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Sea Level Rise and the Vulnerability of Coastal Peoples

Responding to the Local Challenges of Global Climate Change in the 21st Century

Anthony Oliver-Smith

InterSecTions

'Interdisciplinary Security ConnecTions'
Publication Series of UNU-EHS

No. 7/2009

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Cover design by Gerd Zschäbitz

Copy editor: Ilona Roberts, Deborah Odumuyiwa

Printed at Paffenholz, Bornheim, Germany

July 2009, 1000 print run

The views expressed in this publication are those of the author(s).
Publication does not imply endorsement by the UNU-EHS or
the United Nations University of any of the views expressed.

ISBN: 978-3-939923-28-2 (printed version)

ISBN: 978-3-939923-29-9 (electronic version)

ISSN: 1814-6430

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Anthony Oliver-Smith

Acknowledgements

We would like to thank Ilona Roberts, Deborah Odumuyiwa, Paola Tejada-Lalinde and Ben Zhu for the editing work. Ms. Xiaomeng Shen and three anonymous peers reviewed this article. We would like to thank them for their critiques and comments of individual chapters.

We appreciate the collaboration of the *Munich Re Foundation* in promoting the publication of social vulnerability-relevant research. The partnership UNU-EHS enjoys with the *Munich Re Foundation* makes the *Munich Re Foundation Chair on Social Vulnerability*, held, among others, by Professor Anthony Oliver-Smith, possible.

Foreword

Climate change and its physical, biological and social consequences are certainly in the limelight of both scientific and political interest.

Signs, that climate change is already happening now, and that it is not a vague future threat, cannot be overlooked. While there is still considerable uncertainty about course and magnitude of changes, there is little doubt that the rise of sea level is a long lasting unavoidable phenomenon. Increasing eustatic sea levels compounded by growing frequency and magnitude of sea-born hazards like storm surges and hurricanes threaten the low elevation coastal zone (LECZ) including small islands and deltas. While the share of these landforms is a mere 2% of the total landmass of the earth, the LECZ is home for 10% of the present world population. Sixty-five per cent of megacities with more than 5 million inhabitants are located in these coastal zones, with a still increasing tendency. Deltas with their dense populations serve as rice bowl of entire countries.

These numbers illustrate the magnitude and global characteristics of the challenge. Yet, what looks like the threatening interplay of geophysical factors is in fact rather a socio-ecological problem. Human induced climate change threatens the very fabric of human society. Prof. Oliver-Smith argues that this is a multiple scale challenge affecting local communities in their efforts to mitigate, cope with and adapt to the unprecedented form and pace of change.

Migration, while an age-old feature of human existence, a historical means to survive and to adapt by remaining mobile, will once again be in the focus of concern.

It might be the subject of scientific curiosity to observe and to predict when the migratory trend toward the LECZ will massively reverse as people will increasingly be forced to abandon uninhabitable areas. But curiosity-based science is not enough.

The great virtue of Prof. Oliver-Smith's monograph is that he defines the decision (or force) to migrate not as a solution but as the start of yet a new phase of adaptation faced by communities and individuals losing their habitat, livelihoods, culture, and social networks.

To see sea level rise and its consequences as a social problem and the subject of policy-relevant, human-centred, interdisciplinary science is the forceful message of Prof. Oliver-Smith.

Five case studies from: Tuvalu, the Mekong delta in Vietnam, Bangladesh, Alaska, and the US Gulf Coast, do not only serve as vivid mementos that (forced) displacement is already happening, but they also illustrate the versatility of geographical and socioeconomic settings of its occurrence.

Vulnerability of coastal people, the uncertain magnitude and pace of sea level rise, migration and resettlement as a possible response are the core elements of what might be the biggest challenge for humanity in the 21st century. We are grateful for Prof. Oliver-Smith for his eye-opening monograph analysing this global challenge and formulating (mapping) inherent multiple-scale research questions to be answered with urgency to help avoid sea level rise from triggering an unprecedented humanitarian catastrophe.



Janos J. Bogardi
Director UNU-EHS

Foreword

The earth's climate undergoes constant change, as a rule, over a very long period. Since the mid-19th century, however, our globe has been steering towards a warm period such as the earth has not experienced over the last several million years. If the projections of the UN's *Intergovernmental Panel on Climate Change* (IPCC) actually materialise, which is more than likely in the absence of any appropriate counter-measures, the mean temperature of the atmosphere will continue to rise by up to several degrees centigrade by the end of the century, with fatal implications for mankind, flora and fauna. One of the consequences will manifest itself in terms of the increased intensity and greater frequency of weather-related natural hazards.

Natural catastrophes have existed since time immemorial. A clear distinction can be made between sudden, and to some extent, unforeseen events and those which emerge relatively slowly. The former include earthquakes, severe weather and flash floods, the latter droughts and rising sea levels, which occur very slowly and foreseeably. Scientists from the IPCC world climate council estimate that the sea level can rise by up to one metre over the next 100 years. Even if the sea were to rise by only half this figure, immense numbers of people in the world's coastal regions and in the major river deltas will be affected. Even today it is clear that millions will have to abandon their traditional homes as a result. Environmental migration has already started; just think of Tuvalu Island in the Pacific or indigenous people in parts of Alaska or Canada who have to leave their homes. In view of this, it is actually surprising that important topics such as elevated sea levels and environmental-related migration still tend to be comparatively under-analysed as linked phenomena with immense impacts. The legal parameters for a social, environment-friendly and future-proof development are even not particularly well defined.

In this paper, Anthony Oliver-Smith provides a very good and interesting overview of the impact of sea level rise. His analysis is not restricted to the risks directly occurring in the coastal zones; it also includes social, economic and cultural impacts in the inland regions of the countries affected. The extent to which people are impacted depends on such factors as vulnerability, adaptability, flexibility as well as the political framework.

It is obvious that researchers and politicians will have to devote much more time to such topics to avoid being "all of a sudden overwhelmed by surprising phenomena" and humanitarian crises that might be by then out of control.



Thomas Loster
Chairman of the Munich Re Foundation

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User Guide

The Margins of the InterSecTions Series – A Service for the Cursory Reader

The InterSections Series means to provide direct, knowledge-based recommendations as basis for well founded decisions. Our InterSecTions Series provides authoritative research and information for policy and decision makers; additionally we provide a service for the cursory reader. To receive the full message of the respective page one has to read the quotations provided in the margins. In those margins the reader will find thought provoking, but well researched policy recommendations and the quintessence of the page. Additionally, the quotations are placed directly beside the position in the text, so if the reader wishes to find out more, he can easily find the text quotation and take the reading from there. The editorial team of UNU-EHS hopes this service will be well received. However, any comments and/or recommendations of improvements are very welcome.

Abstract

Our most recent scientific assessments indicate that sea level rises of up to one meter are likely in this century. There is the further possibility, in the event of the collapse of the Greenland and West Antarctic ice sheets, of increases of as much as five meters. Such rises in sea level are extremely threatening in general, but particularly so to the roughly 600 million people (around 10% of the current global population) residing in communities in the low elevation zone (0-10 meters above sea level (ASL)). However, sea level rise (SLR) will not be uniformly felt, varying largely by such forces as local geomorphology, forms of environmental degradation, adaptive capacity, and levels of development. Moreover, SLR is likely to combine with other forms of climate change to bring about further pressures for uprooting and forced migration. This paper will consider the likely economic, social and cultural impacts on coastal communities by displacement due to climate change induced sea level rise. Additionally, it will take into account the secondary risks associated with uprooting and resettlement, particularly within the context of current policy and research frameworks that generally have yet to address the probabilities of large scale forced migration.

Introduction

Today, despite the fact that the reality of climate change is generally accepted, the impacts of actual and projected effects are still much debated in both scientific and political forums. There is considerable uncertainty about local manifestations of global climate change and what necessary adjustments will be induced in natural and human systems (Dessai et al 2007:1). The uncertainty, in fact, characterizes the problem both at the level of physical impacts and at the level of responses and adaptations in human communities. Indeed, the projected effects of climate change, particularly as they pertain to specific human communities, have entered as much into political controversy as they have into academic debate. There is one dimension of climate change, however, about which climate and oceanographic scientists have very high confidence. Although sea levels have been rising slowly for centuries, global change driven increases in the rate of rise will result in increased exposure to coastlines and coastal systems around the world. In fact, sea level rise is predicted to have major effects on terrestrial and marine life and is considered to portend significant population displacements over the next century, particularly in the developing world (McGranahan et al 2007).

However, how people will respond to actual and future impacts of sea level rise is an issue that is also characterized by considerable uncertainty. Will adaptations be possible that will allow people to maintain stable communities in place? How costly both in economic and in sociocultural terms will these adaptations be? Will there be mass displacements and migrations? Will these displacements and migrations be truly environ-

Global change will result in increased exposure to coastlines and coastal systems around the world.

To develop adequate responses to these questions regarding the social impacts of sea level rise we must begin by addressing them at the multiple levels at which they exist, and particularly in the complex interrelationships between nature and society.

mentally driven or will they be caused by economic or political factors simply exacerbated by sea level rise? Will the affected populations be internally displaced or will they migrate internationally? If these mass displacements occur, will they take place as the result of sudden onset disasters produced by sea level made more intense by coastal storms and hurricanes or will they be the result of gradual increases in sea levels that slowly make habitats uninhabitable? Will these migrations be the outcome of decisions made by individuals and families, or will entire communities be displaced and resettle as communities? Will these displacements be voluntary or involuntary? Will people be displaced and resettled in some organized fashion or will it be left up to individual decision making? And lastly, will any measures taken be effective in responding to the needs of displaced populations?

The answers to these questions today are at best conjectural. And, where climate change is concerned, we can expect surprises (Holling 1994). However, it is clear that to develop adequate responses to these questions regarding the social impacts of sea level rise we must begin by addressing them at the multiple levels at which they exist, and particularly in the complex interrelationships between nature and society both conceptually and specifically as expressed in local contexts. Such a perspective has been noticeably lacking in the debates of the issue of environmental migration, which have tended to focus primarily on environmental drivers (Myers 1997) or, conversely, the political and economic causes of migration (Black 2001). The complexity of the interrelationships between ecological and social systems at multiple levels makes crafting a policy relevant research agenda on the social impacts of sea level rise a challenging task because it requires combining global projections with their local and regional manifestations with local patterns of vulnerability that are socially and economically constructed by local, regional and global processes. The research required on which to base appropriate policies for climate change and sea level rise adaptation must therefore be multi-sited (Crate 2008: 584).

In effect, projections from both the ecological and the social domains at the local level must be addressed in ways that reflect their mutual constitution. This mutual constitution must inform any effort to frame a coherent research agenda that will generate the information and perspectives necessary to inform policy that provides for adequate durable solutions for specific coastal populations facing loss of land, ecosystem services, intensified storms and the possibility of forced migration and resettlement. This paper will first examine different concepts that provide the lenses through which to see research on climate change impacts generally and sea level rise specifically. The second section will elaborate on the exposure of coastal peoples to climate change driven sea level rise. The third section will explore the social impacts of sea level rise from the perspective of vulnerability science. Drawing on five specific case studies, the author will illustrate specific local adaptive responses of people affected by sea level rise in the fourth section. The concluding section will assess the implications of these findings for developing policy options and relevant practice strategies.

Section I

1.1 A Human Systems Ecology Perspective

The complex of forces constituted in global warming, sea level rise and their social impacts cannot be addressed independently of a basic understanding of human environment relations. The approach to human-environment relations adopted here most approximates the human systems ecology approach derived from the work of the noted ecological anthropologist, John Bennett (1996), which emphasizes the institutional arrangements that mediate between human beings and physical factors as a single system and includes a focus on regional systems in which different human groups adapt to environmental features, to one another, to hierarchical market and administrative forces and to pressure groups and other forms of social and political interests. As with any conceptual framework, the definitions of the terms employed in human systems ecology must be clear. In particular, for a human systems ecology approach to sea level rise the complexity of socio-ecological interactions demands that the terms society, nature, environment and technology as well as the attendant concepts of adaptation and mitigation be specified.

1.2 Society, Nature and Environment

There are many ambiguities in the way the words society, nature and environment are used. Indeed, their meanings seem frequently to be taken for granted. Society within a human systems ecology perspective refers to the organized behavior of a group of human beings who share a set of relationships expressed through mutual expectations and founded on a minimally shared understanding of certain institutions and beliefs. Writ large, society can encompass nations, but in this discussion, it will generally designate a community, basically a group of interacting people in a common context who share similar understandings, values, life practices, histories and identities within a certain framework of variation. Communities also possess an identity and are capable of acting on its behalf or on behalf of those who have a claim on that identity (Oliver-Smith 2005).

Nature and environment are often used interchangeably, sometimes leading to a blurring of important distinctions that may impede our understanding of complex vulnerability-related phenomena such as disaster driven population uprooting and resettlement. Today the concepts of nature and environment are not interchangeable, but have become quite distinct. Nature is constituted in those biological, chemical, and geophysical features and processes that compose the substance and functioning of terrestrial and aquatic systems, which are characterized by spatial/temporal heterogeneity and functional diversity (Holling 1994). These systems are maintained by cycles of renewability that ensure the capacity of the global system to reproduce itself, maintaining within a range of variation the set of biotic conditions that enable life to persist.

Today the concepts of nature and environment are not interchangeable.

Environments by definition are not naturally created, but socially constructed.

Definitions of environment often embrace definitions of nature. However, for my purposes in the present discussion, environment is the socially constructed outcome of the interaction of natural features and processes with social features and processes. In that sense, the term “natural environment” is an oxymoron. Environments by definition are not naturally created, but socially constructed. Environments consist of the instantiation of social processes in nature, thereby converting the natural into a social product. There are natural features and processes at work in environments, but they are expressed and channeled socially, either as resources, recognized or unrecognized, or threats, recognized or unrecognized. Clearly, however, at the same time natural features and processes continue to operate with effects that are far from being entirely controlled by the social. Therefore, environments, or socio-natural or socio-ecological systems, to use the more current term, are not simply combinations of the two since they function differently (Bennett 1996: 17). However, human and natural systems today are so deeply interpenetrating that differentiating between them can be extremely challenging. Certainly such is the case with anthropogenic climate change and its manifestations in sea level rise and coastal erosion.

From this perspective, then, environment and technology are socially constructed outcomes of social relations between people, rather than empirical givens. The process, through which humans engage nature, is a social process occurring between humans for the satisfaction of some times conflicting needs and interests. Engagement with nature is not just a technical response of an undifferentiated population to physical or material conditions. It is always internally complex, involving the diverse interests and knowledge of a differentiated population interacting within both a dynamic physical setting and a socially structured, political economic set of institutions and circumstances as well. In this regard, a human systems ecological approach bears considerable similarity to some political ecological perspectives in that it examines the interacting roles that international, national, regional, and local institutions play in providing constraints and possibilities that affect the way human beings make decisions that affect in turn both these institutions and both nature and the environment. The advantage of this approach is that it takes into account micro-level decision-making as well as institutional features (pressures, facilities, etc) and allows for the examination of linkages between the local specifics of human thought and behavior and macro-level institutions such as markets and government agencies.

1.3 Adaptation and Mitigation

Adaptation is the fundamental conjunctive concept in human-environment relations. It is through the process of adaptation that humans and natural systems jointly construct socio-ecological systems, or environments.

Adaptation used in a formal analytical sense is a concept borrowed from biological ecology, in which it is defined as the process of developing or enhancing structural, physiological and/or behavioral characteristics

that improve chances for survival and reproduction in a given environment. It is a concept that is inherent in the process of natural selection in which those organisms with the characteristics that best equip them for survival in an environment have higher probabilities for both survival and reproduction and hence passing on those characteristics to succeeding generations.

When used in the social scientific sense, adaptation refers mainly to changes in belief and/or behavior in response to altered circumstances to improve the conditions of life (or survival). Adaptation in its special application to human beings has a wider number of attendant features for adaptive capacity including complex human cognition, social organization, values and meanings. Human adaptations to environmental change are largely social organizational and technological. Some researchers have seen the society as the adaptive unit; that is, adaptation is the ability of a system to return to functionality (Holling 1994). Others see the unit of adaptation as the largest and most inclusive group that makes and implements decisions with respect to the exploitation of energy potentials in the habitat (Bennett 1996). That is, human beings do not just adapt as reactive organisms. Through cultural means humans perceive environmental changes, consider their implications and possible responses through a grid of individually interpreted cultural knowledge and meanings, make decisions and elaborate responses that may reflect a variety of value positions, including the deployment of technology. The cognitively and technologically enhanced adaptive capacity of human culture has enabled human beings to not only adapt but also to alter nature far beyond the quantitative impacts of sheer demography of boom and bust cycles of natural increase and environmental limits that characterizes the impacts of other species (Holling 1994). Humans shape environments in far more ways than sheer numbers. Thus, for human beings, decision-making and implementation are central features of adaptation, of every strategy for exploiting the energy potentials of a particular habitat.

Humans interact with both natural and cultural circumstances. In that sense, we have to adapt to a set of socially constructed institutional circumstances. We don't just adapt to natural features, land or water, for example, but also to human institutions such as labor, economics, markets, schools, governments, and churches and the resources and constraints they present. That is, our institutions are at once part of our adaptation, but must be adapted to as well.

Bennett sees an important distinction between what he calls adaptive strategies, which are patterns formed by the many separate adjustments that people devise to obtain and use resources and solve immediate problems. In other words, adaptive strategies involve coping behavior, immediate problem solving and decision-making. Adaptive processes are changes introduced over long periods of time by repeated use of particular strategies that have become part of the fund of general knowledge and practice in a culture.

Adaptation refers mainly to changes in response to altered circumstances to improve the conditions of life (or survival).

Mitigation is a form of adaptation that concerns itself with impact minimizing strategies, to minimize loss and facilitate recovery.

There are human rights implications to this distinction. That is, if people are unequally subjected to risks that they must cope with, they must develop strategies and make decisions in order to survive. However, there may be a significant difference between coping to stay alive and a long-term adaptive process. The distinction between an adaptation and a coping strategy can be crucial in assessing the effectiveness of adjustments to environmental change. An adaptation to a systemic hazard or risk feature developed over many years may be adopted and subsumed into the general fund of cultural knowledge and practice and may be more or less effective. A coping strategy is an immediate response to a challenge for which there may be no culturally constructed adaptive responses. In the context of sea level rise, will migration be a coping strategy or an adaptation? Since sea level rise promises to be a slow onset process, adaptations (sometimes in the form of mitigation strategies) will most likely be the mode of response. However, if migration and resettlement merely allow people to survive in an impoverished camp or urban slum, then it is a far cry from adaptation. It more approximates an immediate coping strategy that enables survival, but it is hardly adaptive.

Mitigation is a form of adaptation that concerns itself with impact minimizing strategies to minimize loss and facilitate recovery. Mitigation, to the degree that it addresses how systemic features contribute to vulnerability, addresses cause, although such action may be undertaken in response to the impact of a hazard. Adaptation in general is reactive, adjusting primarily to effects. Mitigation, on the other hand, is proactive, increasing the resilience of a society; that is, increasing the capacity to absorb the impacts of hazards that exist in its surroundings without major disruption of basic functions. Such strategies are extremely diverse. Some mitigation measures can be technological, such as building defensive structures including levees, sea walls, and dikes. Other mitigation measures will include social organizational or economic strategies, such as organizing community alert or information distribution systems or diversifying production or income strategies, as well as purely social strategies such as strengthening social support networks. Mitigation aims to increase the self-reliance of people in hazard prone environments to demonstrate that they have the resources and organization to withstand the worst effects of the hazards to which they are vulnerable (Wisner et al 2004).

1.4 Vulnerability and Risk

Clearly, one of the fundamental tasks that societies must address is some kind of adjustment to the hazardous features of the environment to which they are exposed. These adaptations will almost always be approximate in that all impacts from a hazard will not be completely absorbable. Were that not the case, that is, if the society could absorb all impacts of a hazard without effect, it would not be a hazard. Therefore, both exposure to a hazard and the capacity to adapt to it are also fundamental aspects of vulnerability (Adger and Vincent 2005: 400). The concepts of vulnerability and resilience address the degree to which at a given point

in time a society is adapted to the hazards of its environment. However, the relationship between vulnerability and resilience is not linear, but rather dialectical (Aguirre 2007). That is, lowering vulnerability may or may not increase resilience, but it also may create other forms of vulnerability. Vulnerability describes the degree to which a socio-ecological system is either susceptible or resilient to the impact of natural hazards. It is the outcome of various factors, including awareness of hazards, settlement and infrastructural patterns, public policy and administration, the level of societal development and institutional capacities in disaster and risk management (Nicholls and Hoozemans 2005; Brooks et al 2005). Vulnerability and risk refer to the relationships between people and the environment including the physical setting and the sociopolitical structures that frame the conditions in which people live. The concept of vulnerability is fundamentally a political ecological concept, integrating not only political economic, but environmental forces in terms of both biophysical and socially constructed risk. Vulnerability links the relationship that people have with their environment with social forces and institutions and the cultural values that sustain or contest them. Therefore, it links general political economic conditions to very particular environmental forces to understand how basic conditions such as poverty or racism produce susceptibilities to specific environmental hazards. In so far as vulnerability is socially produced, risk is therefore not evenly distributed across the social spectrum, prompting the question whether everyone in coastal environments will be equally vulnerable to the impacts of sea level rise. High levels of vulnerability reflect a lack of or inappropriate adaptations and therefore low levels of resilience. Vulnerability thus explicitly links environmental issues, such as hazards, with the structure and organization of society, and the rights associated with membership.

It is clear that the differential endangerment is a violation of human rights and is deeply embedded in the patterns of inequality that characterize not only the distribution of impacts of climate change, but also the question of responsibility in causality. It is also clear that those who will be most affected are the least responsible for producing the causal features of global climate change (Adger et al 2006).

United Nations covenants and conventions establish the human rights to health, a decent existence, work and occupational safety, an adequate standard of living, freedom from hunger, an adequate and wholesome diet, decent housing, education, culture, equality and non-discrimination, dignity, and harmonious development of the personality, the right to security of person and of the family, the right to peace and the right to development (United Nations Universal Declaration of Human Rights 1948).

These rights are considered the ideal that all governments should strive for; that is, basic life requirements that all human beings are entitled to. At some level all these rights depend on the environment. Global environmental change will challenge all of these human rights, but we must be clear that environmental change does not necessarily undermine human security in the absence of poverty, lack of economic opportunity,

Vulnerability describes the degree to which a socio-ecological system is either susceptible or resilient to the impact of natural hazards.

Vulnerability to sea level rise is most suffered by those who have had very little to do with climate change.

lack of state support, good governance, and social cohesion with surrounding groups (Hamza 2007).

Traditionally and still today in many contexts, respect for human rights is framed in moral arguments. Abuse of human rights brings expression of moral outrage. By contrast, environmental issues and policies have been framed in economic arguments; abuse of the environment causes quantifiable economic harm. Around the mid 1980s in various locations around the world two important social movements, human rights and environmentalism, converged. The key issue in this convergence is selective victimization, the abuse of environmental rights. Essentially the linking of human rights abuse and environmental degradation takes place through the process of selective victimization in which pre-existing social conditions result in the loss of critical resources and a healthy environment, exposing certain groups to hazardous environmental conditions while others are free to live in a healthy setting. Vulnerability to sea level rise is most suffered by those who have had very little to do with the processes driving climate change.

Section II

2.1 Global Climate Change

Global climate change has already begun to have serious impacts on socio-ecological systems around the world. Increased average temperatures have set in motion a variety of forces that are producing rises in sea levels globally and, in a number of specific locales, they promise to have serious impacts in both proximate (decades) and distant (centuries) futures. Most recent scientific assessments of global climate change indicate that sea level rise will have significant impacts on coastal environments and their biotic communities, including human settlements. Moreover, the quantity of greenhouse gases already in the atmosphere has entrained the process of climate change beyond prevention. Essentially, we must now engage in processes of mitigation and adaptation. In effect, climate change is taking place and will cause sea levels to rise for centuries even if greenhouse gas emissions are stabilized (Alley et al 2007: 17). Therefore, climate stabilization may reduce potential impacts, but there will still be the need to adapt to sea level rise (Nicholls and Tol 2006: 1089). The major issue now at hand is how much sea level rise will take place, particularly if efforts at stabilizing or diminishing greenhouse gas emissions are either non-existent or not effective.

To assess the likely impacts on human populations from sea level rise, we should consider the following issues: projected increases in sea level, physical exposure, socially constructed vulnerability and the impacts of sea level rise on specific exposed populations. However, assessment of these factors constitutes only a partial analysis of the displacement and migration processes. The potential impacts of adaptation and mitigation policies as well as potential local level adaptations, including migration/displacement and resettlement processes, on people affected by sea level rise must also be considered with a concern for policy development aimed at positive responses to such outcomes.

The three basic questions that the research community must answer and the policy community must respond to are:

- 1) What combination of factors of sea level rise and social vulnerability will require significant adaptive strategies by affected populations?
- 2) Are there culturally constructed adaptive/mitigative strategies that will enable people to remain in place in viable communities?
- 3) If people are displaced by sea level rise, what will happen to them?

Indeed, in much of the debate surrounding environment and migration, the great unanswered question, almost in fact, the great unasked question, is what will happen to people uprooted by the forces set in motion by environmental change? Where will they go? And what will they do when they get there? And, as Cannavò suggests, are we fooling ourselves to think that we can simply move populations out of

The quantity of greenhouse gases already in the atmosphere has entrained the process of climate change beyond prevention.

The factors largely responsible for sea level rise are ocean thermal expansion and glacial melt.

harm's way and they will weather environmental change relatively easily (2008: 178; Oliver-Smith 2009)? Up to this point in time, the major focus of attention has been on the relationship between environmental change and migration. I would suggest that we should include in that focus the problem of resettlement which is a far more stressful and complex process than some have imagined (Beckerman 1992 as cited in Cannavò 2008).

2.2 Global Climate Change and Sea Level Rise

The factors largely responsible for sea level rise are ocean thermal expansion, which expands existing water volume, and glacial melt, largely from Greenland and Antarctica that adds water to the oceans (Hemming et al 2007). Other researchers add the additional factor of changes in terrestrial water storage (Dasgupta et al 2007). Estimates of the extent of sea level rise, including those from most recent research over the last five years, have varied considerably. These variations, or uncertainties, in projections are due largely to differences between the various Global Climate Models employed and the assumptions made about future greenhouse gas emissions (Hemming et al 2007). In addition, global sea level changes will not be uniform. Due to regional variations in the gravity field of the earth driven by changes in the West Antarctic Ice Sheet (WAIS) ice mass, deformations of solid earth mass and alterations in the rotation vector of the planet caused by mass redistribution, certain areas, such as the Pacific and Atlantic coasts of the United States and the nations bordering the Indian ocean will experience significantly higher sea level rises (Bamber et al 2009: 902; Mitrovica et al 2009: 753). Because of the various assumptions and different scenarios on which studies have been based, they have proved difficult to synthesize to the larger scales that are necessary for policy discussion (Nicholls and Hoozemans 2005). The *Intergovernmental Panel on Climate Change (IPCC) Third Assessment Report* (2001) predicted sea level rises of approximately one meter in the 21st century. Hemming et al (2007) project that by 2030 seas will rise from between 8 cm and 13 cm; by 2050 from 17 cm to 29 cm, and by 2100 from between 35 cm and 82 cm. The *IPCC Fourth Assessment Report* places estimated sea level rise at up to 0.6 meters or more by 2100 (IPCC 2007).

However, recent research on rates of glaciological change in Greenland and Antarctica indicates a need to rethink the upper limits of estimates of sea level rise. Data based on expansion of glacial flow from lower to higher latitudes when combined with surface loss estimates for the Greenland ice sheet indicate a doubling of the rate and twice the loss of the previous decade as estimated in the *IPCC Third Assessment* in 2001 (Ringot and Kanagaratnam 2006; Hanna et al 2005; Dasgupta et al (2007). Even greater losses were recorded in Antarctica, in particular for the WAIS. Moreover, the stability of the WAIS, resting on bedrock below sea level is a cause for concern. If global warming results in the collapse of the WAIS into the sea, the displacement alone would raise average sea levels by approximately

500-600 cm (Tol et al 2006; Dasgupta et al 2007). Pfeffer et al, combine likely projection methods for Greenland, Antarctica and marine terminating glaciers and ice caps, offer three scenarios that roughly bracket the spread of near future sea level rise possibilities (2008). A low range estimate, including thermal expansion, places sea level rise, 78.5 cm by 2100. A second low range estimate, arrived at by slightly accelerating rates of net discharge for Antarctica, produced a rise of 83.3 cm, including thermal expansion, by 2100. A third scenario, produced from high, but still reasonable values, represents the likely upper limits at 200.8cm including thermal expansion by 2100 (Pfeffer et al 2008: 1342). These scenarios suggest that sea level rise may occur at greater volume and in significantly reduced time frames than those projected by the IPCC (Pfeffer et al 2008); Dasgupta et al 2007; Vaughan and Spouge 2002). And finally, Bamber et al (2009:903) have reassessed potential sea level rise from WAIS collapse, concluding that increases will only reach 3.2 meters, roughly half of previous predictions. However, 3.2 meters will still constitute an enormous rise in sea level with catastrophic potential for coastal dwelling populations. There is considerable discussion surrounding the question of the rates at which seas will rise. Despite some short-term variation, global sea level is rising at rates significantly faster than expected. In addition, those rates are expected to accelerate as global warming increases the temperatures of the air, hastening land ice melting and in the ocean, adding to thermal expansion of seawater.

Sea level rise will manifest itself basically in two forms: through gradual increases in eustatic sea level and their effects over time and through rapid onset events, whose effects will be expressed and exacerbated by sea level rise and related phenomena. Gradual manifestations will include geomorphic changes (primarily coastal erosion and subsidence), altered hydrology, habitat and species change, changes in water temperature and chemistry, changes in air temperature and chemistry, impacts on human economy and health, infrastructure, land use changes, variable risk, and ultimately inundation of land and communities (Beever 2009). Altered hydrology will include salinization of fresh water aquifers, including agricultural land and water supplies. Sea level rise may also be expressed through sudden onset phenomena such as storms, hurricanes, typhoons, and monsoon rains that will flood and inundate occupied lands much more rapidly and much more extensively because of sea level rise. Natural system effects from sea level rise will be inundation, flood and sea surge and backwater effect, wetland loss, erosion, saltwater intrusion into surface waters and groundwater and rising water tables with impeded drainage (Nicholls and Tol 2006: 1075).

2.3 Physical Exposure to Sea Level Rise

A number of attempts have been made to characterize physical exposure to sea level rise. Such projections tend to vary somewhat according to scale or unit of analysis, which range from global elevation zones to hypothetical scenarios, which vary themselves according to

Sea level rise may also be expressed through storms, hurricanes, typhoons, and monsoon rains that will flood and inundate occupied lands much more rapidly and much more extensively because of sea level rise.

Human settlements have historically been situated in or within 100 miles of coastal or riverine areas for both production and exchange purposes.

a range of evolving factors such as increased or decreased greenhouse gas emissions, lack of construction of defensive structures, and demographic growth or movement. The uncertainties in sea level rise and coastal impacts are due primarily to different climate models. In most cases the uncertainties are smaller than average sea level rise projections, but in some regions (northern Greenland, the Arctic Islands, the southern tip of South America and the Falkland Islands) they are similar or greater than the average. These representations, however, constitute only a part of the total uncertainties in sea level rise and coastal impact projections. They cannot represent the uncertainties in coastal data pertaining to population, defensive structures, or storm characteristics and their evolution through time (Hemming et al 2007).

Demarcating a coastal exposure zone, McGranahan and his colleagues carried out a global review of population and urban settlement patterns in the *Low Elevation Coastal Zone* (LECZ) (0-10 meters above sea level (2007). The LECZ was chosen for reasons of data reliability at the global scale, which is able to encompass the variation between areas such as the deltas of major rivers, in which the LECZ extends far inland (over 100 kilometers) as well as regions such as mountainous bays where the zone is significantly narrower. Noting that human settlements have historically been situated in or within 100 miles of coastal or riverine areas for both production and exchange purposes, McGranahan and his colleagues also point to the hazards those advantages present, particularly for urban populations. Currently, 10 % of the global population (600 million people) reside in the LECZ (2 % of the world's land mass), but there has been and continues to be a steady demographic increase through migration to coastal regions. In addition, 13 % of the world's urban population lives in the LECZ, residing in 65 % of cities with populations larger than five million people. As can be seen in the following table, Asia contains fully one third of the land in the LECZ, but the small island states show the highest percentage of land in the LECZ.

Table 1**Population and land area in the Low Elevation Coastal Zone (LECZ) by region, 2000**

Region	Population and land area in LECZ				Share of population and land area in LECZ			
	Population (million)		Land ('000 km ²)		Population (%)		Land (%)	
	Total	Urban	Total	Urban	Total	Urban	Total	Urban
Africa	56	31	191	15	7	12	1	7
Asia	466	238	881	113	13	18	3	12
Europe	50	40	490	56	7	8	2	7
Latin America	29	23	397	33	6	7	2	7
Australia and New Zealand	3	3	131	6	13	13	2	13
North America	24	21	553	52	8	8	3	6
Small Island States	6	4	58	5	13	13	16	13
World	634	360	2,700	279	10	13	2	8

(McGranahan et al 2007: 24)

Researchers at the *Hadley Centre for Climate Prediction and Research* project that global average sea level will rise between 0.10m and 0.15m by 2030, 0.18m and 0.30m by 2050 and 0.41m and 0.88m by 2100, the variations due to differences in emission levels projected and in models used. They assess that thermal expansion accounts for 58% of the absolute sea level rise, while glacial melt is the source of 35% and about 8% is due to melt from the Greenland ice sheet, although it is expected to increase over the century as Antarctic melt contributes less. The largest relative sea level rises will occur by 2030 in areas such as the eastern seaboard of the United States, the Gulf of Mexico, the southern tip of South America, the Falkland Islands, and the Netherlands. In addition, many of the deltas of large rivers, such as the Mississippi, Rio Grande, Rhone, Nile, Bramaputra, Euphrates/Tigris and the Niger are predicted to experience significant sea level rise as well. They estimate that the rate of global land loss will increase from 2,500 km² per year between 1990 and 2040 to 17,500km² per year between 2040 and 2100. They further indicate that 50,000 square kilometers of land could be submerged globally by 2030, increasing to 180,000 square kilometers in 2050 and 1,130,000 by 2100. The areas experiencing the largest land loss by 2030 and 2050 are projected to be the Arctic Ocean coasts of Canada, Alaska, Siberia and Greenland. The coasts of Pakistan, Sri Lanka, southeastern Indonesia and eastern Africa from Kenya south to Mozambique will experience land losses of between 2,500 and 5,000 square kilometers a year. If both population and emissions continue to grow at high rates, the

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number of people flooded per year will reach 21 million by 2030, 55 million by 2050 and 370 million by 2100. The populations with greatest exposure to coastal flooding from sea level rise are in South and Southeast Asia, especially Bangladesh, India, Pakistan, eastern China and southern Indonesia (Hemming et al 2007).

Dasgupta et al (2007) in a *World Bank Policy Research Working Paper* on the impact of sea level rise on developing countries reviewed data on 84 coastal developing countries in five regions that correspond to the five regional departments of the bank. Their review revealed that approximately 0.3% (194,000 square kilometers) of the territory of the 84 developing countries would be impacted by a 1 meter sea level rise, increasing to 1.2% if the sea rose 5 meters. Population exposure at 1 meter would involve approximately 56 million people, increasing to 89 million at a 2 meter rise and 245 million for a 5 meter rise (Dasgupta et al 2007: 9-10) for the 84 developing countries reviewed. In terms of land area exposure, their research asserts that at one meter increase in sea level the ten most exposed developing world nations are The Bahamas, Vietnam, Qatar, Belize, Puerto Rico, Cuba, Taiwan, China, The Gambia, Jamaica and Bangladesh. In terms of percentage of population, the most exposed nations to one meter of sea level rise are Vietnam, A. R. Egypt, Mauritania, Suriname, Guyana, French Guiana, Tunisia, Syria, The Bahamas, and Benin. These figures, useful as they are, however, should be seen in context. In absolute numbers, a high percentage of a relatively small population, such as in Suriname (36% of 476,000), is considerably fewer people than a lower percentage of a much larger population, such as in Bangladesh (9.1% of 153.5 million), where it is possible that almost 14 million people would be impacted.

The authors of the chapter on coastal systems and low-lying areas of the *Fourth Assessment Report* of the IPCC, under the coordination of Robert J. Nicholls of the *Tyndall Centre for Climate Change Research*, estimate a rise in sea level of up to 0.6 meters or more by 2100. This research focuses on geomorphological and biological features in assessing areas of physical exposure to sea level rise. They consider beaches, rocky shorelines, cliffed coasts, deltas, estuaries, lagoons, mangroves, salt marshes, sea grasses and coral reefs before assessing any exposure of human communities (Nicholls et al 2007). Their examination makes clear, however, that impacts on the systemic dimensions of these natural features have serious implications for both proximate and distant human communities. In terms of population and economies, they pay special attention to deltas and mega deltas as hotspots for exposure. Assuming no upgrade in defensive structures, a 40 cm sea level rise is projected to flood more than 100 million people per year (Nicholls et al 2007: 334). Ericson et al (2006) in a study of 40 river deltas worldwide, representing all climate zones, levels of population density and degrees of economic development, assert that at contemporary rates of sea level rise through 2050, 8.7 million people and 28,000 km² could experience inundation and increased soil erosion (2000: 63). Their study also found that direct

anthropogenic effects greatly affected estimated sea level rise in the majority of the deltas examined, with relatively less impact from eustatic sea level rise (Ericson et al 2006: 63). The implications of these findings indicate that human-environment interactions play a major role in the vulnerability of human communities in the delta regions of the world.

However, in the assessment of impacts of sea level rise, the global or regional average is less important than the local change or rate of change in relative sea level. Relative sea level, or observed sea level, is the level of the sea in relation to the land. Relative sea level is influenced by global or absolute sea level change, but it is also affected by vertical movements, either uplift or subsidence, which are regionally and locally variable as well as non-uniform distribution of water from ice melt. Vertical movements are mostly the outcomes of natural processes, but human induced changes such as groundwater extraction or removal of sediments in deltas can accentuate subsidence (Klein and Nicholls 1999: 182-3). For example, despite a 20th century Northeast Pacific rate of sea level rise consistent with global average estimates, tectonic and sediment loading subsidence in the Puget lowland-Strait of Georgia area may aggravate predicted sea level rise in the greater Vancouver-Seattle-Tacoma area. However, tectonic uplift along sections of the west coast may also compensate for roughly half of projected sea level rise (Mazzotti et al 2007).

Many of these projections have recently been called into question, however, for being too conservative. Research presented at the just concluded *Copenhagen Climate Congress* (2009) indicates that current high rates of greenhouse gas emission are pushing the worst case IPCC scenarios to greater extremes at even faster rates. The key parameters of the climate system, including global mean surface temperature, sea-level rise, ocean and ice sheet dynamics, ocean acidification and extreme climatic events, have surpassed patterns of natural variability that have traditionally sustained societies and economies (Climate Congress 2009). Particularly significant for sea-level rise, ice sheet and glacial loss, omitted from the 2007 IPCC report because these processes were poorly understood, is now better grasped and is accelerating, with glacial melt constituting two thirds of the loss (Kintisch 2009: 1546). Furthermore, recent data from satellites and field research reveal that the ice sheets are diminishing in Greenland and Antarctica and at current rates will produce a rise of one meter or more around the world. Although not projected to disintegrate entirely, even a 15% loss to the Greenland Ice Sheet would generate a one meter rise in sea level (Kintisch 2009: 1546). And compounding these alarming findings, improved methodologies revealed two further trends that will increase temperatures. Now estimated at containing 1.7 trillion tons of carbon, more than twice the IPCC estimate, permafrost melt could release even more greenhouse gases from permafrost, especially methane, into the atmosphere, thereby adding to the warming of the climate. Warming temperatures could trigger droughts that could lead to the loss of 40% of the Amazon,

Human-environment interactions play a major role in the vulnerability of human communities in the delta regions of the world.

turning it into a carbon producer, through decay of dead vegetation, from its current role as a carbon sink or absorber (Kintisch 2009: 1547). Fires, provoked in drought affected forests, could produce similar outcomes.

These recent projections will make assessments of local vulnerability easier or surer only at the extremes. Adequate projections of local impacts will still depend on the careful analysis of local vulnerabilities which continues to represent a significant challenge. The main obstacles to comprehensive vulnerability assessment at any scale are: 1) incomplete knowledge of the processes involved in sea level and their interactions; 2) inadequate data on existing conditions; 3) challenges in developing scenarios for climate change at local and regional levels; and 4) the dearth of appropriate analytical methods for some kinds of impacts (Nicholls and Hoozemans 2004: 486).

2.4 Sea Level Rise and Socially Constructed Vulnerability

Vulnerability science has made clear, however, that exposure to hazards alone, does not determine where the serious effects of any hazard, including sea level rise will most likely be experienced. And focusing solely on exposure is, as Finan, points out, climate change without a human face (2009). What can we expect from future increased sea levels for specific regions and communities? To answer that question is difficult because of the numerous variables and the non-linearity of their interactions, but we can look to current instances of sea level rise and local adaptations for aid in constructing the necessary scenarios with which to frame appropriate policy responses and effective practice.

The challenge lies in determining not just absolute exposed land and absolute exposed population but specific lands and populations in different socially configured conditions of resilience or vulnerability. These conditions of vulnerability are accentuating rapidly due to increasing human induced pressures on coastal systems. Coastal populations around the world have increased enormously in the 20th century and are expected to continue to grow in the 21st century from 1.2 billion (in 1990) to between 1.8 and 5.2 billion by 2080 (Nicholls et al 2007: 317). Moreover, the vulnerability of a nation to coastal hazards and climate change is partially a function of its level of development and per capita income (Nicholls et al 2007: 331). The lesser developed countries have a significantly higher proportion of their total populations and their urban populations in the low elevation coastal zone (McGranahan et al 2007: 26), suggesting that the impacts of climate change, including the heavier socio-economic costs created by climate related hazards and disasters, will probably be greater on coastal regions of developing countries with fewer resources for mitigation and adaptation (Nicholls et al 2007: 331).

However, the problem with assessing the exposure of both land and population to sea level rise is that not only are we dealing with projected increases in sea level, but also with various future projections about various physical, societal and infrastructural trajectories in-

The challenge lies in determining not just absolute exposed land and absolute exposed population but specific lands and populations in different socially configured conditions of resilience or vulnerability.

cluding greenhouse gas emissions, demographic change, migration trends, infra-structural development, mitigation strategies, adaptive capacities, vulnerabilities and patterns of economic change, all of which will play out in different ways, according to the political, economic and socio-cultural dispositions of national governments, international organizations and general populations (Nicholls and Toll 2006: 1077).

In order to generate projections that lend themselves to policy construction, the IPCC developed a set of greenhouse gas emissions scenarios to present possible socioeconomic pathways that would affect global outcomes of climate change, including sea level rise (Nakicenovic and Swart 2000). Creating scenarios is important, not because they are necessarily accurate or true, but because they require improving understanding of the problem in order to be able to frame it properly. Scenarios require us to consider a broader range of eventualities and responses. The *Special Report on Emission Scenarios* (SRES) produced a set of four storylines that are basically alternative socioeconomic pathways that the world might follow in terms of political, economic, social and technological development. Called the A1, A2, B1 and B2 worlds, each scenario is thus a short narrative of alternatives of future global development that is meant to assist in climate change analysis and the assessment of impacts, adaptation and mitigation.

Each scenario depicts a set of social, economic, political and technical conditions, quantified at a global and regional scale. The scenarios are constructed in the following fashion:

Table 2

A1 World	B1 World
Increasing globalization/ convergence	Increasing global cooperation/ convergence
Materialist/consumerist	environmental priority
Rapid uniform technological innovation	clean and efficient technologies
A2 World	B2 World
Heterogeneous world	heterogeneous world/ local emphasis
Materialist/consumerist	environmental priority
Diverse technological innovation	clean and efficient technologies

(Nicholls and Tol 2006: 1076)

The scenarios are based on the assumption that the main driving forces of future greenhouse gas trajectories will continue to be demographic change, social and economic development, and the rate and direction of technological change. The analysis of these scenarios in

The problem with assessing the exposure of both land and population to sea level rise is that not only are we dealing with projected increases in sea level, but also with various future projections about physical, societal and infrastructural trajectories including demographic change, migration trends, infra-structural development, mitigation strategies, adaptive capacities, vulnerabilities and patterns of economic change.

Human attitudes toward the environment may prove to be more significant than sea level rise, suggesting that if coastal populations act judiciously, there may be a wider array of choices than has been assessed.

the 15 most vulnerable countries assessed in the SRES worlds predicts significant impacts to coastal areas by sea level rise flooding. It should be noted that of the fifteen countries, eight are small island nations and three are home to large river deltas. The analysis also shows that these impacts can be mitigated through climate stabilization and adapted to by protective measures for coastal settlements. Indeed, the authors contend that human attitudes toward the environment may prove to be more significant than sea level rise, suggesting that if coastal populations act judiciously, there may be a wider array of choices than has been assessed. The key factor in this analysis from an economic (cost-benefit) perspective would appear to be the level of development of the affected region, enabling investment in widespread protection rather than abandoning occupied coastal properties (Nicholls and Tol 2006: 1089). Indeed, it is generally agreed that lower growth and levels of development will likely lead to more destructive episodes. This project has evoked considerable debate, particularly around some of the assumptions on which the scenarios were based. For example, all the scenarios describe futures that are generally more affluent as well as experiencing a reduction in income differences among world regions than the time of their construction, an assumption not entirely warranted given current development outcomes and general world economic conditions.

However, these scenarios and a somewhat more specific sub-set serve as only the broadest guidelines for coastal flooding and economic impact assessments since they are all based on calculations at the national scale and uncertain data sets (Nicholls and Tol 2006: 1089). Interestingly, the SRES scenarios do suggest that the A2 and B2 scenarios project the most vulnerable conditions, but due to differences in the socioeconomic situation (coastal population, gross domestic product, and gross domestic product/capita) rather than to increased sea level rise (Nicholls and Tol 2006: 1073). While this finding is indeed informative, how useful is it for actual identification of specific local populations that are vulnerable to sea level rise?

At this point in time, do we have the methodological and analytical tools to enable the identification of those most vulnerable at the local level to sea level rise today? While our projections of sea level rise have now acquired considerable confidence, short of areas of total inundation, it is still difficult for existing global climate models to profile the scope of changes that will occur in particular nations, much less specific localities (Dow et al 2006: 84). Moreover, our abilities to assess the vulnerability of specific localities are also limited, particularly as these areas interact with larger regional, national or international forces. The identification of vulnerable groups spatially and temporally with sufficiently high accuracy for comparative purposes of climate impacts is currently not possible.

However, we do have sufficient knowledge to identify broad regions that are vulnerable to climate change generally and sea level rise specifically and to design strategies for reducing that vulnerability. In

other words, we know the areas that will be prone to certain types of climate change and extreme events. By combining that general knowledge with specific case studies, we can both track the changes that are occurring, monitor their effects and use the information to generate more focused scenarios to develop appropriate policy responses.

To rephrase our first fundamental research question, how do local socio-ecological (environmental) conditions, including physical (subsidence, erosion, etc) and social conditions (social vulnerability) interact with global sea level rise to induce local measures to adapt, mitigate (exhibit resilience) or, in the worst case, migrate? In reference to social vulnerability, with regard to sea level rise there are processes undertaken by human beings that undermine the natural systems of which they are a part. These forms of socio-ecological vulnerability can be imposed on a local environment, however, by exogenous social, political and economic forces. Such processes as subsidence due to construction, pipelines, etc., erosion of tidal marshes, and the destruction of mangroves, are the outcomes of human action on the natural features that increase exposure of land (and occupant populations) to sea level rise.

Other outcomes of particular social and economic configurations such as tourism or fishing economies, coastal demographic movements, or residential construction on coastlines also render populations vulnerable to sea level rise. For example, the *Fourth Assessment Report* of the IPCC assesses sea level rise in terms of hotspots that exhibit both exposure and vulnerability:

Table 3

Controlling factors	Examples from this Chapter
Coastal areas where there are substantial barriers to adaptation (economic, institutional, environmental, technical, etc.)	Venice, Asian megadeltas, atolls and small islands, New Orleans
Coastal areas subject to multiple natural and human-induced stresses, such as subsidence or declining natural defences	Mississippi, Nile and Asian megadeltas, the Netherlands, Mediterranean, Maldives
Coastal areas already experiencing adverse effects of temperature rise	Coral reefs, Arctic coasts (USA, Canada, Russia), Antarctic peninsula
Coastal areas with significant flood-plain populations that are exposed to significant storm surge hazards	Bay of Bengal, Gulf of Mexico/Caribbean, Rio de la Plata/Parana delta, North Sea
Coastal areas where freshwater resources are likely to be reduced by climate change	W. Africa, W. Australia, atolls and small islands
Coastal areas with tourist-based economies where major adverse effects on tourism are likely	Caribbean, Mediterranean, Florida, Thailand, Maldives
Highly sensitive coastal systems where the scope for inland migration is limited	Many developed estuarine coasts, low small islands, Bangladesh

(Nicholls et al 2007: 337)

We do have sufficient knowledge to identify broad regions that are vulnerable to climate change generally and sea level rise specifically and to design strategies for reducing that vulnerability.

There are many aspects of sea level rise that will affect the sustainability of coastal peoples and communities, but may or may not pressure people to move.

Section III

3.1 The Social Impacts of Sea Level Rise

The social and cultural impacts of sea level rise are just beginning to be explored, particularly in terms of how resource use will be affected and how these changes in turn will affect social relations as well as belief systems regarding orientations toward the customary environments. Current discussions of adaptation to sea level rise often speak of adaptation as a relatively straight forward process, unencumbered by false starts, discontinuities, conflicts or disorientation.

In the total range of effects of significant sea level rise it is only possible at the extreme of complete and permanent inundation to state that people will be unequivocally displaced. If the land that a community occupies and exploits is completely and permanently submerged, displacement will occur. However, there are many aspects of sea level rise that will affect the sustainability of coastal peoples and communities, but may or may not pressure people to move. Coastal storm surges, subsidence and erosion, salinization of ground water and rising water tables, and impeded drainage all may seriously impact both residence and agricultural production in vulnerable communities. Wetlands, estuaries and mangroves, constituting both the ecological and economic base, of many coastal communities may be seriously damaged by sea level rise, requiring adaptation, mitigation or forcing people to leave. In resilient communities, sea level rise changes that fall short of total submergence may be adapted to and/or mitigated by a variety of strategies. Mitigation and adaptation will generally be characterized by changes in technology and social (and economic) organization. Restoration of mangroves and wetlands or protective structures (dikes, levies, etc) may afford sufficient defenses from storm surges. Or adaptive strategies, such as adoption of new forms of economic activities, may enable people to adapt to changing conditions. However, while the effects of sea level rise may in many cases be gradual, they will probably not be gradual enough to avoid the disorientation that comes from the loss of familiar staple crops, the failure of traditional livelihoods or the transformation of known environments. People may adapt, but the process promises to be disruptive and difficult, particularly for indigenous peoples whose relationship to their environment tends to provide a key element in their identity.

How can we construct scenarios that will aid in the elaboration of strategies that people can use to adapt to or mitigate sea level rise? As mentioned earlier, specific case studies of local efforts to adapt will play a key role when combined with the broader patterns of vulnerability and exposure that have been identified (Dow et al 2004). The local level occurrences of sea level rise that are now taking place can provide insight into both the range of its effects, the challenges they represent and possible adaptive options available to communities.

Moreover, the experience and knowledge of local people gleaned from local cases can add to the fund of options available to similar communities facing similar challenges. Such information is best obtained through in-depth ethnographic research that explores traditional environmental knowledge and practice.

In a study of adaptation to climate extremes, Finan and his colleagues developed an approach to building local adaptations (Finan et al 2002). They start with the assertion that adaptation will be based primarily on changes in two interrelated features, technology and social organization. It is well established that changes in technology frequently require the reorganization of rules and regulations regarding the distribution and use of resources by a population of users (Johnson and Earle 1987). In terms of a focus on adaptation the interaction of technology and social organization has three dimensions: distributive, institutional, and empowerment (Finan 2009: 182-3). The distributive dimension focuses on those variables affecting livelihood, including household assets, local resource knowledge and mobilization strategies, environmental stressors, and outcomes like income, food security, health, and other possible benefits. Institutional analysis links local contexts to broader forces and domains of power such as markets, political systems, government and international organizations and agencies, both enabling access to non-local resources as well as the limitations of externally imposed constraints. The empowerment dimension encompasses systems of common property management and community based and driven development. Although all three domains will be affected by and will respond to environmental stressors, it is likely that many communities will face the need to reorganize local institutions or devise new ones to adapt effectively (Finan 2009: 182-3).

While this approach might not fit all cases equally well, it provides insight into how the problem of adaptation to climate change can be framed both conceptually and confronted on the ground. The following case studies provide examples of combining broadly drawn patterns of exposure and vulnerability with local case material developed through detailed ethnographic research.

3.2 Local Culture and Sea Level Rise in Tuvalu

As Nicholls and Tol (2006) point out, local attitudes toward the environment will play a central role in adjustments to climate change. For example, since human induced coastal subsidence increases exposure to sea level rise, the capacity of societies to change both belief and behavior regarding the use of the environment will be key in mitigating these risks. Moreover, local knowledge will be instrumental in the patterns of adaptation and mitigation of climate induced sea level rise.

From the point of view of exposure, there would seem to be few places on earth more exposed to sea level rise than the *Small Island Developing States* (SIDS) of the Pacific, particularly Tuvalu, Kiribati, and

Local attitudes toward the environment will play a central role in adjustments to climate change.

Sea level rise is a major concern for low-lying islands, but there are other issues that demand as much or more attention, such as agriculture.

the Carteret Islands; and their exposure is followed closely by that of those in the Indian Ocean, particularly the Maldives, although the *Third Assessment Report* of the IPCC asserted that all island states would be negatively impacted by increases in sea levels (IPCC 2001; Pelling and Uitto 2001:56).

As is increasingly well known, Tuvalu, the Pacific Island country of low lying atolls and reef islands, is one of the most exposed places in the world to the effects of global climate change caused sea level rise. Tuvaluans are portrayed in the popular press as the poster children for climate change impacts. A great deal of attention has been paid to the accord called the *Pacific Access Category*, erroneously represented in the press as the environmental migration agreement, through which an annual quota of 75 Tuvaluans (among various numbers from other Pacific Island nations) is allowed to migrate to New Zealand. The Pacific Island category was not developed as an adaptation to climate change and sea level rise, but rather to facilitate migration, which is an economic necessity as well as part of a lifestyle, even a social routine, of Pacific Islanders (Gemenne and Shen 2009: 9,11).

The environmental threats from climate change to Tuvalu are considerable. Undoubtedly, sea level rise is a major concern for these low-lying islands, but there are other issues that demand as much or more attention. Agriculture is extremely difficult in Tuvalu because of the salinity of the soil, which is now considerably increasing, making the cultivation of taro, the main crop, ever more difficult. In addition, the increasing intensity and frequency of extreme weather events are issues that Tuvaluans must contend with, especially in the context of sea level rise, which would exacerbate the already serious impacts of these storms. Increased intensity, but decreasing frequency in rainfall regimes also represent a threat to life on these water scarce islands, where both saltwater flooding and droughts have reduced supplies for the growing population (Gemenne and Shen 2009: 9). Other effects of climate change include changes in surface and subsurface ocean temperatures, ocean acidification and coral bleaching, pest infestations, reef fisheries deterioration, increase in communicable diseases and infra-structural damage (Lazrus 2009: 242).

Despite the scientific consensus on these effects, local experiences and understandings of climate change, and particularly sea level rise are clearly mediated through linguistic and cultural grids, and account for greater variability in assessments of risk and vulnerability (Oliver-Smith 2004: 17). Lazrus documents a cultural tradition of narratives, stories, and legends that recount how the challenges of island life are endured and survived, providing mythical metaphors for understanding and adapting to environmental changes (2009a: 243). This tradition reinforces peoples' belief in their understanding of environmental change and their faith in their capacity to adapt and cope with the challenges that sea level rise in particular, presents to them (Lazrus 2009a). Using traditional environmental markers to establish changes, Tuvaluans are well aware of the threats of sea level

rise, but their response in large part is to develop locally based responses and adaptations rather than whole scale migration, which some admit may become a necessity in the future. This does not mean that people are not migrating, but, as mentioned earlier, their motivations for migration are still primarily economic (Gemenne and Shen 2009: 24). Local constructions of vulnerability and climate change, especially sea level rise, however, contend with at least four other approaches to the problem, setting up tensions between local people, nationalist frameworks, scientific and technical assessments, apocalyptic journalistic interpretations, and NGOs and international organizations concerned with the impacts of climate change (Lazrus 2009b). In many respects, the contending interpretations come from sectors that possess much greater political and social power and threaten to subsume or ignore local interpretations, thereby undermining local capacities to respond to the difficult conditions that may emerge in the relatively near future.

The response of Tuvaluans to current conditions provides an important lesson for the construction of scenarios for island nations under threat from sea level rise. It is clear that effective adaptations, whether moderate or extreme, must be based on, or at the minimum, be consistent with local interpretations and values. And it is equally clear that any scenario that is constructed for use in guiding both policy and strategy in dealing with sea level rise, must allow traditional knowledge and local interpretation to frame the challenges faced if culturally acceptable as well as effective adaptations are to be developed. The assertions of the people of Shishmaref on the Seward Peninsula in Alaska (discussed below), facing similar threats from sea level rise and coastal erosion, confirm this position (Marino and Schweitzer 2009). Local knowledge and control are essential if outside agencies expect to work effectively with local communities in developing adaptations to sea level rise and climate change in general. As Bankoff points out, local knowledge must be respected, not merely tolerated as an alternative discourse, if serious missteps with potentially calamitous results are to be avoided in coping with sea level rise (2004: 35; Lazrus 2009a: 247).

3.3 Local Economy and Sea Level Rise in Bangladesh

Barring outright displacement, a primary field of adaptation to sea level rise will be in the realm of economics. Sea level rise, particularly as manifested in the loss of land through soil and water salinization, coastal erosion, reef fisheries infestation and other impacts, will require major adjustments in economic structures and practices by affected communities to sustain production and distribution of resources. Regional, national and international agencies hoping to assist people coping with sea level rise will need focused scenarios to craft appropriate policies and practices that enable people to adapt economically to the changing access to resources.

Effective adaptations, whether moderate or extreme, must be based on, or at the minimum, be consistent with local interpretations and values.

Roughly half the nation of Bangladesh will be flooded if sea level rises were to reach a meter, well within the most recent estimates.

Sea level rise is expected to inflict some of its most grievous impacts on the nation of Bangladesh, one of the poorest and most densely populated countries in the world. As home to seven major and more than two hundred minor rivers, rivers in Bangladesh dominate the ecology, the economy and the culture of the country. Rivers are used for irrigation, transportation and aquatic resources. As a delta country, most of Bangladesh is well within the LECZ of 10 meters or less (Poncelet 2009: 3; McGranahan et al 2006). As such, roughly half the nation will be flooded if sea level rises were to reach a meter, well within the most recent estimates (Ali 1996; Kintisch 2009). The delta of the Ganges-Brahmaputra-Meghna river system affects roughly one third of the nation's land area and 70% of the people. In addition, the region is prone to cyclones, storm surges and backwater effects (saltwater intrusion). Dasgupta et al rank Bangladesh first in South Asia for percentages of population, GDP, urban extent, and agricultural extent impacted and third for wetlands impacted from 1 to 5 meters of sea level rise (2007: 37-39). In Bangladesh two thirds of the total population of 150 million people, more than half of whom subsist on less than a dollar a day, are likely to be affected. In addition, 10% of fertile land will be ruined, and the unique biodiversity of the Sunderbans mangrove forests imperiled (Finan 2009: 178). Moreover, fishing and farming livelihoods of the vast majority of the people in exposed zones will be seriously compromised.

The coastal area of Bangladesh occupies over 36,000 km² and contains a very dense population. In the southern coastal region the complex and dynamic hydrological system is based the interaction of both natural and human factors. The interplay of seasonal flooding, water body salinity and tidal movements affects species diversity and distribution as well as the quality and quantity of agricultural land. Global economic trends as well as government investment in earthworks in turn influence the way farmers make decisions in the deployment of resources for production. In this context, Finan's research on beels, small open water bodies located in lowland depressions that are used for aquaculture of shrimp, offers a fruitful context to develop scenarios for economic adaptation to sea level rise (Finan 2009).¹

Beels, containing brackish, salt water or fresh water, vary in size from a few acres to several square miles. During dry winter months fresh water beels shrink to small pools and become small lakes in the monsoon season. In the winter beels are used for rice cultivation and the land around them for pasture. During the monsoon season, the beels fill with rain and floodwaters from rivers and canals in the delta, offering an opportunity for the development of productive shrimp aquaculture in the last twenty years. To cultivate the shrimp, earthen walls (*ghers*) are built to enclose areas within the beel. Subsidiary industries in fry collection and feed provision have also emerged. Vegetables also may be grown along the dike walls, which women

¹ Unless otherwise noted, all material in the following section is drawn from Finan 2009.

largely care for and market. Over the last two decades, the export of shrimp aquaculture has grown into a 350 million dollar industry, and has dramatically improved local livelihoods, increasing income earning possibilities for poor farm families, in particular, women. Although the introduction of aquaculture has produced some environmental changes, altering some traditional production patterns in rice farming and fishing, it has provided an alternative livelihood that has improved the well-being of local households.

However, the combination beel shrimp/gher vegetable production system is also highly vulnerable. The infrastructure of gher technology, the biology of shrimp production and the unpredictability of international markets all contain risks that are not entirely controllable. Sea level rise also represents a major source of uncertainty for this form of livelihood, largely in the form of cyclone driven flooding and back-water saline intrusion as seawater is forced further up into the delta region. Increases in sea levels may increase the salinity of the fresh water in the beels or cyclone driven floods may compromise the gher walls, thus destroying an industry that helps to sustain half a million people, among aquaculturalists, fry collectors and food providers, in a region of dire economic need.

Following the previously mentioned template, Finan suggests that, a long term process of adaptation to sea level rise can be enhanced by attention to two interrelated features: technology and social organization. For the beel/gher system of coastal Bangladesh, the distributive dimension focuses on resource access and resource management strategies, which in effect constitute a livelihood assessment that specifies resource access across a population composed of farmers, laborers, fishers, and shopkeepers. This livelihood assessment constitutes in turn the "response space" of the beel/gher communities, their capacity to respond, or, in other words, their resilience.

The institutional dimension pertains to the power relationships, forms of dependency, local and global markets (and their distortions) and the effects of outside private and public interventions that focus on the sets of resources and practices that exceed the capacity of the community to mobilize. These aspects include major infrastructure, access to new technology, sources of information and networks. For the Bangladesh coast, the institutional dimension includes government water agencies, local, national and international NGOs, local universities and research centers, and the national disaster response and management systems. In sum, the institutional dimension addresses those outside resources (and constraints) that will affect local adaptive efforts.

The third dimension addresses the empowerment of local management. Currently, beels are privately managed and recognized land rights govern the construction and location of gher, in effect reducing the common property available for use during the monsoon season when the beels become open access bodies of water. This also means that decisions on the part of one beel owner can have effects

Sea level rise also represents a major source of uncertainty for aquaculture. Increases in sea levels may destroy an industry that helps to sustain half a million people in a region of dire economic need.

Climate change is happening more rapidly in the Arctic than in any other region and is having serious impacts on both the environment and the people.

on the entire system, adversely impacting other beel owners and gher farmers, particularly in terms of waterlogging and health vectors. To address the vulnerability associated with sea level rise, some kind of social organizational adjustment is indicated, very likely in the direction of common property. Finan suggests that the beel as a hydrological system, would come under collective management, while each farmer would maintain control over individual production, much as lobster stocks are managed by fishermen in the north-eastern US. Beel management can then be organized through a framework of participatory decision-making that will enable system wide technological responses to saltwater intrusion and storm surges. The adaptation process must be localized so that communities can reorganize to address increased environmental uncertainty. In the final analysis, the approach must be organized around local resources, adaptive capacity, and the empowerment of local social organization for decision-making, albeit perhaps enhanced by outside resources and/or hindered by outside constraints.

3.4 Sea Level Rise and Impending Displacement in Alaska

Climate change is happening more rapidly in the Arctic than in any other region and is having serious impacts on both the environment and the people. Known as *Polar Amplification*, the rapid changes are driven by an increase in temperature from 2 to 3.5 degrees Celsius (IPCC 2007). The people of the region have detailed knowledge of widespread coastal changes in the North American arctic, including the Northwest Territories, Yukon, and from Alaska in the west to Nunavut in the east (IPCC 2007:320; Marino and Schweitzer 2009). The increase in temperature has accelerated the melting of sea ice, reducing both extent and thickness, which creates the potential for increased wave generation on exposed coasts. In addition, sea level rise for low relief shorelines is driving rapid erosion, exacerbated by melting permafrost that traditionally has bound coastal soils, warmer ground temperatures, increased thaw and more subsidence linked to ground ice melting (IPCC 2007: 320). The loss of sea ice has severely affected the economics and life ways of resident Native Alaskan populations. In addition, permafrost thawing intensifies release of methane, thus compounding the warming trend by adding yet more greenhouse gas to the atmosphere (IPCC 2007: 320).

Resident Inupiaq people on the Seward Peninsula in Alaska have been witnessing environmental changes that are impacting their subsistence and livelihood for some time (Marino and Schweitzer 2009: 211). Indeed, the erosion of coastal Inuit villages has made one of them, Shishmaref, as emblematic of the impacts of global climate change as Tuvalu in the popular press. Four other villages, Kivalina, Newtok, Koyukuk, and Shaktoolik are also facing immediate displacement and resettlement (Bronen 2009). Each fall storms making land-fall from the Chukchi sea cause massive flooding and erosion, plaguing 86% of Alaska Native villages (184 of 213) (Marino 2009: 3).

For most of these villages there is no higher ground and few distant sites where they could move (Bronen 2009: 4).

In Shishmaref the villagers face imminent danger. A longer fall with warming temperatures and diminishing sea ice no longer protects the village from Chukchi sea storms and the erosion and flooding they produce. It is important to note that residence on the island of Sarichef was seasonal before 1906. The people were transhumant, spending the summer and fall on the mainland, hunting land mammals and fishing and passing the winter and spring on the island hunting sea mammals on the ice (Marino 2009). They were sedentarized permanently in 1906 with the establishment of a government school as part of an overall government and missionary emphasis on settled western style villages. With obligatory education and subsequent infrastructural development, the Seward Peninsula tribes took up permanent residence on the island. Marino reports that today village elders recount that their ancestors knew the barrier reef island was constantly changing and would eventually disappear (Marino 2009: 4). The drive to sedentarize, westernize and otherwise integrate into national cultures has characterized both US and Canadian indigenous policies, frequently with tragic outcomes, as people are exposed to dangers and risks in new sites that traditional culture and adaptation had avoided (Schkilnyk 1985; Oliver-Smith 1996).

Today, fully cognizant of the dangers they face from erosion and flooding, the villagers of Shishmaref have now officially voted to relocate and have chosen a resettlement site. A "research inquiry" published by the *US Army Corps of Engineers* establishes three possible scenarios: complete resettlement of the village on the mainland, relocation of the villagers to the cities of Nome or Kotzebue, or continued residence on the island. However, the villagers' plans have been frustrated by the lack of clear responsible agencies and a systematic strategy for resettlement on the part of state and federal authorities (Marino 2009). There is, in fact, no lead agency, responsible for relocation planning and the coordination of all the various agencies working on housing, transportation, community infrastructure, education, health and other related needs (Bronen 2009: 7). This confusion and the lack of expertise and coordination have produced resettlement budgets that range between \$100-200 million dollars for a village of roughly 600 people, which would range between \$150,000-330,000 dollars per person.

Shishmaref residents were unanimous in their refusal to move to Kotzebue because of long standing difficult relations with the people there would make integration into the community problematical. By the same token, villagers considered Nome to be vice-ridden, exposing people to alcoholism and health problems and eventually loss of language and cultural disintegration. Some people said they would refuse to move if the government tried to relocate them in urban centers (Marino 2009: 6). Local people are very skeptical of outside led resettlement strategies and relocation authorities report that there is

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Vietnam is one of the nations slated to be most impacted by sea level rise.

contention in the village over who is in charge of the planning process (Marino 2009:7). Shishmaref and several other villages have taken their case into the public forum, lobbying extensively at state and federal levels and working the media in a sophisticated fashion (Marino 2008:8). The fundamental issues for the people of Shishmaref are continuity of culture as a discrete village on their own land and local control over resettlement decision-making. Disempowerment and potential impoverishment have proven to be strong incentives for resistance to resettlement in a variety of contexts (Oliver-Smith, in press). Furthermore, bureaucratic inconsistencies, agency contradiction, and planning and procedural rigidities, so typical of development forced displacement and resettlement; seem to be part of future scenarios for people facing displacement by sea level rise, unless significant progress in the field is achieved.

3.5 The Unexpected Risks of Resettlement in Vietnam

Vietnam is one of the nations slated to be most impacted by sea level rise. Dasgupta et al rank Vietnam among the top five most impacted nations in the world and it ranks first in East Asia for area impacted, exposed population, GDP impacted, urban area impacted, agriculture impacted and wetlands impacted (2007: 29-33). Vietnam's exposure is considerable because of its long coastline, vulnerable to storms and high seas and extensive low-lying areas in the southern Mekong Delta, the elevation of which is only 0.5-4 meters above sea level. Compounding the physical exposure, the Mekong Delta, as home to eighteen million people (22% of the total population), is one of the most densely populated regions on earth. The IPCC has calculated that one meter of sea level rise will affect more than one million people in the Mekong Delta (2007: 327).

Furthermore, since the Mekong Delta is also the principle rice growing area of the nation, producing half of that staple food for the nation, any significant alteration in the status of these lands will have serious implications for the economy and the health and nutrition of the people of Vietnam. The fertility of the delta is dependent on continued soil replenishment through the distribution of upstream sediments by the river, especially during regular slow onset seasonal flooding (July-November). The Mekong is also an important breeding ground for fish and shrimp, and the source of 60% of annual national production (Dun 2008).

Thus, within the normal range, the annual flood pattern in Vietnam is essential to the ecological health of the region and the economic well being of the population. Low or "nice" floods range from 0.5-4. meters, while moderate flood reach just 4.5 meters. Disastrous floods exceed 5 meters (Dun 2008: 5). Frequency of major 1 in 50 year floods in the Mekong River is a source of concern and flood patterns in the delta of that river display a worsening trend (White 2002; Be et al 2007; Dun 2009). Coupled with greater intensity and frequency of coastal storms and the rise in sea level, the exposure of even greater numbers of

people in the Mekong region appears to be increasing. There are also human-induced changes upstream, including industrial use of water, dam building, drainage of waterways into the Mekong, flood mitigation programs, farming, sand extraction and irrigation, that will affect the flooding processes in the delta (Dun 2009:7).

In the view of *World Bank* (Dasgupta et al 2007) and IPCC (Nicholls et al 2007) findings, the national government of Vietnam has taken the need to deal with climate change seriously. The government intends to develop a *National Adaptation Program of Action* (NAPA) under the provision of the *United Nations Framework Convention on Climate Change* (UNFCCC) to deal with sea level rise in particular. Developing the NAPA will include plans for resettling affected populations and finding alternative sources of income if they lose farmland (Dun 2009: 7). Although not developed to deal with sea level rise driven floods, current government programs dealing with flood management and environmental sanitation that have resettled people point to challenges that will be faced when resettlement policies are designed for sea level rise. Dun's research with people living along the riverbanks in Cho Moi district in An Giang province focused partly on government plans to relocate poor and landless people living along the riverbanks as mitigation against increased flooding. Being landless, these people are often dependent on day-to-day employment as wage laborers. Consequently, the social networks of these households are essential to daily subsistence. Dun's interviews revealed fears that relocation to planned residential clusters would destroy their social networks and endanger daily income. They also feared competition for employment among poor communities that would be relocated together. Relocation would also distance them from wealthier inhabitants and landowners of the district who may employ them or loan them money.

Furthermore, to move to the residential clusters, people are required to buy a plot of land in the resettlement area with a government provided five year interest-free loan to purchase a housing plot and a basic house frame structure. However, households will also need further loans to complete construction around the basic frame provided. Thus, resettlement puts people further in debt, facing the risk of unemployment, enduring the lack of access to infrastructure such as waste water treatment facilities, health and schooling and suffering the loss of support of their social networks. The residential projects are also designed as semi-urban with side-by side plots for people who formerly lived in comparatively dispersed households along the riverbank edges (Dun 2008: 7-8). The resettlement process has thus resulted in a further impoverishment of already poor people, perhaps removing them from exposure, but doing little to lessen their vulnerability. In that sense, the flood management mitigation oriented resettlement program bears considerable resemblance to much development forced displacement and resettlement (Oliver-Smith 2009).

A resettlement process in Vietnam has resulted in a further impoverishment of already poor people, perhaps removing them from exposure, but doing little to lessen their vulnerability.

3.6 Building Resilience to Sea Level Rise on the US Gulf Coast

There is no question that human alteration of significant aspects of coastal ecology has accentuated vulnerability to sea level rise. Nowhere is this truer than on the Gulf Coast of the United States. The research of Shirley Laska et al (2005) and Robert Gramling and Ronald Hagelman (2005), among others, tells us that the vulnerability profile of the Gulf Coast combines natural ecological features of the region with factors emerging out of human exploitation of the environment. The region of the Gulf Coast and particularly surrounding New Orleans is close to or below sea level, leaving it vulnerable to storms and hurricanes, a fact tragically demonstrated by Hurricane Katrina. Although the devastation caused by Katrina was not the result of sea level rise, it indicates that climate change driven sea level rise may intensify devastation in the future on the Gulf Coast because of the flat terrain, land subsidence and increased coastal development (Button and Peterson 2009).

Environmental degradation produced by multiple causes has also compounded the natural exposure of the region. Louisiana ranks second only to Texas in terms of hazardous industrial waste generated. Much of the waste that is flushed down river leaves through the mouth of the Mississippi contaminating large areas of the Gulf Coast (Oliver-Smith and Button 2005). The digging of a Mississippi Gulf outlet has also weakened the natural defensive features of the environment. Coastal erosion has been precipitated by the clear-cutting of cypress for garden mulch and the location of hundreds of gas/oil rigs and pipelines along the coast has further added to environmental degradation. Moreover, the building of transportation canals for the petrochemical industry has contributed to the destruction of the natural protection of coastal marshes as well (Laska, et al, 2005). Tens of thousands of cuts open the marshes to seawater flooding, turning them into small lakes and reducing their defensive capabilities for storms and tidal surges. Every 2.7 miles of marsh is capable of absorbing one foot of land surge of a hurricane (Tidwell 2006). Moreover, natural subsidence accounts for a loss of more than two feet of elevation. Natural subsidence in the region was traditionally offset by the deposition of silt and sedimentation by the Mississippi river, but the construction of dikes and levees by the US Army Corps of Engineers have since precluded that restorative process (Button and Peterson 2009). The loss of coastal marshes has accelerated the loss of coastal land and increased the vulnerability of the populace. It is estimated that the Gulf Coastal loses about thirty-five square miles of coast each year due to these factors (Gramling and Hagelman 2005). Louisiana lost 1,900 square miles of coastal land between 1932 and 2000. Plaquemines parish, southwest of New Orleans, lost over 60 square miles of land to Hurricanes Katrina and Rita (Button and Peterson 2009: 331).

The loss of coastal marshes has accelerated the loss of coastal land and increased the vulnerability of the populace.

The socio-economic factors contributing to the vulnerability profile of the Gulf Coast are now well known. The city of New Orleans suffers from a condition of endemic economic crisis, compounded by a political system in which corruption also seriously undermined its capacity to cope with an array of serious social problems. Louisiana has one of the lowest levels of educational attainment in the nation; one quarter of all adults, age 25 and over lack a high school education. Further vulnerability is indicated by the fact in over-all health indicators Louisiana ranked last among the 50 states in 2002 and 49th in 2003 (U.S. Census 2000). Indeed, the institutional vulnerability of local, state and federal agencies was made manifest in the secondary disaster of displacement, subsequent to the failure of the levies after Hurricane Katrina (Button and Oliver-Smith 2008; Cannavò 2008).

Grand Bayou, a Native American fishing community about an hour and a half south of New Orleans in Plaquemines Parish, was almost entirely destroyed by Hurricane Katrina.² All 25 families, 125 individuals in total, were displaced by the storm. Although traditional environmental knowledge enabled the community to be resilient to the impact of previous hurricanes, the two 2005 storms obliterated all but one house in the community. However, traditional local knowledge enabled them to save all their boats and preserve the principle tools of their economic life. And no one perished in the storm that killed more than three thousand people elsewhere in the region. Today in 2009 they continue to reside in the parish, many still in mobile homes provided by the *Federal Emergency Management Agency* (FEMA), and they are determined to rebuild their community and to sustain their culture.

Since 2003 the community had been engaged in a *Participatory Action Research* (PAR) project with faculty and graduate students from the *Coastal Hazards Assessment Resource Technology Center* (CHART) of the *University of New Orleans and Louisiana State University* to test the effectiveness of PAR in improving community resilience to tropical storms and hurricanes. A parallel purpose was to explore the ways in which the PAR process improves the intersection between traditional ecological knowledge and scientific knowledge to generate locally effective perspectives on meeting the challenges facing coastal communities. With a strong ethnographic base, the project focused on oral history, preservation of local knowledge and cultural practices that underlie local resilience, providing an important focus around which a sense of community could be strengthened and local knowledge could be validated. In addition, the project contained a major outreach component. Community members have shared their knowledge and concerns about the environment and their cultural heritage with a wide variety of groups, including the *US Army Corps of Engineers*, the *National Hazards Workshop*, the *National Academies of*

The institutional vulnerability of local, state and federal agencies of the city of New Orleans was made manifest in the secondary disaster of displacement, subsequent to the failure of the levies after Hurricane Katrina.

² Unless otherwise indicated, all information in the following section is drawn from Button and Peterson (2009).

Local knowledge can lessen the vulnerability of a community.

Science, Oxfam America, the National Council of Churches, the National Science Foundation, NOAA Coastal Services Center, and many others. These encounters have informed and educated these organizations and foundations about the challenges confronted by coastal communities throughout the region. In addition, the community has entered into dialogue with people from the Caribbean and Central America regarding common challenges they face and potential resilience building options. A much desired long term goal is the establishment of a collaborative relationship with a sister community facing similar challenges in Alaska.

In particular, the outreach effort has demonstrated to experts the value of local knowledge for understanding and analysis of environmental problems. In contemporary society, science reigns supreme while local knowledge, based on experience, narrative and tradition, has often been summarily dismissed or relegated to the category of “alternative” interpretations, thus silencing local perspectives. The outreach aspect of the PAR project demonstrated clearly to the scientific community that local knowledge can lessen the vulnerability of a community. In Grand Bayou, scientists came to agree that it was far more efficient and effective to tap local knowledge about hydrological and environmental processes than to try to generate projections for research projects through models. At the same time, local residents, now facing radically altered environmental conditions, have come to value scientific insights that may assist them in facing these novel problems. For example, traditional safe harbor locations for boats have been destroyed, and local fishermen are working with their scientific partners in developing new risk assessments and future secure sites for boats during storms.

It is clear that vulnerability reduction will require reducing the environmental degradation that left the region bereft of natural defenses against systemic hazards. Addressing root causes, reversing the *Pressure and Release Model* as Wisner et al (2004) suggest, will mean taking actions that both reduce the exploitation and efficiency of transport of basic features of the economy, namely petroleum, chemicals and shipping. It is equally clear that adaptation and resilience to climate change generally and sea level rise specifically must also be undertaken at the local level. The Grand Bayou project demonstrates amply the importance of local knowledge and control in meeting the challenges of sea level rise. Policies that fail to factor in local knowledge and silence local perspectives will reduce the chances of success in dealing with these problems effectively.

Section IV

4.1 Sea Level Rise and Population Displacement and Resettlement

If sea level rise damages or engulfs coastal communities, either gradually through erosion and coastal land inundation or suddenly through storm surges with increased inland reach, and adaptation and mitigation measures are inadequate, national governments and international organizations must be prepared to assist affected peoples, especially those displaced due to loss of land and livelihood. Involuntary displacement involves far more than just physical movement. It is important to understand what is lost in displacement and what needs to be recovered if effective policy is going to be developed to avoid creating permanent refugee camps and dependent populations. Here human rights concerns focus not only on the injustice of differential vulnerability, but also on the injustice of inadequate resettlement that is generally considered a secondary disaster, leaving people destitute and disempowered. Poorly implemented resettlement both compounds and makes permanent many of the losses incurred in displacement (Cernea 2000; Scudder 1982; Oliver-Smith 2009).

Environmentally displaced people will face a complex series of events most often involving: dislocation, homelessness, unemployment, the dismantling of families and communities, adaptive stresses, food insecurity, loss of privacy, marginalization, loss of access to common property, a decrease in mental and physical health status, social disarticulation and the daunting challenge of reconstituting one's livelihood, family, and community (Cernea 1996, 1990, 2000; Scudder 1981). When people are forced from their known environments, they become separated from the material and cultural resource base upon which they have depended for life as individuals and as communities. The destruction or loss through uprooting of livelihood and community require impacted people to engage in a process of social and material reinvention. In addition to physical damage, material losses resonate profoundly, compounding the serious losses also inflicted in the economic, social and cultural life of affected people. For example, the loss of livelihood, through loss of worksite, tools and equipment, land or common property resources means loss of the capacity to sustain oneself, thus endangering individual and social identity resulting in marginalization and social disarticulation. And the community, the social world, is endangered by such individual losses.

The dispersal of family members that often occurs in displacement fragments not only a household, but erodes the social cohesion of a community as well, shredding those networks of relationships that form the basis of personal and social identity, setting people adrift, without those ties that anchor the self in the social world. The loss and destruction of important cultural sites, shrines, religious objects, the

The destruction or loss through uprooting of livelihood and community require impacted people to engage in a process of social and material reinvention.

The process of resettlement, formally or informally, must address these losses, not only to reconstitute the community in a material sense, but to support the community's efforts to make itself whole again, to re-knit the fabric of life in some coherent fashion.

interruption of important sacred and secular events and rituals undermines the community's sense of itself. The loss of personal relationships and the social context in which they were expressed and in which the individual was affirmed, may leave people bereft of a sense of meaning, a sense of purpose in life. In summary, removal from one's place in the world can be a form of removal from life (Basso 1988).

People uprooted by sea level rise will face the daunting task of rebuilding not only personal lives, but also those relationships, networks, and structures that support people as individuals that we understand as communities. The disarticulation of spatially and culturally based patterns of self-organization, social interaction and reciprocity constitutes a loss of essential social ties that affect access to resources, compounding the loss of natural and man-made capital (McDowell 2002). When an entire community is resettled, it is not simply lifted up and set down whole in a new site. In many respects, resettlement will not necessarily destroy "local cultures" as much as it appropriates them and restructures them in terms of values and goals often originating from far beyond the local context.

The process of resettlement, formally or informally, must address these losses, not only to reconstitute the community in a material sense, but to support the community's efforts to make itself whole again, to re-knit the fabric of life in some coherent fashion. In general, however, the process of resettlement has been approached largely as a material problem driven largely by donor priorities and frequently is delivered in content and form in ways that compound the social and psychological effects of displacement by undermining self-esteem, compromising community integrity and identity and creating patterns of dependency.

There is a complexity in resettlement that is inherent in

"the interrelatedness of a range of factors of different orders: cultural, social, environmental, economic, institutional and political – all of which are taking place in the context of imposed space change and of local level responses and initiatives" (de Wet 2006).

Despite this daunting complexity, planners and administrators of projects dealing with uprooted peoples have generally approached their tasks as a straightforward material transfer. Indeed, the goals of such undertakings frequently stress efficiency and cost containment over restoration of community. Such top-down initiatives have a poor record of success because of a lack of regard for local community resources. Planners often perceive the culture of uprooted people as an obstacle to success, rather than as a resource. The challenge thus becomes the development of policy that supports a genuine participatory and open-ended approach to resettlement planning and decision-making (De Wet 2006).

Conclusions

Toward a Policy and Practice Relevant Research Agenda for the Social Impacts of Sea Level Rise

A policy and practice relevant research program should clearly focus on documenting and analyzing regionally and locally those combinations of exposure and vulnerability that under expected sea level rise estimates can be projected to require significant adaptive efforts, including the potential displacement of communities. The SRES storylines can be helpful generally in this effort, but research should attempt to gain a much tighter focus on local socio-ecological systems than those scenarios permit. Local conditions, such as those described in the case studies discussed in this paper, will exhibit different kinds and degrees of vulnerability to the various physical manifestations that sea level rise will produce. By the same token, research should also explore those adaptive strategies, such as those suggested in the case studies that permit continued occupation of lands affected by sea level rise. Policy goals should include mitigation, vulnerability reduction and climate change stabilization.

Given the dismal record of involuntary resettlement projects, a second general research focus on displacement and resettlement should emphasize the analysis of climate change driven displacement and resettlement as they emerge to explore those factors that lead to success or failure. There is a pressing need to deepen understanding of the displacement and resettlement process in general and researchers focusing on climate change driven displacement must contribute to that effort. This research should inform the development of policy to improve resettlement practice with particular attention to the education and training of resettlement project managers and personnel.

Third, although the issue of “environmental refugees” has generated significant attention (and debate) over the last twenty years, appropriate policies pertaining to environmentally displaced peoples or other internally displaced populations have yet to attain legal status. Moreover, “there are no well recognized and comprehensive legal instruments which identify internationally agreed rules, principles and standards for the protection and assistance of people affected by natural and technological disasters” (IFRC 2004:1). As a result, many international disaster response operations “are subject to ad hoc rules and systems, which vary dramatically from country to country and impede the provision of fast and effective assistance – putting lives and dignity at risk” (IFRC 2004: 1).

The *Guiding Principles on Internal Displacement* defines internally displaced persons as

“...persons or groups of persons who have been forced or obliged to flee or leave their homes or places of habitual residence, in particular as a result of or in order to avoid the effects of armed conflict, situations of

Policy goals should include mitigation, vulnerability reduction and climate change stabilization.

This paper demonstrates the importance of local knowledge and perspectives in the development of appropriate policies and programs of adaptation and mitigation to sea level rise.

generalized violence, violations of human rights or natural or human made disasters, and who have not crossed an internally recognized state border” (UNHCR 2009).

However, although widely recognized as an international standard, and certainly helpful in guiding NGOs and other aid organizations in assisting *Internally Displaced Persons* (IDPs), the guiding principles have not been agreed upon in a binding covenant or treaty and have no legal standing. We must also recognize the very real potential for global climate change to generate displacements and migrations across international borders.

Many of the emerging global environmental changes will very likely increase the severity of impacts in the relatively near future. For example, sea level rise and storm surges will likely impact other cities such as Mumbai, Cape Town, Dar es Salaam, Manila, and Darwin, Australia, which, although they do not share New Orleans’ particular set of vulnerabilities, are similarly vulnerable to serious coastal flooding. The combination of increasing population, population density, increasing poverty, and occupation of coastal lands has accentuated vulnerability to both sea level rise and coastal storms and increases the probability of severe social impacts including forced displacement. While many of the changes associated with increasing state and market integration have established more resilient infrastructures in some regions of the world, they have also frequently undermined traditional adaptations of rural populations to natural hazards. In that context, the cases discussed in this paper demonstrate the importance of local knowledge and perspectives in the development of appropriate policies and programs of adaptation and mitigation to sea level rise. Given the vulnerability of millions of people, most of them among the poorest of the poor, it is both urgent and incumbent upon national and international actors and agencies to develop the conceptual, strategic and material tools to confront the increasing challenges to coastal populations that global climate change in general and sea level rise specifically are projected to cause.

Abbreviations

ASL	Above Sea Level
CHART	Coastal Hazards Assessment Resource Technology Center
IDPs	Internally Displaced Persons
FEMA	Federal Emergency Management Agency
IFRC	International Federation of Red Cross and Red Crescent Society
IPCC	Intergovernmental Panel on Climate Change
LECZ	Low Elevation Coastal Zone
NAPA	National Adaptation Program of Action
NGO	Non-Governmental Organisation
PAR	Participatory Action Research
SIDS	Small Island Developing States
SLR	Sea Level Rise
SRES	Special Report on Emission Scenarios
UNFCCC	United Nations Framework Convention on Climate Change
UNHCR	United Nations High Commissioner for Refugees
WAIS	West Antarctic Ice Sheet

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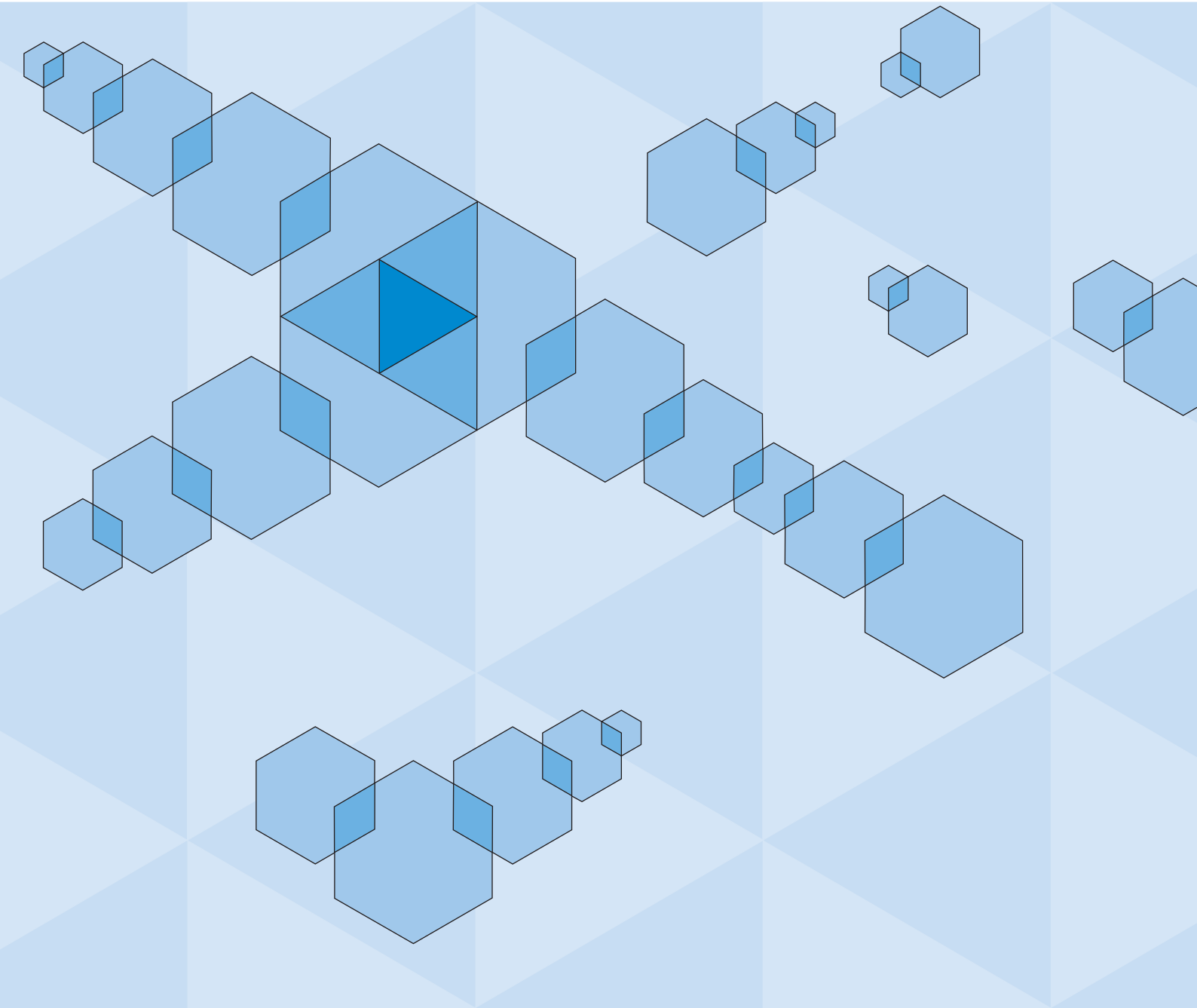
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