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Human Security, Vulnerability and Sustainable Adaptation

Karen O'Brien and Robin Leichenko

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1. Introduction

Four assessments carried out by the Intergovernmental Panel on Climate Change (IPCC) over the past 15 years have contributed to a growing consensus among the scientific community that humans are influencing the global climate system. These assessments confirm that climate change is contributing to dramatic transformations of the biophysical environment that will affect human settlements, ecosystem services, water resources, and food production, among other things. These transformations are likely to have widespread implications for individuals, communities, regions, and nations. Although there is considerable uncertainty about the future trajectory of climate change, related in part to the amount and rate of greenhouse gas emissions, the consequences of climate change represent an unprecedented threat to human security.

Human security is closely linked to the development of human capabilities in the face of change and uncertainty. Individuals and communities faced with both rapid change and increasing uncertainty are challenged to respond to climate change in new ways that protect their social, environmental, and human rights, and that empower them to respond through both mitigation and adaptation. Surprisingly, the issue of climate change has been widely discussed and debated among scientists and policymakers as an environmental issue, rather than as human security issue. Current discourses on climate change draw attention to growing bodies of research on biophysical changes to the earth system, as well as on the economics and politics of climate change management. Although the climate change vulnerability literature has emphasized differential exposure, sensitivities, and adaptive capacities, as well as the concept of social vulnerability, there has been relatively little attention to the implications of differential outcomes and changing vulnerabilities for human security.

In this paper, we consider climate change within an emerging discourse on human security. We emphasize two important dimensions of human security that are directly influenced by climate change: 1) an equity dimension and 2) a connectivity dimension. The equity dimension draws attention to the fact that not all individuals, communities, regions, and nations will be equally affected by climate change. The connectivity dimension emphasizes that the security of individuals and communities is increasingly linked across both space and time, such that outcomes for one group are increasingly related to outcomes in other areas or for other groups, both in the present and future. These interrelated dimensions of human security challenge current discussions and debates about climate change as an environmental issue, and call instead for a more people-based approach to climate change. Drawing upon case studies and examples from the climate change literature, we emphasize four key points about climate change from a human security perspective.

First, vulnerability to climate change is influenced by multiple processes of global change. Using examples from southern Africa, we illustrate how the changing burden of disease, economic changes, conflict and other "stressors" contribute to climate change vulnerability.

Together, multiple stressors create a context for vulnerability. The equity dimension of climate change is closely linked to this context, in that many of these changes benefit some, while contributing to new challenges for other individuals and communities. In some contexts, even small changes or variations in climate can have a large influence on human security. Consequently, dangerous climate change should not be measured by parts per million or degrees of temperature change, but by the dynamic social context, captured by indicators of capabilities and human development, such as health status of the population, presence and quality of social and community networks, and access to information and education.

Second, changing economic and social policies strongly influence the capacity to cope with and adapt to climate change. In most countries and regions, economic and social policies and institutions have undergone dramatic change as the result of globalization. These changes, which are sometimes defined under the term 'neoliberalism,' entail a wide range of policy measures including liberalization of trade and investment policy, privatization of state-owned enterprises, reduction in state subsidies for various industries, loss of social safety nets, and devolution of responsibility for planning from national to local levels. A case study on climate change and economic changes in India shows that the differential capacity to adapt to climate change can be partly linked to policies associated with globalization. An increased recognition of the interactions between climate change and trade liberalization points to the growing importance of institutional and policy changes as keys to reducing vulnerability.

Third, vulnerabilities are linked through an increasingly connected global economy and society, such that actions and behaviors taken in one place have implications for other places. This point draws upon the connectivity dimension of human security, emphasizing that outcomes in one place increasingly reverberate to other people and places. Using examples from coastal megacities, we show how the consequences of climate change related-sea level rise and increased storm surges will not only have significant impacts within specific cities, but will also have consequences for other areas. The case study of Shanghai shows how rapid spatial expansion of the city, coupled with increasing global economic independencies may exacerbate the negative outcomes of climate change within the city, with repercussions throughout China and other parts of the world.

Fourth, vulnerability to climate change is not limited to developing countries. There are vulnerable individuals, communities, and groups within most countries, and new vulnerabilities are emerging in response to the impacts and consequences of climate change, in combination with other societal changes. Our case study focuses on the growing vulnerability of elderly populations in both developed and developing countries to climate-related shocks and stressors. Climate change is not a North-South issue, but an issue of human security that is relevant to all societies.

The four case studies together suggest that there is a significant gap between current responses to climate change and approaches that address the social and ecological challenges posed by climate change. Current climate change policy responses do not take into account multiple and interacting processes of change, the importance of linking economic and social policies with climate change policies, or the linkages betweens adaptations and human capabilities, and differing values. Sustainable mitigation and adaptation to climate change requires consideration

not only of the environmental and economic outcomes, but also of the consequences for human security. While there are many potential responses to climate change, and many potential pathways of development, responses that take into account both equity and connectivity are more likely to contribute to human security in the 21st century.

2. Human Security in the 21st Century

Human security relates to the well-being of individuals, including both freedom from fear and freedom from wants. As a concept, human security refers not only to security from physical violence, but also to food security, livelihood security, environmental security, health security and energy security. Although there are many definitions of human security, a prominent feature among all of them is reference to the security of individuals rather than the state. Importantly, the concept of human security is also relevant to communities and groups. In some cultures, the needs, values, and interests of a collective group are more important than those of the individuals within that groups (Barnett 2006). From this perspective, human security can be considered a condition whereby individuals and communities have the options necessary to end, mitigate, or adapt to threats to their human, social, and environmental rights, and where they have the capacity and freedom to exercise these options (GECHS 1999).

The discourse on human security goes beyond its mere definition. As Gasper (2005, p. 228) argues, it "includes normative claims that what matters is the content of individuals' lives, including a reasonable degree of stability." It stands apart from other discourses (e.g., human needs and human development) by disaggregating down to the level of the individual, taking a human rights stance that the basic requirements of no individual are to be sacrificed. This reflects John Rawls (1971) theory of justice, and human security indeed has a strong link to notions of justice, equity, and fairness. But human security is also about freedom from threats and risks – risks that are increasingly likely to become global in their scale (Beck 1992)

Human security is a concept that links together different issues and allows one to look at power, politics, and the contextual factors that create insecurities. It is considered an emerging theme among international institutions, encompassing issues related to human development, human rights, and environmental sustainability (Gasper 2005). The discourse on human security has developed since the early 1990s, when the first Human Development Report was published by UNDP, with the explicit goal of putting people at the center of the development process. The notion of human security has been increasingly promoted as an integrative concept that focuses on both protection and empowerment. The Sen-Ogata Commission's 2003 report "Human Security Now" raised the visibility of human security, and the concept has been widely used in policy circles, particularly in the United Nations system, but also in the Human Security Network, which is made up of 14 countries that identify important themes or issues of concern that are linked to a human security agendas.

The promotion of human security is also closely linked to a "positive vision" of society that is encapsulated in notions such as well-being, quality of life, and human flourishing (Lister 2004). This positive vision has been elaborated through the capabilities approach, which emphasizes the freedom of people to choose among different ways of living, and to pursue opportunities to

achieve outcomes that they value (Sen 1999, p. 291). In viewing development as freedom, Sen draws attention to the notion of opportunities, and in particular focuses on the role of human beings as instruments of social change. Freedoms emphasize "both the *processes* that allow freedom of actions and decisions, and the actual *opportunities* that people have, given their personal and social circumstances" (Sen 1999, p. 17). Human security thus implies both protection from threats, and empowerment to respond to those threats in a positive manner.

The human security discourse recognizes that diverse worldviews and values exist, and presents an analytical tool for understanding outcomes of complex interactions (Commission on Human Security 2003). Below, we discuss two key dimensions to human security, both of which are relevant to climate change. The first is an equity dimension, and the second is a connectivity dimension. Understanding how these two dimensions relate to each other is essential to understanding the implications of climate change for human security in the 21st Century.

2.1 The Equity Dimension of Human Security

The equity dimension to human security focuses on the juxtaposition of both security and insecurity. Human insecurities are closely related to the deep social and economic inequities that exist among individuals and communities. It is often the case that one person's security is another's insecurity. In fact, exclusion, racism, sexism, religious intolerance, and prejudices of many types have often been justified in the name of human security. Gated houses, gated communities, and gated countries symbolize how some deal with notions of security and insecurity. Hunger, malnutrition, disease, and homelessness are powerful reminders of how insecurities remain unaddressed.

Equity is considered an important prerequisite for both social development and human security (O'Brien and Leichenko 2006; UN 2005; Dodds and Pipper 2005; Held and Kaya 2007). The concept of equity is associated with the freedom from bias or favoritism, and entails outcomes that are perceived as fair to all concerned. The idea of equity is often related to questions of justice and the notion that there should equal treatment for equal cases (Rawls 1971). Equity is a key component of movements for social justice, where the term "social justice" includes both fairness and equity in the distribution of economic, political, environmental and other types of outcomes (Rawls 1971; Boulding 1978; Smith 1994; Ikeme 2003). Equity also has a temporal dimension, such that outcomes future generations can be treated with the same consideration as outcomes in the present (O'Brien and Leichenko 2006). Recent economic research shows that, "ceteris paribus, the more egalitarian a society, the better its growth record and growth potential (Sanchez 2003, p. 1988). Relative income equality is also associated with greater social cohesiveness and a higher quality of democratic governance (Sanchez 2003; Held and Kaya 2007).

Climate change is among the most challenging issues facing society in the 21st century, and it is a process that both reinforces existing inequities, and creates new inequities. There is widespread recognition that the effects of climate change are likely to be highly uneven, with some individuals, households, communities, or regions experiencing significant negative effects, such as the loss of life and property due to climate extremes, the loss of agricultural productivity, increased water stress, damage to infrastructure from the melting of permafrost, and so on

(Adger 2004; Thomas 2005; Leichenko and O'Brien 2008). Others may experience only minor negative effects or may be able to successfully adapt to changing environmental conditions. Still others may experience net benefits, such as lower winter heating costs or an expansion of tourism due to warmer temperatures, a longer agricultural growing season, and increased forest productivity. It is becoming increasingly clear that there are going to be both winners and losers with climate change—at least in the short run—and that these are likely to change over time, depending on the rate and magnitude of climate change, and whether "catastrophic changes" occur. Catastrophic changes include changes in the thermohaline circulation, accelerated sea level rise, and other "tipping points" (Steffen et al. 2003; O'Brien and Leichenko 2003; Leichenko and O'Brien 2006).

If all humans were contributing equally to climate change, the emergence of winners and losers might be considered an inevitable outcome of human development (O'Brien and Leichenko, 2006). However, all humans are *not* contributing equally. The drivers of global environmental change—such as fossil fuel consumption, urban and coastal development, industrialization, deforestation, and other land use changes—are also inequitable and can be disproportionately attributed to some nations, regions, and social groups. In general, higher consumers of energy are making a more substantial contribution to climate change than are lower energy consumers. Moreover, all humans do not have an equal voice—or in some cases any form of representation—in key decisions about energy usage patterns, land use changes, industrial emissions, and so forth even though these decisions affect the integrity of the ecological systems on which all humans and all other species depend. Equity is thus at the heart of the climate change issue (O'Brien and Leichenko 2006; Parks and Roberts 2006; Roberts and Parks 2007)

Issues of equity are not simply about the drivers or economic impacts of climate change; they also depend on intangibles such as loss of cultural heritage or traditions. Equity issues may arise when climate change affects what some people value, whether it is cold conditions and snow, the presence of a particular species, or simply rain. In a world of varied values and beliefs, climate change will take on different meanings for different groups. Differing worldviews, captured by individualism, egalitarianism, materialism, fatalism, influence how people may respond to both the drivers and consequences of climate change (O'Riordon and Jordan 1999). When the things that people value contribute to their sense of well-being and security, their loss may be significant. Addressing inequities does not mean reducing diversity or limiting preferences, but emphasizing freedoms and capabilities (Sen 1999).

Although climate change raises a suite of equity-related issues, differential vulnerabilities to climate change are perhaps the most pressing issue from the standpoint of human security. The concept of vulnerability has been increasingly used to describe and assess the differential contexts that climate change will affect, as well as the uneven outcomes that will result. Vulnerability is typically defined as a function of exposure to climate change, sensitivity, and the capacity to respond to climate change (O'Brien at el 2004a). The most vulnerable are those who are highly exposed and sensitive to change *and* who have limited freedoms and capabilities to respond positively to change. Vulnerability to climate change is influenced by many other processes of change, including ongoing social and economic shocks and transformations linked to globalization, the spread of infectious diseases, conflict, and urbanization. In some cases, these changes are occurring faster than people, ecosystems, and institutions can successfully respond.

In other cases, these changes create tremendous opportunities and benefits. This results in increasingly divergent outcomes, and widening inequality. Although it is difficult to foresee who will be most vulnerable to climate change in the future, it is very likely to be closely related to the inequalities that are visible today, and a strong reflection of the contextual conditions that create these inequalities. Given that outcomes are increasingly linked across both space and time, the equity dimension of human security cannot be dissociated from what can be considered a connectivity dimension.

2.2 The Connectivity Dimension of Human Security

The "connectivity dimension" of human security is becoming more and more visible and important in a globalizing world characterized by transformative changes. This dimension emphasizes that humans are part of a larger "global system," with linkages between people and places that are reinforced and accentuated through large-scale processes of global environmental change and globalization (Leichenko and O'Brien 2008). Human security is intimately related to the state of the biosphere, atmosphere, cryosphere and oceans, a state that is increasingly threatened by human activities. Issues like ozone depletion, climate change, biodiversity loss, the spread of invasive species, and the collapse of fisheries, have impacts that are not simply local, but extend to larger populations. The connectivity dimension of human security recognizes that such processes and their outcomes are related across space and time.

The connectivity dimension also recognizes that global economic and social changes are increasing the linkages between people and places, whether through markets and trade, globalized commodity chains, transport and communication technology, migration, or travel and tourism (Leichenko and O'Brien 2008). Global processes intertwine the fates of people across the globe (Held and McGrew 2002), such that human security is increasingly about the security of not just individuals and communities in one place or time – but about a new and connected notion of human security. Climate change highlights the connective dimension of human security. Climate change is not a local pollution problem, but a global issue that emphasizes linkages among individuals and communities within a larger earth system. Greenhouse gas emissions in one place contribute to climatic changes in other places, and the livelihoods of individuals and communities are thus increasingly linked to the economic activities of others. Through the connective dimension, human security across the globe is affected by events and changes in specific locations, whether it is changes to the Greenland Ice Sheet affecting port areas in coastal cities, growing meat consumption in China affecting Brazilian soybean farmers, or growing dependencies in rural agricultural areas on remittances from migrants to large cities.

Global connectivities have critical implications for efforts to promote resilience to climate change. Resilience is typically defined as the ability of a system to respond and adapt to various types of change without long-term negative effects. Often considered to be the opposite of vulnerability, resilience entails characteristics that help individuals and communities to respond to change, whether in the form of shocks or long-term transformations (Walker and Salt 2006). Diversity is often an integral component of resilience, whether in relation to diversity of species, of human opportunity, or of economic options (Folke et al. 2002; Chapin et al. 2004). Diversity enables ecological and human systems to respond and adapt to all types of change. Many types

of diversity are currently threatened by processes of globalization. Globalization may, for example reduce cultural diversity, diversity of livelihood options, and diversity of agricultural varieties, among other things. This loss of diversity means that individuals and communities have fewer options for responding to the shocks and stresses associated with climate change. As a result global connectivities, the resilience of one individual or group is closely linked to changes in the larger system, both now and in the future.

3. Vulnerability to Multiple Stressors: Climate Change in Southern Africa

Across the globe, the conditions that either generate vulnerability or promote human security are influenced by what appears to be accelerating processes of social, political, economic, cultural, and environmental change (Leichenko and O'Brien 2008). Processes of change are often referred to in general terms, e.g., global environmental change, globalization, urbanization, transmission of infectious diseases, or institutional reforms. If processes lead to negative outcomes, they are often considered *stressors* that have the potential to reinforce or create vulnerability. If they lead to positive outcomes, they may be considered *opportunities* that may enhance human security. A human security approach to climate change focuses on both the stressors and opportunities that arise from multiple and interacting processes of change.

Whether a change or an outcome is perceived as a stressor or an opportunity depends on initial conditions and the capacity to respond to stresses or grasp opportunities, both of which are shaped by multiple processes of change. Human capabilities are an important factor in determining outcomes from interacting processes of change. At the same time, the outcomes of interacting processes of change are also influenced by political, economic, social, cultural, religious and environmental factors that have both historical and contemporary roots. These factors generate conditions of marginalization, disempowerment, and impoverishment for some, while also generating enrichment and entitlement for others. The differential outcomes from global change may also perpetuate or enhance existing inequalities. Furthermore, power struggles aimed at influencing outcomes or controlling responses may lead to conflicts, which can be seen as stressors or opportunities, depending on the perspective.

Many processes of change are considered negative and undesirable, particularly if the rate and magnitude of change is rapid. Climate change is often considered a stressor, in that it leads to outcomes that decrease human security, including loss of lives or livelihoods, or decreased availability of food and water. As a *stressor*, climate change can manifest in a number of ways, creating different types of *stress*, such drought, salinization of soils, or increased climate variability and uncertainty. Shocks (floods, storm surges, or pest outbreaks) are a specific type of stress that tends to arise unexpectedly, often with a more violent impact (de Haan 2000). Each of these stresses triggers a series of responses, leading to either positive or negative outcomes. It is important to emphasize that climate change and responses to climate change may lead to positive outcomes for some. Nonetheless, climate change often interacts with existing vulnerabilities, and may compound poverty for many (Eriksen et al. 2007). In the example of Southern Africa, we draw attention to both the challenges and opportunities that may emerge from multiple and overlapping processes of change. We show that climate change will have different consequences

and meanings for individuals and communities in southern Africa, which may enhance existing inequities.

3.1 Southern Africa case study

Southern Africa[1] is a region that is increasingly seen to be characterized by chronic poverty and high vulnerability (CPRC 2004; WRC 2006). In this region, vulnerability is continually generated and reinforced by interacting processes of change, whereas opportunities are often difficult to realize due to institutional and governance failures, delinkages between economic and social policies, the weakening or removal of social safety nets, and the disadvantaged role of the region in the international political economy (Mills 2002). Researchers and practitioners working on environment, development, and health issues in urban and rural communities in southern Africa are paying growing attention to the intersections and interactions among multiple stressors, and how they shape vulnerability and influence human security (Mgquba, S.K. and Vogel 2004; Gregory et al. 2005; Meadows 2006; Reid and Vogel 2006; Ziervogel et al. 2006c). They have also been keenly aware of the new opportunities that arise from change, including how the ability to grasp these opportunities is conditioned by the outcomes of multiple and interacting processes of change.

3.1.1 Climate Variability and Change in Southern Africa

As a semiarid tropical region, southern Africa is among the most drought-vulnerable regions in the world (Hulme 1996; Dilley 2000). In this region, inter- and intra-annual variability of rainfall are considered key climatic elements that determine the success of agriculture, particularly for small-scale farmers practicing rainfed cultivation (Tadross et al. 2005; Sivakumar 1998). With regard to future climate change, the dominant physical effects of climate change in southern Africa will include changes in biodiversity and biome distributions and altered water balances, the latter of which will change hydrological regimes and influence agricultural productivity (Hulme 1996; Downing et al. 1997; Desanker and Magadza 2001). Temperatures are projected to increase across southern Africa, influencing water availability, plant growth and the length of the growing season. Importantly, the frequency distributions of temperature and rainfall may change as a result of climate change, influencing climate variability and the intensity of extreme events. This may lead to more severe droughts or flooding, depending on the timing and distribution of rainfall.

The potential implications of climate change for agriculture is of particular concern in southern Africa, where agriculture plays a predominant role in the lives of 75 percent of the population (Leichenko and O'Brien 2002; Vogel 2005; Meadows 2006). However, the region is heterogeneous, and the agricultural share of employment varies substantially by country. In Tanzania, Mozambique, and Malawi, for example, more than 80 percent of the population is employed in agriculture, in contrast to South Africa and Mauritius, where less than 20 percent of the population is dependent on agriculture. The majority of southern Africa's farmers rely on traditional agricultural methods, in contrast to a minority involved in high-input commercial

[1] We define southern Africa as including fourteen member countries of the Southern African Development Community (SADC): Angola, Botswana, Democratic Republic of Congo, Lesotho, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Tanzania, Zambia, and Zimbabwe.

farming. Furthermore, vulnerability to climate change varies greatly between regions, sectors and social groups in southern Africa (Downing et al. 1997; Gregory et al. 2005; Kurukulasuriya 2006; Meadows 2006). Within this region, drought-prone areas of Namibia, Botswana and Zimbabwe are likely to be more vulnerable to climate change than the more humid areas of Tanzania or Zambia (Low 2005). For the region as a whole, net productivity reductions of 10 percent are more are possible in the case of maize and other major crops, such as sugar cane, and wheat (Jones and Thornton 2003; Meadows 2006). In some areas, commercial ranching may marginally improve as the result of increased rainfall, whereas communal ranching might be disadvantaged because of increased erosion and the incursion of woody weeds (Hulme 1996). However, current patterns of vulnerability are also being reshaped as many other changes, which together are altering the conditions for agricultural production in southern Africa.

3.1.2 Multiple Stressors in Southern Africa

In addition to climate change, southern Africa is experiencing a wide range of other economic, political and social changes, each of which may represent stressors to individuals and communities who have limited capacity to respond (O'Brien et al. 2000; O'Brien and Vogel 2001; Leichenko and O'Brien 2002; Misselhorn 2005; Vogel 2005; Ziervogel et al. 2006c). In this section, we highlight two of these stressors, including the spread of infectious diseases and economic changes, and show that they influence vulnerability to climate change.

Infectious Diseases. The spread of HIV/AIDS and other infectious diseases represents a key is stressor that is having a profound affect throughout southern Africa. Across southern Africa, rates of HIV/AIDS are among the highest in the world, exceeding 15 percent of the adult population in most countries of the region (UNAIDS 2006).[2] AIDS rates are often higher in areas near major cities and along major transport corridors, and links have been made between HIV/AIDS and globalization processes (Poku 2007). Nonetheless, high rates of rural-urban migration, rural-urban circulation, and return migration facilitate the spread of HIV to rural regions (Harpham and Grant, 2002). As a result of HIV/AIDS, life expectancy has decreased in most southern African countries. The effects of HIV/AIDS extend far beyond those individuals who become infected, also influencing families, co-workers, businesses, communities, and health care systems (O'Brien et al. submitted; Booysen et al., 2002; Floyd et al., 2003; Mushati et al., 2003). For areas dependent on agriculture, the effects of HIV/AIDS are particular devastating. As discussed by Eriksen et al (2003):

> "HIV/AIDS makes people too weak to carry out the hard physical labor demanded by agriculture, such as planting and harvesting. The illness and death of parents causes dramatic upheaval in the family as a social and production unit. It is often people in their prime productive years and with the most education that are hit, leaving grandparents and other relatives to take care of orphaned children. The extent of this epidemic….has become so great that traditional survival mechanisms in some families are to some extent breaking down."

[2] While AIDS rates are stable or increasing in many countries in southern Africa, it important to note that AIDS rates have shown a marked decline in Zimbabwe (UNAIDS 2006).

Health is impaired by poverty and inequality and, as argued by MacLean (2007), the burden of health is greater for poor people and poor countries. The devastating effects of HIV/AIDS are exacerbated by poor public health care systems and by the spread of other diseases that are endemic to the region, particularly malaria (DaSilva et al. 2004). Food insecurity and poor nutrition likewise exacerbate the effects of infectious diseases (Drinkwater 2005). While the effects of climate change on rates of HIV/AIDS and other diseases remain uncertain (Meadows 2006), many other societal changes are influencing both infection rates and the burden of disease. As McMichael (2004) notes, "The contemporary spread and increased ability of various infectious diseases, new and old, reflects the combined impacts of demographic, environmental, behavioural, technological and other rapid changes in human ecology." Recent research suggests that higher temperatures may mean that previously unsuitable areas will become suitable for transmission of vector borne diseases such as malaria (Ebi 2005). Through its influence on health and livelihoods, infectious diseases reduce the capacity to cope with and adapt to shocks and stressors linked to climate change. These connections are evidenced in a growing body of literature that shows increasing levels of impoverishment among HIV/AIDS affected households (Booysen et al., 2002; Floyd et al., 2003; Mushati et al., 2003; O'Brien et al. submitted). The exacerbating effects of the HIV/AIDS pandemic on drought and the subsequent distribution of food aid in Swaziland were described by de Waal and Whiteside (2003) as a 'new variant famine'.

Examining the dynamics of vulnerability among rural households in Zambia, Malawi, and South Africa, Ziervogel et al. (2006a) found that different households experienced different stresses to be the most important. While the purpose of the study was to identify how individuals and households respond to stress when household members are faced with chronic illnesses such as HIV/AIDS, climate was seen as an important stress among households, particularly in Malawi and South Africa. Nonetheless, lack of labor due to poor health was considered to exacerbate vulnerability. It also became evident that higher rates of illness and death due to HIV/AIDS have put a strain on the extended family and community relations as the 'traditional' means to mitigate shocks to individual families. It is, however, the increasing cost of traveling to care for sick relatives and friends and to attend funerals that is the underlying threat to people's ability to meet social obligations (Ziervogel et al. 2006a). In another study in South Africa, Ziervogel et al. (2006b, p. 7) found that the consequences of HIV/AIDS had implications for how climate variability and water stress are experienced, and that "households that have lost members and those that have few resources, might be unable to cope with small shocks."

Yet this research also show that human capabilities are important, and that youth and good education are important factors in promoting resilience. Social networks and community gatherings, which include home-based care groups, religious gatherings, and credit schemes, can contribute to resilience in the face of multiple stressors (Ziervogel et al. 2006a). The results emphasize that, in spite of multiple stressors, people manage their lives, perhaps in part due to the existence of a culture of caring for the needy, including the orphans, elderly, and infirm. Ziervogel et al. (2006c) emphasize the importance of considering community needs, which involves finding out what people want to know and change, then drawing upon their capabilities to access information and support to create the desired changes. The research also supports the need for integrated policy responses that support people, organizations, and institutions that are

addressing issues of vulnerability and resilience in the face of multiple stressors (Ziervogel et al. 2006b).

Economic Changes. While is often the lack of economic globalization that receives attention in southern Africa (Castells 1998; Mittleman 1994), many countries in this region have made significant progress in their efforts to promote international trade and to open their doors to foreign investment (Leichenko and O'Brien 2002). Because agriculture is a key activity in southern Africa, the effects of changing economic policies are felt profoundly within this sector. Potential agricultural impacts of a shift toward greater export-orientation in southern Africa include shifts in cultivation patterns toward cash-crop exports, improved access to advanced technologies including drought-resistant seeds, and better access to credit for some farmers. In terms of effects on specific types of farmers, agricultural export promotion efforts are argued to be beneficial for poorer, subsistence-oriented farmers in particular because rising exports will increase incomes by fostering production and sales of cash crops in many regions (Jacques 1997). Yet increased involvement in the international economy may also leave some farmers vulnerable to fluctuating world prices and changing terms of trade. Small-scale farmers in particular may lack access to agricultural credit, fertilizers, alternative seeds, and other factors indispensable for succeeding in international agricultural markets (Leichenko and O'Brien 2002).

In addition to efforts by individual nations to promote trade and investment, there are also a number of ongoing efforts aimed at regional economic integration across the countries of southern Africa. These include formation of the Southern African Customs Union (SACU), the SADC Trade Agreement, the Common Monetary Area, and the Common Market for Eastern and Southern Africa (COMESA). The general aims of these various initiatives are to increase intra-regional trade throughout southern Africa and to foster economies of scale in production that would increase the global competitiveness of the southern African region. In 2001, a New Partnership for Africa's Development (NEPAD) was established as an Africa-wide framework for economic development. In conjunction with these institutional trading arrangements, a number of regional industrial collaborations have also occurred. Noteworthy examples from the agricultural sectors include the citrus industry across Zimbabwe, South Africa, Swaziland, and Mozambique and the cut-flower industry across Malawi, South Africa, Zambia, and Zimbabwe (Sidaway and Gibb 1998; Dixie 1999; Malter et al. 1999).

Concurrent with the above changes, many countries in southern Africa are implementing national-level economic policy changes in response to Poverty Reduction Strategy Papers (PRSPs), which "describe a country's macroeconomic, structural and social policies and programs to promote growth and reduce poverty, as well as associated external financing needs" (World Bank 2007). Considered as follow-ups to structural adjustment programs, PRSPs have been criticized for applying conditionality to debt relief and for promoting neoliberal policies that do not address the key causes of poverty (Gould 2006). PRSPs carried out for Lesotho, Madagascar, Malawi, Mozambique, Tanzania, and Zambia have pointed to concerns about the pace, manner, and circumstances in which privatization and trade liberalization have been carried out, while at the same time recognizing that they also create opportunities for others (Tanzania 2005). PRSPs also recognize that cross-cutting issues such as gender HIV/AIDS, environment,

rural development, and natural disasters contribute to poverty, and that they must be addressed through well-integrated action (see Mozambique 2006)

In considering climate change vulnerability in southern Africa in the context of economic changes, it is important to emphasize that the effects of all types of change are unevenly distributed, both between and within countries (Leichenko and O'Brien 2008; O'Brien and Leichenko 2003). Local-scale vulnerability to multiple stresses can be illustrated though the work of Eriksen and Silva (2007) in Mozambique. This study explored coping strategies of small farmers in response to drought in two villages, Massavasse and Matidze, in the Limpopo River Valley in Mozambique. Exposure to market liberalization differs between the two villages: farmers in Massavasse are relatively well-integrated into regional and international markets for agricultural products, while farmers in Matidze are more reliant on subsistence agriculture and sales to local markets. These differences in degree of exposure to liberalization were found to play an important role in influencing vulnerability to the 2001-2003 drought that occurred in this region. Greater market integration in Massavasse benefited smallholders who were able to obtain employment as casual laborers on commercial farms during periods of drought. By contrast, smallholders in the less integrated village had few response options and were forced to rely on highly labor-intensive, marginal activities such as making and selling charcoal. It also important to note that the effects of globalization on drought response options vary among different types of farmers within Massavasse. Eriksen (2004) observes that larger and more capital-rich, commercial farmers were able to profit from the drought because they were able to pump water from the regional irrigation scheme and to utilize their own means of transport (trucks) to deliver products to urban markets, where they were able to command relatively higher prices for their produce. Overall, the findings of this study suggest that differential exposure to liberalization may be exacerbating inequalities both across villages and across different types of farmers within Mozambique (Silva 2007).

The linkages between multiple stressors and climate vulnerability are also illustrated by the work of Gandure (2005) in Zimbabwe. This study investigated the extent to which factors including unequal distribution and access to markets, power structures and breakdown of social networks generate vulnerability in two villages with varied climate and biophysical conditions in Zimbabwe. The first village, Matema, was located in a high rainfall area, while the second village, Tjaheta, was located in a low rainfall area. Using a combination of methods to assess and evaluate vulnerability, Gandure (2005) showed that Tjaheta village is more vulnerable to climate events because of poor infrastructure, lack of markets, limited institutional support, and a poor and deteriorating biophysical environment. Documenting the role of external interventions of food aid by NGOs in Tjaheta during times of crisis, the study emphasized that interventions do not represent long-term responses to vulnerability. Matema village was found to be less vulnerable because it has a developed infrastructure and developed markets. Nevertheless, differential vulnerability was evident within Matema, as some had greater access to resources, including power, as well as good health. In the case of Zimbabwe (Gandure 2005), those who have the capital and resources have seized opportunities to generate resilience.

Closely related to the economic changes described above are efforts to promote privatization. In particular, the privatization of water is influencing vulnerability to climate change in southern Africa (Leichenko and O'Brien 2008). For example, a number of cities and towns in South

Africa have recently privatized water supplies (McDonald and Ruiters 2005). This marketization process means that water is no longer supplied as a free or nominally priced public good, but instead follows market prices. When water supply decreases, as during years of drought, prices can potentially increase to ensure full recovery cost for infrastructure and service delivery. There is sometimes a tension between water pricing and cost recovery practices and the language of rights and social equity (McInnes 2005; Funke et al. 2007). Although the constitutional reform of 1996-1997 in South Africa recognized socio-economic rights, including guaranteed access to sufficient food and water (Jones and Stokke 2005, Conca 2006), the contextual environment in South Africa is characterized by deeply entrenched social and economic inequality (a legacy of apartheid) and limited political representation for many groups. Not surprisingly, poor residents who have been most negatively affected by water privatization are also significantly affected by lack of available water supplies as the result of overpumping, pollution, and drought. These inequities in the ability to pay for water may become more pronounced under future climate change, as surface water supplies are projected to decrease significantly with climate change, particularly in the Western Cape region of South Africa (de Wit and Stankiewicz 2006).

While privatization of water services may compound vulnerability and generate new inequities, there is a role for demand-side management of water resources in the face of climate change. A study carried out in the Northern Cape province of South Africa shows that water restrictions have been implemented as a means of curbing water demand in towns such as Carnavon (Kareeberg) and Calvinia (Hantam), through rising block tariffs or restrictions on watering domestic gardens. Tariff mechanisms designed along the principle of "the more you use, the more you pay" have been implemented in the city of Cape Town, in an effort to curb excessive water use in response to drought conditions in 2003 and 2004 (Mukheibir and Sparks 2005). While this represent an effective response to climate change, other research has noted that "water scarcity is considered to be the result of a combination of insufficient and highly variable rainfall conditions, issues of equitable water resource management, and the absence of drinking water, bulk water and irrigation infrastructure that would enable the distribution of water to all rural villages and hospitals" (Ziervogel et al. 2006b). It is not simply the supply and demand for water that will determine climate change vulnerability, but also the distribution and access to water.

3.2 Summary

The context in which climate change occurs matters, and this context is influenced by multiple, interacting factors. These interactions are highly visible in southern Africa, but by no means limited to this region. In fact, as discussed in Box 1, individuals and communities throughout the world are experiencing multiple stressors that can enhance vulnerability to climate variability and change, such that even a small degree of climate change, a small change in variability, or a small increase in uncertainty can have large consequences. While we focused on the spread of infectious disease and economic changes, it is important to note that there are other stressors within southern African, including political conflict and instability. For example, recent events in Zimbabwe illustrate how a non-accountable and repressive government can disrupt an agricultural economy and contribute to climate change vulnerability. In contrast, the termination of conflict in Angola may make it easier to cope with and adapt to climate variability and change, particularly if reconstruction and rehabilitation efforts are targeted at health, education, and the needs of children—a group that was particularly vulnerable to conflict (Clover 2002).

Vulnerability to climate change is influenced by multiple processes of change, and multiple stressors may mean that small changes in climate create significant consequences for human security. Although climate change negotiations aimed at reducing greenhouse gas emissions have focused on avoidance of dangerous anthropogenic interference with the climate system, as outlined in UN Framework Convention on Climate Change, vulnerability research shows that dangerous climate change depends very much on the context in which the change occurs (Lorenzoni et al. 2005). This context may be best captured by vulnerability indicators that emphasize the dynamics of interacting processes, such as changes in health status, access to information and education, or the presence and quality of social and community networks (Leichenko and O'Brien 2002). An emphasis on human capabilities and human security draws attention to the differential consequences of climate change for individuals and communities resulting first and foremost from disparities in human development.

Box 1. Multiple Stessors in Mexican Agriculture: Climatic Risks and Market Volatility

The influence of multiple stressors on agricultural vulnerability is illustrated by the research of Hallie Eakin in Mexico. Eakin (2003, 2005, 2006) describes how farmers in three communities in Central Mexico cope with changes in climate variability, at the same time that institutional changes have transformed the context for agriculture in Mexico through NAFTA and accompanying neoliberal policies. The three communities differ in their access to markets, irrigation, and alternative sources of livelihoods, as the result of both locational and historical factors. The farmers in the village of Jesús Nazareno in the state of Puebla, and in the ejido the ejido Plan de Ayala and the village Los Torres in Tlaxcala, can all be considered highly vulnerable to climate variability for a number of reasons, including lack of irrigation, fertilizers, electricity, education, credit, and tractors. But their vulnerability is not linked to climate alone – it is also linked to broader global changes in the agricultural sector, as well as Mexican agricultural policies. International agricultural markets influence the viability of agriculture, as much as the presence or absence of frosts, floods, droughts. Vulnerability is thus compounded and complicated by increasing linkages to global markets and prices, changing production costs in other places, new economic opportunities, and international migration.Market volatility and uncertainty has played an important role in generating vulnerability for even those farmers with access to irrigation, including those who produce vegetables for the markets of southeastern Mexico. When farmers in high-volume vegetable-producing regions of Mexico could not export their produce to the United States, they turned to domestic markets, driving down prices for producers of lower-quality products who operate with smaller volumes. Furthermore, farmers in Eakin's study (2006, p. 150) emphasized that their production costs were becoming increasingly unviable in the face of the rising prices of imported inputs in Mexico's liberalized markets: "The farmers noted that the price of seed, pesticides, and fertilizers fluctuated with international exchange rates for the U.S. dollar, causing significant uncertainty in their estimations of their investment requirements." One-quarter of the households surveyed by Eakin in the community

of Nazareno reported plowing under the crop in at least one field each year because the prevailing market price did not justify the cost of harvesting. Thus even for irrigated farming, Eakin (2006, p. 155) found that "within the constraints of seasonal climatic variability and perceived market opportunity, households face significant financial obstacles to pursuing a consistent commercial production strategy."

Eakin's research shows that not all farmers in the three communities included in her study are equally able to cope with a changing climate, which raises some important equity dimensions of climate change. She shows that globalization-related price volatility and market uncertainty interact with climatic risks to affect livelihood strategies. Eakin stresses the importance of income diversification and the role of nonfarm income as part of agricultural adaptations to climate variability and change, yet warns that "buying farm households out of agriculture [through land sales facilitated by the government's land titling program] without viable livelihood alternatives to sustain them may only increase economic marginalization, reproducing the chaos of urban poverty that has characterized Mexico's border cities" (Eakin 2006, p. 186). One lesson from her research is that policy decisions to support a narrow definition of commercially viable farmers have significant welfare consequences for those who are, by definition, excluded. Climate change and market volatility together may threaten the security of farmers and agricultural communities.

4. Adapting to Climate Change in a Globalizing Context: A Growing Role for Institutional Support

Economic and social institutions play a critical role in facilitating or hindering adaptation to climate change. Yet it countries and regions throughout the world, these institutions are undergoing dramatic changes as the result of globalization. Globalization is often understood as a movement toward greater economic, political and cultural integration across nations (Held et al. 1999; Sklair 2002; Dicken 2007). Globalization is also frequently associated with adoption of neoliberal policies advocating free market approaches to economic activity (Leichenko and O'Brien 2008). Neoliberalism represents an ideology that emphasizes growth, productivity and market efficiency. The ideology, in turn, affects policy choices and decisions at all levels, from international forums to promote free trade such as the World Trade Organization (WTO), to national and sub-national efforts to attract foreign direct investment, privatize state-owned enterprises, and to regional and local measures promoting decentralization of state political power and local capacity building (Peck and Tickell 2002; Leichenko and Solecki 2005; Leichenko and O'Brien 2008). As we show in this section, institutional changes associated with globalization are dramatically altering the context through which individuals and communities will experience and adapt to changing climatic conditions.

The effects of institutional changes are especially apparent in the agricultural sector where various policy measures may facilitate or hinder adaptation to climate change (Leichenko and O'Brien 2002; 2008). Agricultural trade liberalization, for example, may provide easier access to agricultural inputs, foster shifts in agricultural production in response to changing biophysical

conditions, and allow those regions that lose productive capacity to benefit from cheap imported grains. Yet globalization-related institutional changes may also perpetuate or exacerbate agricultural vulnerability, particularly for small farmers in poor countries. Indeed, reductions in agricultural subsidies or elimination of crop insurance may make it more difficult for some farmers to adapt and respond to the extreme climatic events and other uncertainties associated with climate change. While it is clear that vulnerability to climate change is shaped by multiple stressors, the potential for social and economic policies and institutional changes to increase vulnerability or promote resilience must also be recognized.

Situating vulnerability to climate change within the context of globalization is also critical to understanding the implications for human security. In the case study below, we show how economic and social policies linked to globalization have influenced the vulnerability of the agricultural sector to climate change in India. A district-level mapping of social factors that influence adaptive capacity suggests that adaptive capacity is highly variable across India and with many hot spots of vulnerability. Case studies in several villages show that the role of infrastructure and access to markets is critical to the capacity of individuals and communities to respond to climate change.

4.1 Indian Agriculture in a Changing Context

As is the case in southern Africa, the agricultural sector dominates the economy of India. Among a population of over 1 billion people, more than 60 percent are directly or indirectly involved in the agricultural sector. Because the majority of Indian agriculture is rainfed, climatic changes that alter temperature and precipitation patterns may pose serious threats to agricultural production. However, economic changes associated with globalization are also having a substantial impact on the agricultural sector.

The effects of climate change on Indian agriculture are likely to vary across different regions of India and among different types of farmers (Kumar and Parikh 2002; O'Brien et al. 2004a). Scenarios generated by general circulation models show that some parts of India could experience warmer and wetter conditions under climate change, including an increase in the frequency and intensity of heavy rains, while other regions may experience net reductions their water balance due to higher rates of evapotranspiration (Watson et al. 1996). Inland agricultural regions, in particular, including Gujarat, Maharashtra Madhya Pradesh are expected to be among the most negatively affected by climate change (O'Brien at al 2004). While wheat-producing regions including Punjab and Haryana may also be negatively affected, the projected impacts are not expected to be as pronounced (Luo and Lin 1999). Furthermore, adaptation strategies, including increased irrigation and fertilizer use, are likely to be more accessible to farmers in these highly productive regions than in other areas.

While climatic change may increase the physical vulnerability of Indian farmers, ongoing economic reforms may expose other types of vulnerabilities. The reform process, which began in 1991 in response to a balance of payments crisis, has involved deregulation of the domestic economy, liberalization of international investment and trade policies, and implementation of fiscal stabilization policies. Deregulation and privatization have been key features of economic reforms in India. As a result, many segments of the public sector have been privatized over the

past decade. Foreign investment has also been welcomed in India as part of the economic reforms, in sharp contrast to earlier policies that restricted investment. As a result, total foreign direct investment (FDI) increased dramatically, jumping from $150 million in 1990/91 to $4.8 billion in 1993/94 (UNIDO 1995). The cumulative FDI flow into India from 1991 to 2007 is estimated at over US$50 billion, with the majority directed towards the electronics, services, telecommunications and transport sectors (Indian Ministry of Commerce and Industry 2007). The Indian government has also introduced significant unilateral trade reforms, with both tariffs and non-tariff barriers being reduced. For example, between 1991 and 1994, the minimum tariff rate was reduced from 250 percent to 65 percent (UNIDO 1995). Within India's agricultural sector, the main rationale for economic reforms in India has been to remove distortions and create an appropriate incentive structure for increasing agricultural production (Bhalla 1994, 1995; Gulati and Kelley 1999; Rajan and Sen 2002). Yet for most agricultural producers in India, the full effects of economic reform are yet to be felt. Although some crops such as oilseeds have been fully liberalized, other crops such as rice, wheat, and sugar remain subject to many barriers to internal and external trade, procurement policies, and implicit and explicit subsidies.

Other facets of India's reform program also affect India's agricultural sectors. Bhalla (1994) notes that a reduced role for the public sector and limited planning, combined with fiscal compression, could result in significant reductions in public investments in agriculture. As with climate change, the effects of these and other reforms are also likely to vary across regions in India (O'Brien et al 2004). With respect to, for example, infrastructure provision, India's regional disparities in agricultural productivity and growth have been partially traced to differences in levels of public investment in agriculture, particularly via funding for irrigation technologies and rural credit programs (Rao 1994b; Datt and Ravallion 1998; Gulati and Kelley 1999). In areas where these investments in agricultural infrastructure, have lagged, such as Maharashtra and Madhya Pradesh, rates of growth in agricultural productivity and poverty reduction have also lagged (Datt and Ravillion 1998). Should economic reforms result in significant reductions in public infrastructure, India's less-developed regions may have little chance to "catch up" with relatively better-off regions; climate change may further exacerbate these regional differentials, because regions with limited irrigation infrastructure are also the areas where agriculture is most vulnerable to climate variability and change (Rao 1994a). Below we consider how the climate vulnerability of agricultural districts and has been influenced by on-going economic changes associated with globalization.

4.2. Vulnerability in Indian Agricultural Districts

As in southern Africa, the ability to respond and adapt to climate change is highly variable across agricultural regions in India. A widely used approach to capturing these types of differentials is via the construction of vulnerability maps. Such maps reveal spatial patterns of vulnerability and allow identification of vulnerability hotspots (O'Brien et al. 2004). Figure 1 illustrates vulnerability mapping through presentation of a composite index of social vulnerability to climate change across districts in India in 2001. Social vulnerability, which is based on factors such as literacy rates, gender equity and economic opportunities, provides an indicator of a district's resilience and capacity to adapt to climate change and other types of stresses. Those areas with higher degrees of social vulnerability including portions of northern, central and southern India are likely to have more limited capacity to adapt to climate change. Areas with

lower levels of social vulnerability including northwestern India and the Gangenic plain are be expected to have a greater capacity to adapt to climate change.

[Insert Figure 1. Social Vulnerability in Indian Agricultural Districts]

While vulnerability maps offer general guidance regarding those areas that may need additional attention from policymakers at the national level, local-level case studies for specific districts enable identification of state and local-level institutions and policies that influence coping and adaptation strategies used by farmers in specific areas. Here we discuss how three different districts in India are being affected by both climatic change and economic changes associated with globalization (see O'Brien et al. 2004). These districts, which include Jhalawar, Anantapur, and Chitradurga, are each faced with different types of institutional challenges in conjunction with both processes of global change.

Jhalawar district is located in the northwestern state of Rajasthan, The climate of this district is semi-arid area, with an average of 943 mm of rainfall annually. The district may become dryer and hotter under climate change (O'Brien et al. 2004). The district has also recently experienced a multi-year drought, which as particularly devastating to the majority farmers who lack access to irrigation. Such drought events may become more frequent and more severe under climate change. In addition to climate change, the district is also undergoing significant economic changes. Over the past decade or so many farmers in Jhalawar have shifted from traditional crops, such as sorghum and pearl millet, to the production of soybeans. Soybeans are seen as more desirable crops due higher market prices under liberalized trade. Yet because soybean prices also fluctuate according to world markets, this shift has made these farmers more vulnerable to external market price shocks. Furthermore, institutional credit for agriculture in Rajasthan has become less available after structural adjustment, and many farmers must obtain loans from private moneylenders at interest rates that may run as high as 36%. Paying back these loans has become difficult when both yields and market prices have been low. The lack of investment in infrastructure, education, and health emerged as significant factors influencing coping and adaptation strategies in communities in Jhalawar. While the case of Jhalawar reveals the continuing need for state credit supports and other types of investments and subsidies to help farmers adapt to increased uncertainty under both climate change and trade liberalization (O'Brien et al. 2004), local initiatives in other farming areas of Rajasthan have, with the support of NGOs, promoted water harvesting and conservation techniques that can potentially reduce the impacts of drought (Chatterjee et al. 2005; Narain et al. 2005).

Anantapur district, located in Andhra Pradesh is another drought-prone area that can be considered "double exposed" to both climate change and globalization (O'Brien et al 2004; Leichenko and O'Brien 2008). Groundnut is the principal crop grown in Anantapur, and farmers in the region have faced persistent crises due to growing import competition, stagnating market prices, and lengthy droughts. These crises have contributed to a rash of debt-related farmer suicides in the region over the past decade. Farmers in Anantapur have been unable to respond to price stagnation and drought by shifting to production of more alternative, drought-tolerant, and economically viable crops, in part because local institutional and barriers have made these

options unprofitable. Alternative rainfed crops which could be economically viable, such as different fruit varieties, either require too much capital, or do not have a long enough shelf life to be marketable under current circumstances. State and local institutional support for crop storage and transport infrastructure and provision of irrigation or water harvesting systems would be among the steps necessary in order to make farmers in the region less vulnerable to both climate change and trade liberalization (O'Brien et al 2004).

Chitradurga district, which is located next to Anantapur but is part of the state of Karnataka, is also highly subject to drought. Yet farmers in the district tend to be less vulnerable to climate change due to greater access to irrigation. Irrigation access has also allowed farmers to take advantage of economic opportunities associated with globalization. Many farmers in this district have also been encouraged through state government and private initiatives to cultivate alternatives to groundnuts, including crops such as areca-nut, pomegranate, and banana. In recent years, export companies have also entered into buy-back contracts with farmers for production of crops such as gherkins, which are aimed at European markets. These various initiatives have been supported by state and local government subsidies ranging from provision of drip irrigation and provision of formal bank credit, to support for crop insurance, have made these alternatives affordable to farmers in Chitradurga (O'Brien et al. 2004). As the result of these types of government financial and institutional supports, a wider range of adaptation strategies are available to farmers in Chitradurga, as compared with Jhalawar or Anantapur. Yet is important to emphasize that it is the larger farmers in Chitradurga who often tend to benefit more from government supports, particularly the promotion of increased access to international markets. Smaller farmers, by contrast, are sometimes disadvantaged due to lack of information and dependence on local merchants for credit. It is also important to recognize that the district's increasing reliance on irrigation may not be sustainable if water availability is reduced due to climate change (O'Brien et al. 2004).

4.3. Summary

Globalization processes are affecting vulnerability to climate change in agricultural regions throughout the world. In some cases, globalization may create opportunities for farmers to respond positively to climate change via shifts in production patterns in response to new export markets (e.g., shade-tolerant organic coffee) or through reductions in the costs of agricultural inputs due to increased price competition among input providers. Livelihood diversification attributable to globalization (e.g., new jobs in industry and service sectors) may also reduce the impacts of climate variability and change on households and communities. In other cases, globalization is constraining farmer response to climate change by reducing crop subsidies, lowering prices for import-competing crops, or introducing new competition from distant locations. Yet adaptation to globalization and climate change at the local level requires more than just changes by agricultural producers; it also requires flexibility on the part of local and state institutions. As demonstrated in the case of India, institutional supports – both governmental and non-governmental – for infrastructure and marketing are vital to ensure that both large and small farmers are able to adapt to climatic change. In the cases of Jhalawar and Anantapur, lack of credit, infrastructure, and other institutional barriers left farmers poorly equipped to adapt to either of the stressors, let alone both simultaneously. In Chitradurga, on the other hand, institutional support appears to facilitate adaptation to both climatic change and trade

liberalization (O'Brien et al. 2004; Leichenko and O'Brien 2008). The larger lesson from India is that institutional factors will play a decisive role in promoting adaptation and resilience to climate change for all types of farmers.

Box 2. The role of changing economic and social policies in climate change adaptation: The Case of Vietnam

The critical role of economic and social policies in influencing climate change adaptation may be illustrated through the work of Neil Adger (1999, 2000) on climate change, coastal flooding and institutional changes in Vietnam. Coastal flooding as the result of typhoon-related storm surges is a continuous threat along Vietnam's 3000 km coastline. Under climate change, coastal flooding hazards are expected to worsen as a result sea level rise and an increase in frequency and magnitude of typhoons. Because coastal flooding is a "normal" risk in Vietnam, various institutions have evolved to help reduce risk and enhance response capacity. These institutions range from formal district and commune-level governments to informal arrangements and reciprocal networks. The flood control activities of these formal institutions are typically funded via local taxes and may include supervision of work brigades to maintain flood walls and dike systems, and the large-scale mobilization of labor and resources following a flood event. The informal arrangements typically entail social reciprocity between neighboring communes for flood protection. These institutional arrangements, which are supported by norms and worldviews that have entailed expectations of community participation in flood wall maintenance and related activities, represent a critical part of the contextual conditions that influence exposure to coastal flood hazards (Adger 2000).

These institutions have been transformed by globalization. Under globalization, some facets of this institutional context, especially formal state institutions, are rapidly changing. Since the early 1990s, Vietnam has undergone a series of economic and political shifts that signaled a transition away from a centralized, state-planned economy toward a market-oriented economy. These changes, which include reform of land tenure practices toward private ownership of land and reductions in public expenditure for flood control, are altering the formal institutional context affecting both exposure and responses to existing coastal flood hazards. At the same time, however other facets of the institutional context, particularly worldviews that are influenced by prior communist history and cultural norms and entail an expectation that higher-level authorities will take responsibility for protecting communities from flood hazards are much slower to change. This combination of rapid, globalization-related institutional changes and lack of change in worldviews is exacerbating vulnerability to current and future, climate-change related flood hazards. Exposure to globalization is thus changing the contextual conditions that will affect future exposure, outcomes and response to climate change (Leichenko and O'Brien 2008).

5. Linkages and Connectivities: The Vulnerability of Coastal Megacities

The connectivity dimension of human security emphasizes that actions and events that occur in one location increasingly influence human security in other locations. With respect to climate

change, these connectivities have to do with responsibility for driving climate change, efforts to mitigate climate change, and vulnerability to climate change. In all cases, the connectivities raise issues of equity and justice. Those most responsible for the greenhouse emissions that drive climate change, including advanced and industrializing countries, high-polluting industries, and high-consuming individuals, are not necessarily located in the same regions as those likely to experience the negative effects of climate change. The countries of southern Africa, for example, contribute relatively little to net global emissions of greenhouse gases, yet as demonstrated above, are highly subject to the negative consequences of climate change. Efforts to mitigate climate change increasingly occur in regions remote from the sources of pollution, as we discuss later in the case of carbon trading and green development mechanisms. Vulnerabilities of one region are also often connected to other regions, such that the impacts of climate change related shocks or stresses may reverberate from one region to affect populations living in other regions. In this section we emphasize these types of connections, showing how the effects climate change in coastal areas and particularly within coastal megacities are not limited to these areas, but will have consequences for human security and vulnerability in other areas.

Coastal areas are home to a growing share of the world's population. Currently more than half of the world's population lives within 200 kilometers miles of a coast (U.N. 2006), and coastal population growth is substantially outpacing that of inland areas due to both in-migration from inland regions and high rates natural population increase. These total estimates for coastal populations include approximately 618 million people (i.e. nearly one tenth of the world's population) who live in coastal locations with an elevation of less than 10 meters above sea level (McGranahan et al. 2007). These residents of low lying coastal areas are primarily concentrated in low and lower-middle countries of Asia including large countries such as China, India, Bangladesh, Vietnam, Indonesia and Egypt, as well as in small island nations such as the Bahamas, Surinam and Guyana (McGranahan et al. 2007).

The vulnerability of coastal areas is well-recognized within the climate change research community (Nicholls 1995; Adger 1999; Agrawala et al. 2004; McGranahan et al. 2007). Two of the most significant climate-related threats to coastal areas include sea level rise and increased frequency and magnitude of coastal storms. Over the next century, global sea levels are projected to rise between 0.5 and 1.4 meters (compared to 1990 levels) (Rahmstorf 2007). Some of this increase is likely to be attributed to the thermal expansion of oceans, and some is linked to the melting of glaciers and ice on land (Church et al. 2001; Meehl et al. 2005; Alley et al. 2005). While the magnitude of the increase will be vary spatially, those populations living in low-lying coastal areas will be particularly subject to the effects of sea level rise.

Climate change is also expected to influence to magnitude and frequency of coastal extreme weather events such as hurricanes and tropical cyclones (Mearns et al. 1997; Leichenko and O'Brien 2008). These events, which already represent a major threat to coastal areas in both tropical and mid-latitude regions, are likely to be exacerbated by increased storm surges associated with sea level rise. These types of surges are already responsible for a significant amount of damage in coastal areas. While wetlands, coral reefs, and coastal ecosystems often buffer coastal regions from such extremes, absorbing much of the energy and impact, land use changes in many regions lead to large-scale reductions in wetlands, beaches, and other protective features (Leichenko and O'Brien 2008). In conjunction with sea level rise, another climate

change related threat in coastal areas relates to freshwater supply and water quality. Many coastal areas are already experienced significant water shortages and water quality problems due to lack of freshwater supplies, salt-water intrusion in aquifers, inadequate reservoirs and other constraints. Increased temperatures, reduced precipitation, sea level rise, or increased variability of rainfall water as the result of climate change is likely exacerbate these and other water resource problems.

5.1. Coastal Megacities

Coastal areas are home to the majority of the world's largest cities. Among the world's 25 largest megacities – those with a population of over 10 million people – 16 are located in coastal areas (see figure 2). Among cities with populations over 5 million, 65 cities worldwide have some portion of their settlement area location in a coastal area with an elevation of 10 meters or less (McGranahan et al. 2007). Furthermore, the population of each of these coastal megacities is likely to increase substantially over the next several decades due to both natural increase and current patterns of population in-migration from rural, interior regions. For many coastal megacities, the vulnerabilities and human security concerns associated with climate change are not limited to populations residing within and around these cities. The vulnerabilities of megacities may also reverberate to other areas as the result of various types of economic, social and political connections.

[Insert Figure 2. The 25 largest urban agglomerations in 2007.]

With the hazard and disaster research community, megacities have long been recognized as 'hotspots' for various types of risks, including climate change (Mitchell 1995; 1999a; 1999b; Nicholls 1995; Huq et al. 2007). Megacities have been defined as 'crucibles of hazard' because of their large and highly concentrated populations, and the economic and political significance of these cities (Mitchell 1999a; Cross 2001). The potential for the consequences of extreme events in cities to reverberate to other areas is especially apparent in the case of megacities. Coastal megacities such as New York, London, Toyko, and Bombay are vitally important hubs for the global economy, serving as both centers of commerce and trade and as control points for many multinational firms, national governments and large international agencies. Risks to these cities are not confined to the large populations living in the city, but they inevitably affect those areas that are economically and politically dependent on the city, whether as markets or suppliers of good and services, as destination for migrant family residents who send remittances to other regions, or as center of political decision-making.

The connectivities and potential for the wider reverberations of stresses within megacities can also be linked to the ecological footprint of these cities. Ecological footprints provide a measure of the total land area and water resources that are required to meet the needs of an urban population (Wackernagel and Rees 1996). In some cases the ecological footprint of a city is 100 times larger than the land area of the city itself. With respect to water supplies, for example, coastal megacities such as Los Angeles and Karachi meet their water supply needs through water transfers from distant regions via extensive aqueduct and reservoir systems. Reduced

precipitation or increased evapotranspiration under climate change may lead to greater demands and greater water withdrawals from these cities. These actions may, in turn, contribute to water shortages and conflicts in upland areas that are also dependent on these resources. These types of connectivities may increase vulnerability to climate change within distance regions that provide ecosystem services to these and other large megacities.

5.2 Case study of Shanghai: Connective Vulnerabilities

Shanghai exemplifies many of the vulnerabilities associated with coastal megacities. For China as a whole, rapid economic growth since 1990 has been accompanied by dramatic rates of migration from rural to urban coastal areas. The trend of coastward migration has been especially pronounced in lower-lying coastal areas of China, where the population grew at a rate nearly double the national rate of growth between 1990 and 2000 (McGranahan et al. 2007). Shanghai's population in 2000 was estimated at approximate 16.5 million, with 10 million living in the city proper. This rapid growth since 1990 has been accompanied by significant spatial expansion of the urbanized area, including extension of port facilities, expansion of city special economic zones for export production, and construction of the Pudong Development Zone, which includes a new central business district (Solecki and Leichenko 2006). The suddenness and magnitude of Shanghai's growth can be also illustrated via real estate investment, which increased from 1.3 billion Yuan (approximately US$160 million) in 1992 to 74.9 billion Yuan in 2002 (approximately US$9.2 billion). During roughly the same period, the amount of urban settlement area grew from approximately 144 square kilometers to 410 square kilometers. By 2010, the city's urban settlement area is projected to increase to 1,100 square kilometers (Solecki and Leichenko 2006, 18).

As a coastal megacity in a subtropical region, Shanghai is particularly vulnerable to climate-related hazards. The coastal city is located at the mouth of the Yangtze river, and its elevation averages only 4 meters above sea level (de Sherbin et al. 2007). Summer typhoons often contribute to flooding, due to both excessive surface runoff and storm surges. The city is frequently deluged by torrential rainstorms, but also subject to water shortages due to summer droughts (Chao and Yuanfei 1998; Chaoyi, Jiong and Wei 1998; de Sherbin et al. 2007). Water shortages are compounded by rapid and uncontrolled rates of groundwater withdrawal, which has led to problems of saltwater intrusion into the groundwater table and substantial subsidence (Naisheng and Baogen 1998). Given Shanghai's current vulnerability to both floods and droughts, the potential for climate change-related sea level rise, increased climatic variability, and higher mean temperatures pose significant threats to the city and its residents (de Sherbin et al 2007).

Shanghai's vulnerability to climate change is not limited to those living and working in the geographical area of the city. It also extends to regions that are economically connected to the city. Nicknamed "The Dragon's Head," Shanghai has long been a significant city within the global economy (Ning 2001; Solecki and Leichenko 2006). Among the most important cities in global finance in early part of the 20th century, Shanghai has reemerged in this role as the result of policies and actions initiated by the Chinese government in the mid-1980s. Among the most notable are the construction of the Pudong Economic Development and the opening of the city to vast amounts of foreign investment (Ning 2001; Olds 2001). The growing economic importance

of Shanghai and China internationally may be illustrated by the Shanghai stock market fall in March 2007 which has had significant and continuing repercussions for markets worldwide. Given Shanghai's growing economic importance, climate change-related disruptions, particularly as the result of sea level rise under climate change, are likely to have major repercussions throughout China: "Unless something is done, there is the possibility that, as well as the people living in the low-elevation coastal zone, China's economic success will be placed at risk," (McGranahan et al. 2007, 33).

Shanghai's connectivities may also be understood in terms of 'human' connectivities. As a city of immigrants, most residents of Shanghai have personal, social, and economic ties to other regions of the country. Shanghai has a significant population of floating residents who have come to the city seeking temporary employment (Ning 2001). Many of these people retain connections to home regions in China via remittances and/or circular migration. This floating population, which was estimated at over 3 million or 13 percent of the city's population in the mid-1990s (Ning 2001), has temporary status in the city and is more likely to live in transient areas, in and around construction sites, or in flood prone or other physically vulnerable areas. As a consequence, members of the floating population are more likely to be vulnerable to extreme climate events, particularly flooding. Furthermore, because this population is economically and socially connected to so many areas of the country, such events may have economic repercussions throughout China. The populations living in other provinces of China that depend upon those living in Shanghai are also vulnerable to climate change related shocks and stresses that occur within the city.

5.3 Summary

Vulnerability assessments typically focus on the effects of climate change for populations living in specific regions. Connections and linkages between regions and the potential for climate impacts in one area to reverberate to other areas are less well recognized. As the case of Shanghai demonstrates, climate vulnerability in coastal megacities are likely to affect distant regions as the result of both formal economic and political linkages as well as personal, social, and family ties. While the case of Shanghai illustrates many types of connective vulnerabilities, it also highlights some of the positive connectivities that may help to enhance human security via efforts to promote sustainable mitigation. Shanghai is a leader in green development planning, in efforts to promote sustainable public transport, and in other measures to improve environmental quality (Solecki and Leichenko 2006). As we discuss later, these activities in Shanghai and other cities may offer positive lessons for other cities on sustainable mitigation.

6. Emerging Vulnerabilities: The Growing Vulnerability of Elderly Populations

Climate change will have differential consequences among individuals and communities around the world. Much attention has been given to the disproportionate vulnerability of developing countries to climate change, based on the importance of agriculture and other climate-sensitive sectors in national economies, and on limited resources to direct towards climate change adaptation. A human security perspective on climate change draws attention to differential

vulnerabilities *within* countries, focusing on individuals and communities and the factors that influence both exposure and the capacity to respond to change.

The context in which climate change is experienced is also changing, as described by the examples discussed earlier in this paper. Vulnerability is, however, not only related to the dynamic context in which climate change is experienced, but it may also be considered as an emergent property resulting from exposure to new types of shocks and stressors, particularly those which create conditions that people cannot cope with. This is often the case when rapid changes create new conditions on timescales that surpasses the capacity of individuals and communities to respond positively. Temperatures or rainfall patterns that are normal to one region or group may represent extreme conditions to others. Climatic surprises can be illustrated by the extreme cold air incursion from the south that affected more than 86,000 people in southeast Peru in 2002, killing 59 people, as well as llamas and alpacas -- livestock that are the basis for local livelihoods (OCHA 2002).

Climate change may contribute to the emerging vulnerability of places and groups that were previously not considered vulnerable. Elderly populations provide an example of an emerging vulnerability to climate change that cuts across the North-South divide: “The infirm, the elderly, and the poor may be disproportionately and negatively impacted should climate change result in more severe and/or more frequent episodes of heat waves and air pollution” (Simpson 2006). Below, we use this example to illustrate that vulnerability is dynamic over time, and that climate change interacts with demographic and socioeconomic changes to influence vulnerability to climate change, both now and in the future.

6.1 Case Study: Elderly Populations

The elderly represent one part of the population that is emerging as highly vulnerable to climate change. The factors that contribute to the vulnerability of people over 60 years of age to climate change are likely to be similar to factors that make them vulnerable to hazards such as accidental falls: progress in age, deterioration of health, personal lifestyles, loneliness, poverty, or inadequate health and social structures are all elements that can contribute to vulnerability (OECD 2006). In addition, the elderly often have difficulty adjusting to stressful or changing environmental conditions, which may lead to depression and ill-health (Montorio Cerrato and Fernández de Trocóniz 1998).

The world’s population is aging rapidly, thus more elderly will be exposed to climate change in the coming decades, particularly in OECD countries. By 2050, it is estimated that 1 in 3 people will be above 60 in OECD countries, as well as 1 in 5 at the global scale (UN 2002). As the UN (2002) report notes, “The declines in fertility reinforced by increasing longevity have produced and will continue to produce unprecedented changes in the structure of all societies, notably the historic reversal in the proportions of young and older persons.” It is expected that there will be an estimated two billion elderly persons in the world in 2050, with a majority of these women (UN 2002). There is also expected to be a rapid growth in the number of very old people (80+). The increases in the elderly population is not matched by an increase in the working age population, leading to a decline in the potential support ratio (i.e., the number of persons aged 15-64 per one older person aged 65 years or older) (UN 2002). It is important to stress that

population ageing is a global phenomenon that will have consequences for both intergenerational and intragenerational equity and solidarity (UN 2002).

It is not only the number of elderly that is significant, but also the context in which people are aging that will influence vulnerability to climate change. This context includes changing health conditions, as well as issues of social inclusion; welfare programme reforms and their impact on the elderly income; developments in the health and social care system; and finally the evolution of family structures (OECD 2006). The changing context can be linked to trends and structural transformations associated with globalization, including an increased emphasis on institutional efficiency and New Public Management (Christensen and Lægreid 2001). As seen in the case of the French heat wave described below, the vulnerability of the elderly to climate change is emerging as a challenge for human security.

6.2 The Elderly and the French heat wave of 2003

Heat waves represent a major risk among "natural hazards" in postindustrial societies (Poumadère et al. 2005). In recent years, a number of large cities in developed countries have experienced significant loss of life among elderly residents as the results of heat events. Among the most notable are the heat waves in Chicago in 1995 and Paris in 2003, both of which led to disproportionate loss of life among older residents of each city (Klinenberg 2003; Pirard et al 2005) Although these and other heat waves cannot be decisively attributed to climate change (Chase et al. 2006), several studies have demonstrated that these types of heat events are statistically unlikely to have occurred randomly, without human-induced climate change (Schär at al 2004; Stott et al. 2004). Nonetheless, these events are symptomatic of the types of extreme climate events that are likely to recur more frequently—and more intensely—with increases in atmospheric concentrations of greenhouse gases (Meehl and Tebaldi 2004; Beniston 2004; Leichenko and O'Brien 2008).

In the case of Paris, the heat wave was part of a severe heat event that affected most of Western Europe during the summer of 2003. The heave wave caused more than 22,000 heat-related human deaths in Europe, nearly 15,000 of which occurred in France (Pirard et al. 2005). These deaths represent an increase in excess total mortality of 70% in the 75-94 year age group, as compared to 20% increase in the 45-74 year age group and the 94 and above age group (Pirard et al. 2005). Among the excess deaths in people aged 75 and older, 24% were directly linked to heat (i.e., dehydration and hyperthermia or heat stroke), 22% to cardiovascular diseases, 10% to respiratory diseases, 7% to diseases of the nervous system, and 11% to unknown causes (Pirard et al. 2005). Importantly, Pirard et al. (2005) found that "relative excesses by causes of death were generally more pronounced in women than in men for the same age periods."

High temperatures clearly influenced the disaster that ensued in France. However, changing social and institutional conditions also played a decisive role in determining who survived the heat wave and who did not (Poumadère et al. 2005). Like most countries in Western Europe, France has a growing elderly population relatively to the population of working age individuals (Tapinos 2000). These changes suggest a growing need for family and social supports to ensure that elderly residents are able to cope with and respond to all types of extreme events. However, family social networks have changed in France, such that the elderly are increasingly living

separately from younger generations. This phenomenon, which is present and growing in nearly every advanced economy, is rooted in broad-based societal and demographic shifts. In the case of France, changes in the nature of labor markets, increased mobility, and increased wealth meant that many younger residents left Paris during the heat wave for vacation homes. As a result, less mobile elderly residents were not able to rely on family members to help them manage the heat. The institutional context in France has also undergone changes associated with neoliberal policies and New Public Management (Ferlie et al. 1996). The French administrative system has traditionally been centralized and hierarchical, intervening in all aspects of socioeconomic life. As Cole and Jones (2005, p. 569) point out, "[s]uch state interventionism (*dirigisme*) has declined since the 1980s, a by-product of the globalization of world markets, deregulation, and the rise of consumerism." The state retreat under New Public Management thus coincided with a growing need for state intervention to help growing populations of elderly residents who might have relied on family during a different era (Leichenko and O'Brien 2008).

While the above changes in the demographic, institutional and social context were a critical part of the picture for explaining heat waves deaths, individual perceptions also mattered. Because the heat event was outside the boundaries of what elderly people in France had experienced in terms of climate extremes, many were not prepared with knowledge about how to best respond (Keating 2003). The temperatures in the heat wave were well within the range of normal for cities in other parts of the world such as South Asia, but they far exceeded what people were accustomed to in Western Europe. As noted by Lagadec (2004), most of the resources needed to combat the heat were readily available in France: ice and water, covering windows to keep out the sun, freezing clothes before wearing them, placing humid towels next to a fan. Under a different set of expectations and experiences, the Paris heat wave might have been little more than an annoyance involving a short-term disruption of routine activities; instead, it was transformed into a disaster (Leichenko and O'Brien 2008).

6.3 Summary

The elderly population represents an example of a group that may experience increased vulnerability to climate change in the future, not only because the number of elderly is rapidly growing, but also because the context in which people are ageing is being transformed by social, economic and cultural changes. The vulnerability of the elderly transcends a North-South divide, and it is not limited to urban populations. In fact, the rural elderly—and elderly rural women in particular—may be vulnerable due to both socio-economic and cultural changes (see Box 3). From the perspective of human security, elderly individuals and aging communities are likely to experience climate change as a threat that diminishes their quality of life, if not individual life expectancies. A human security approach to climate change recognizes that vulnerability will be influenced by the capacities and capabilities of individuals and communities to respond to new and unfamiliar threats to their well-being.

Box 4: The Ageing of Rural Populations in Developing Countries

It is not only within countries with advanced economies that the number of elderly is increasing. The UN (2002) notes that whereas only 8 percent of the population of less developed regions was over the age of 60 in 2000, by 2050 this population group will make up almost 20 percent of the population. Moreover, the pace of population ageing is faster in developing countries, thus they will have less time to adjust to the consequences of population aging—and often with fewer resources (UN 2002). This transformation of the age structure of the population has implications for health and other services, particularly in rural areas, where elderly dependency ratios are expected to increase significantly. As du Guerny (1997) notes, this "raises the issue of the possible future vulnerability of the rural elderly as a group in these regions in view of the pressures which will be placed on the family and community institutions." Of significance is the fact a large percentage of the future rural elderly is unlikely to benefit from any significant pension, health insurance, or social security support (du Guerny 1997). In many countries, an increasing number of older people have worked outside of the formal sector, with little capacity to save for old age and a lack of social security or post-retirement benefits (Gupta et al. 2001; Pal 2004).

Developing countries are experiencing social, economic, cultural, and institutional transitions. Van Eeuwijk (2006) notes that the vulnerability of the elderly in Indonesia is increasing as kinship obligations become weaker, since vulnerability is closely linked to the resources, capability, and willingness of family and non-family to act as care-givers for extended periods (Van Eeuwijk 2006). The decay of the extended family and a growing trend towards nuclear families is also increasing the vulnerability of the ageing population in India, a country characterized by a slow but steady rise in the proportion of elderly, many of whom live with their children, especially sons (Pal 2004). Changing household structures associated with increased rural to urban migration have had a profound influence on family support networks, especially since migration flows can leave elderly in rural areas with a reduced pool of potential caregivers, while at the same time increasing the burdens on the elders, since grandchildren often remain in the family home when parents migrate for work. In Africa, a growing number of orphans pose new challenges to the elderly, as they have roles as both care givers and receivers. Elderly women in particular may be more vulnerable than men due to lack of productive employment and income, widowhood status, and low education—factors that make them dependent upon others and less empowered to voice their needs and problems (Gupta et al. 2001). The health-related effects of climate change are thus likely to be experienced by an increasingly vulnerable rural elderly population in less developed countries—with potentially a strong gender dimension.

7. Human Security: Promoting Sustainable Climate Change Mitigation and Adaptation

Climate change represents a significant threat to human security. As we have shown through the examples above, even small degrees of climate change are likely to present challenges to some individuals and communities. Recognition of these existing and emerging vulnerabilities is critical for identification of individuals, groups, and regions in need of policy attention to promote effective responses and coping strategies in the face of climate change. Nevertheless, efforts to both mitigate and adapt to climate change will also be necessary to ensure human security in the 21st century. Below, we present some examples of what can be considered sustainable mitigation and adaptation to climate change. We emphasize that in order to be

sustainable, these efforts must take into account both equity and connectivity dimensions of human security.

7.1. Sustainable Mitigation

Climate change mitigation has already raised many equity-related issues with respect to international negotiations to reduce greenhouses gas emissions (Müller 2002). Distributional equity is a key concern in relation to the Kyoto Protocol, with questions raised about who pays the costs and who bears the burdens for emissions reductions. These types of equity issues arise, in part, "because of the qualitative differences in the effects of climate change *and* climate change policy on the poor and those who are better off" (Rayner and Malone 2001, p. 178, emphasis added). In less developed countries, GHG mitigation may create restrictions on the use of certain types of fuel, such as wood in urban areas, which differentially affects poor residents. Within more affluent countries, GHG mitigation may entail requirements for lower emission vehicles. Such vehicles are typically newer and more expensive, making them harder to afford for lower income groups. As with other efforts to reduce air pollution and increase energy efficiency, middle and higher income consumers are often more easily able to make lifestyle adjustments to meet these requirements than are poorer consumers (O'Brien and Leichenko 2006).

Carbon trading and offset programs utilize emerging regional and global market for carbon, generating new opportunities for investors, banks, corporations and entrepreneurs to profit through quota sales or carbon reduction schemes. Projects associated with programs such as the Clean Development Mechanism (CDM) take advantage of increasing global connectivities, allowing polluters in developed countries to mitigate their carbon emissions through activities that promote cleaner and more sustainable energy use in developing regions. Although CDMs are often intended to improve both energy access and livelihoods in developing countries, many of these efforts have come under fire because of negative environmental and social consequences (Lohmann 2006). For example, the spread of monoculture plantations of eucalyptus trees, such as those cultivated in Minas Gerais, Brazil to replace coal with charcoal in the production of pig iron has desiccated swamps and streams, contaminated air and water, destroyed plant and animal species, and disrupted the livelihoods of small-scale farmers living nearby (Wysham 2005). Recognition of the longer-term impacts of carbon offset projects raises questions of who ultimately benefits from carbon trading and whether this is indeed the most efficient means of reducing negative outcomes from climate change. Likewise, greenhouse gas reduction strategies aimed at reducing "food miles" may create bias against fair trade products that are produced by small-scale farmers in a sustainable way, but which nonetheless travel a farther distance to their final markets. Locally produced foods may, in contrast, have been produced with energy-intensive inputs, yet produce little in transport. Recognizing and addressing the equity dimensions of mitigation is vital to promoting human security, both in the short run and in the long run.

7.1.1. Positive examples of sustainable mitigation

Curitiba, Brazil is often cited as an example of a city that has pursued sustainable mitigation, while at the same time taking into account the equity dimensions of human security (O'Meara

Sheehan 2002). This city of 2.5 million residents has prioritized the development of public transit based on high-quality bus systems and a complementary package of measures that de-emphasize cars, while also preserving green spaces and producing an array of economic, environmental and social co-benefits (Wright and Fulton 2005). What is perhaps more important here is how Curitiba's strategy has been transferred to other cities around the world. As noted by Wright and Fulton (2005, p. 699), the experience of Curitiba has in part influenced new Bus Rapid Transit (BRT) systems in Beijing, Jakarta, Seoul, and Leon (Mexico), and new projects are underway in Cape Town, Dar es Salaam, Hanoi, Lima, Mexico City, and Santiago.

In conjuction with sustainable transport projects, many cities have are initiating more broad-based, green development approaches which emphasize both local and global environmental quality. Within Shanghai, for example, these efforts include campaigns to relocate polluting industries out of residential areas, dramatically increase open space and urban vegetation, promote improved sewage treatment and surface water quality, and development of city and provincial parks and conservation areas (Solecki and Leichenko 2006, 19). The expansion of green spaces and use of green infrastructure (e.g., installation of greenroofs) is also increasingly used in Shanghai and elsewhere as a strategy to both mitigate and adapt to climate change. Green infrastructure reduces local scale urban heat islands effects, which may be exacerbated under climate change (Gill et al 2007), and, at the same time, reduce the need for artificial cooling thus lowering urban energy consumption.

Another type of urban-based effort to mitigate climate is illustrated by the Cities for Climate Protection network, which was established in 1991 by the International Council for Local Environmental Initiatives (ICLEI) (Bulkeley and Betsill 2003; Kousky and Schneider 2003; Slocum 2004). Through this larger network, hundreds of municipalities worldwide have begun to implement climate change abatement strategies. As of 2006, the campaign included more than 675 cities worldwide that were setting greenhouse gases emission reduction targets and developing location action plans to reduce their emissions. The connectivity dimension of human security is addressed through these types of international campaigns and networks, which recognize that the security of individuals and communities is closely connected to the actions that are taken in each city to mitigate climate change. In circumventing the highly politicized national climate change debates and the paralyzing North-South divide, such mitigation efforts are not only likely to be more sustainable, but also more effective in reducing the long term impacts of climate change.

7.2 Sustainable Adaptation

Both the equity and connectivity dimensions of climate change underscore the importance of sustainable adaptation. The broader goals of most sustainability efforts are to foster economic and social practices that contribute to the maintenance of environmental quality, diversity of species and preservation of ecological functions for the benefit of both humans and other living things (Folke et al. 2002; Kemp and Parto 2005). Sustainability emphasizes the idea of using natural resources in a manner that meets the needs of the present generation without compromising the ability of future generations to meet their needs (WCED 1987). Adaptation to climate change can be described as adjustments in practices, processes, or structures to take into account changing climate conditions, to moderate potential damages, or to benefit from

opportunities associated with climate change (McCarthy et al., 2001). Combining aspects of both sustainability and adaptation, the notion of sustainable adaptation entails measures that reduce vulnerability and promote long-term resilience in a changing climate.

Eriksen et al. (2007) point out that not every adaptation measure automatically reduces vulnerability of the poor, or contributes to sustainable development in the face of climate change. Unless adaptation measures are specifically targeted at 1) the risks posed by climate change to the way that people secure basic needs; 2) the adaptive capacity of the poor; and 3) the processes generating their vulnerability, then adaptation has the potential to increase the vulnerability of the poor (Eriksen et al. 2007). For example, irrigation may lead to increased salinization of soils and groundwater, as well as the degradation of wetlands, leaving some households with reduced access to groundwater and productive land and resources. Similarly, coastal infrastructure to protect against sea-level rise may change the offshore sediment balance and increase erosion in adjacent coastal areas (Eriksen et al. 2007). Sustainable adaptation measures include those at the interface between vulnerability reduction and poverty reduction measures. Adger et al (2005) point to a normative set of criteria for judging the sustainability of adaptations at different scales, which includes effectiveness, efficiency, equity, and legitimacy. Sustainable adaptation thus addresses vulnerability in a manner that also promotes more equitable social, economic and environmental practices (Adger et al. 2005; Eriksen et al. 2007). It also involves recognizing the ways that increasing environmental, social, economic and institutional connectivity may influence vulnerability, while at the same time potentially providing a means of communicating and transmitting successful approaches that promote resilience and enhance human security.

7.2.1 Positive examples of sustainable adaptation

A number of positive examples of sustainable adaptation measures can be extracted from the growing literature on climate change adaptation (see Eriksen et al. 2007). For example, measures to improve transport and roads, communications and accessibility during floods to counteract geographic isolation may be considered as a form of sustainable adaptation. Institutional adjustments, such as changing the timing of school fees to avoid periods of the year when the effects of drought are most pronounced can also be considered an adaptive measure to help people to achieve education in the face of climate stress (Eriksen et al. 2007). Improving the quality of housing and infrastructure in low-income urban areas that are vulnerable to cyclones and floods is another measure of sustainable adaptation. Because climate-related risks and other stressors vary from place to place, and between different groups, sustainable adaptation measures are likely to be context specific. Eriksen et al. (2007) stress that there are no one-size-fits-all solutions for sustainable adaptation.

Nonetheless, measures that target risks can be combined with measures aimed at strengthening local adaptive capacity. Among the examples of sustainable adaptation discussed by Eriksen et al. (2007) is the case of Rajasthan, India. Here, Chatterjee et al. (2005) present a case study of adaptation practices in two drought-prone villages in the Tonk district of Rajasthan. The villages of Dotana and Safipura rely on rain-fed agriculture for subsistence, and cattle rearing for revenue. Severe drought in 2002/03 resulted in water stress and crop failure, as well as the abandonment of livestock Responses to decreasing groundwater recharge, decreasing water levels, crop failures and a lack of fodder for animals have been carried out through both policies

and local initiatives by government institutions, development agencies and NGOs. Adaptation measures that build on local knowledge include improved methods of storing grain and fodder; improved water conservation and harvesting techniques; introduction of a diversity of drought-tolerant crops such as chhana, cumin seeds and mustard and the production of vegetables during winter. In addition, the production for commercial sale of high value medicinal crops that do well during drought conditions has become an alternative source of income (Chatterjee et al. 2005).

The connectivity dimension of human security is accentuated through the growing need for multiple and diversified livelihoods in response to multiple stressors. Eriksen et al. 2007 emphasize that efforts aimed at reducing the vulnerability of the poor must target the multiple sectors and spheres in which people are engaged, and not just the sensitivity and performance of one sector, such as agriculture. Sustainable adaptation may thus involve measures that enable movement across national frontiers, facilitate access to land for outsiders, or provide reliable channels for migrant's remittances (Toumlin 2005). Such measures would enhance mobility and flexibility, which are becoming increasingly critical to people's adaptive capacity in the face of climatic variability and change (Eriksen et al. 2007). Other sustainable adaptation measures might include securing migration routes for livestock keepers, providing veterinary, physical and social infrastructure in those areas, and ensuring access rights to important drought grazing areas would enhance adaptation to drought among herders in Kenya (Eriksen et al. 2006). Likewise, strengthening on-farm planting of indigenous trees, facilitating access to forests, and enhancing the processing and value-added of drought products (e.g., indigenous fruits, gums and resins) could increase the viability of forest-based livelihood options in the context of climate change (Owuor et al., 2005; Eriksen et al. 2006; Eriksen et al. 2007). A key point is that there are potentially many sustainable adaptation measures that could reduce vulnerability to climate change, while at the same time promoting both poverty reduction and sustainable development.

7.3. Conclusion

In this paper, we have stressed a number of key points about climate change that are directly related to human security. In particular, we have demonstrated the climate change interacts with other types of stressors, that vulnerability to climate change is dynamic and undergoing continuous change, especially as the result of social and economic changes associated with globalization, and that climate change vulnerabilities are connected across both space and time. Taken together, these points highlight how climate change raises issues related to both the equity and connectivity dimensions of human security. Nevertheless, climate change has for the most part been perceived, debated, and addressed as an environmental issue, rather than as a human security issue. A human security approach to climate change can be considered a people-oriented approach that emphasizes both equity issues and the growing connectivities among people and places. It focuses on the management of threats to the environmental, social and human rights of individuals and communities, while at the same time enhancing the capacity to respond to both change and uncertainty. Responding to climate change from a human security perspective requires that *both* mitigation and adaptation strategies consider the equity and connectivity dimensions of human security.

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Figure Captions

Figure 1. Social Vulnerability to Climate Change in Indian Districts in 2001. Data source: Author's calculations based on Census of India, 2001.

Figure 2. The 25 Largest Urban Agglomerations in 2007. Data source: *Thomas Brinkhoff: City Population.* Accessed at http://www.citypopulation.de on March 20, 2007.