley Longman.

Houghton, J.T., Y. Ding, D.J. Griggs, N. Noguer, P.J. van der Linden, X. Dai, K. Maskell, C.A. Johnson. *Climate Change 2001: The Scientific Basis Impacts - Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press.

Ivey, J., J. Smithers. R.C. de Loe, R.D. Kreutzwiser. 2004. Community capacity for adaptation to climate-induced water shortages: linking institutional complexity and local actors. *Environmental Management*, 33: 36-47.

Jones, R. 2001. An environmental risk assessment/management framework for climate change impact assessments. *Natural Hazards*, 23**:** 197–230.

Kelly, P. M. and W.N. Adger. 2000. Theory and practice in assessing vulnerability to climate change and facilitating adaptation. *Climate Change*, 47: 325-352.

Kemper, K. 2001. The role of institutional arrangements for more efficient water resources use and allocation. *Water, Science and Technology*, 43**:** 111-117.

Khan, S. R. 2003. Adaptation, sustainable development and equity: the case of Pakistan. In J.B. Smith, R.J.T. Klein and S. Huq (eds.), *Climate Change, Adaptive Capacity and Development*. London: Imperial College Press.

Laverack, G. and R. Labonte. A planning framework for community empowerment goals within health promotion. Health Policy and Planning, 15(3): 255-262.

Leichenko, R. M. and K.L. O'Brien. 2002. The dynamics of rural vulnerability to global change: the case of Southern Africa. *Mitigation and Adaptation Strategies for Global Change*, **7:** 1-18.

Liverman, D. M. 1994. Vulnerability to global environmental change. In S.L. Cutter (ed.), *Environmental Risks and Hazard*. Toronto: Prentice Hall, 326-42.

McCarthy, J.J, O.F. Canziani, N.A. Leary, D.J. Dokken, and K.S. White. 2001. *Climate Change 2001: Impacts, Adaptation and Vulnerability - Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press.

Magadza, C.H.D. 2000. Climate change impacts and human settlements in Africa: prospects for adaptation. *Environmental Monitoring and Assessment*, 61**:** 193-205

Magadza, C.H.D. 2003. Engaging Africa in adaptation to climate change. In J.B. Smith, R.J.T. Klein and S. Huq (eds.), *Climate Change, Adaptive Capacity and Development*. London: Imperial College Press.

Miller, A., S.L. Rhodes, L.J. MacDonnell. 1997. Water allocation in a changing climate: institutions and adaptation. Climatic Change **35**: 157-177.

Mirza, M.M.Q. 2003. Climate change and extreme weather events: can developing countries adapt? *Climate Policy*, 3: 233-248.

Muller, M.J. 2001. Layered participatory analysis: new developments in the CARD technique. CHI, 3(1): 90-97

Mustafa, D. 2002. Linking access and vulnerability: perceptions of irrigation and flood management in Pakistan. *The Professional Geographer*, 54**:** 94-105.

Nieto, R.D., D. Schaffner and J.L. Henderson. 1997. Examining community needs through a capacity assessment. Journal of Extension, 35(3): no page numbers [online at www.joe.org].

North, D.C. 1994. Economic performance through time. *American Economic Review*, 84**:** 359-368.

O'Brien, K. L., and Leichenko, R. M. 2000. Double exposure: assessing the impacts of climate change within the context of economic globalization. *Global Environmental Change*, 10: 221-232.

O'Riordan, T., and A. Jordan. 1999. Institutions, climate change and cultural theory: towards a common analytical framework. *Global Environmental Change*, 9**:** 81-93.

Pain, R. and P. Francis. 2003. Reflections on participatory research. Area, 35(1): 46-54.

Pelling, M. 2002. Assessing urban vulnerability and social adaptation to risk - evidence from Santo Domingo. *International Development Planning Review*, 24**:** 59-76.

Pretty, J.N. 1995. Participatory learning for sustainable agriculture. World Development, 23(8): 1247-1263.

Pretty, J.N. and S.D. Vodouhê. 1997. Using rapid or participatory rural appraisal. In Improving Agricultural Extension: A Reference Manual. Rome: FAO.

Rahnema, M. Participation. In W. Sachs (ed.), The Development Dictionary. London: Zed Books, 116-131.

Rosenzweig, C. and M.L. Parry. 1994. Potential impacts of climate change on world food supply. *Nature*, 367: 133-138.

Sen, A. 1981. *Poverty and Famines: an Essay on Entitlement and Deprivation*. Clarendon Press, Oxford.

Schulze, R., J. Meigh and H. Horan. 2001. Present and potential future vulnerability of eastern and southern Africa's hydrology and water resources. *South African Journal of Science*, 97: 150-160.

Smit, B., I. Burton, R.J.T. Klein, R. Street. 1999. The science of adaptation: a framework for assessment. *Mitigation and Adaptation Strategies for Global Change*, 4: 199-213.

Smit B., I. Burton, R. Klein, J. Wandel. 2000. An anatomy of adaptation to climate change and variability. *Climatic Change*, 45: 223-251

Smit, B., and O. Pilifosova. 2001. Adaptation to climate change in the context of sustainable development and equity. Chapter 18 in *Climate Change 2001: Impacts, Adaptation, and Vulnerability - Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, UK: Cambridge University Press.

Smit, B., and O. Pilifosova. 2003. From adaptation to adaptive capacity and vulnerability reduction. In J.B. Smith, R.J.T. Klein and S. Huq (eds.), *Climate Change, Adaptive Capacity and Development*. London: Imperial College Press.

Smith, J.B., Lazo, J.K., 2001. A summary of climate change impact assessments from the US Country Studies Program. *Climatic Change*, 50**:** 1–29.

Smith, J.B. and S.S. Lenhart. 1996, Climate change adaptation policy options. *Climate Research*, 6: 193–201.

Smithers, J., and Smit, B. 1997. Human adaptation to climatic variability and change. *Global Environmental Change*, **7**: 129-146.

Stakhiv, E. Z. 1996. Managing water resources for climate change adaptation. In J. B. Smith, N. Bhatti, G. Menzhulin, R. Benioff, M. I. Budyko, M. Campos, B. Jallow, and F. Rijsberman (eds.), *Adaptation to Climate Change: Assessment and Issues.* New York: Springer, 243-64.

Tol, R.S.J., T.E. Downing, J.K. Kuik and J.B. Smith. 2004. Distributional aspects of climate change impacts. *Global Environmental Change*, 14**:** 259-272

Tompkins, E.L., and W.N. Adger. 2004. Does adaptive management of natural resources enhance resilience to climate change? *Ecology and Society*, 9(2)**:** 10 [online] http://www.ecologyandsociety.org/vol9/iss2/art10

Toth, F.L. 1999. *Fair Weather? Equity Concerns in Climate Change*. London: Eearthscan.

United Nations Disaster Relief Organization.1982. *Natural Hazards and Vulnerability Analysis*. Geneva, Office of the United Nations Disaster Relief Co-ordinator.

Vörösmarty, C.J., P. Green, J. Salisbury and R.B. Lammers. 2000. Global water resources: vulnerability from climate change and population growth. *Science*, 289: 284-288.

Wallersetin, N. 1999. Power between evaluator and community: research relationships within New Mexico's healthier communities. Social Science and Medicine, 49: 39-53.

Watts, M. J. and Bohle, H. G. 1993. The space of vulnerability: the causal structure of hunger and famine. *Progress in Human Geography,* 17: 43-67.

West, J.J., M.J. Small and H. Dowlatabadi. 2001. Storms, investor decisions and the economics of sea level rise. *Climatic Change*, 48(2): 317-342.

Wheaton, E.E. and D.C. MacIver. 1999. A framework and key questions for adapting to climate variability and change. *Mitigation and Adaptation Strategies for Global Change*, 4: 215-225.

Williams, P. 1989. Adapting water resources management to global climate change. Climate Change, 15: 83-93.

Willems, S. and K. Baumert. 2003. Institutional Capacity and Climate Action. Paris: OECD.

Wisner, B., P. Blaikie, T. Cannon, and I. Davis. 2004. *At Risk*. London: Routledge.

World Bank. 2002. Sustainable Development in a Dynamic World. *Transforming Institutions, Growth and Quality of Life*. New York: World Bank and Oxford University Press.

Yohe, G.and R. Tol. 2002. Indicators for social and economic coping capacity - moving toward a working definition of adaptive capacity. *Global Environmental Change*, 12: 25–40.

Yohe, G. and M. Schlesinger. 2002. The economic geography of climate change. *Journal of Economic Geography*, 2: 311-341.

Yohe, G., K. Strzepek, T.Pau and C. Yohe. 2003. Assessing Vulnerability in the context of changing socioeconomic conditions: a study of Egypt. In J.B. Smith, R.J.T. Klein and S. Huq (eds.), *Climate Change, Adaptive Capacity and Development*. London: Imperial College Press.

Ziervogel, G. and R. Calder. 2003. Climate variability and rural livelihoods: assessing the impact of seasonal climate forecasts in Lesotho. *Area*, 35(4): 403-417.